Exeretory Product & their elimination

Topic

Excretory system

Exercises

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Syllabus

Exeretory Product & their elimination

Excretory system

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

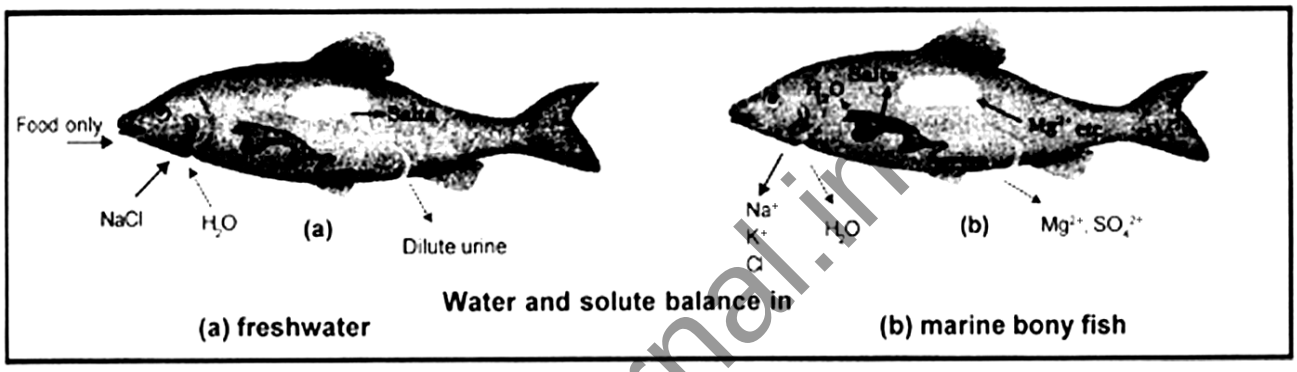
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

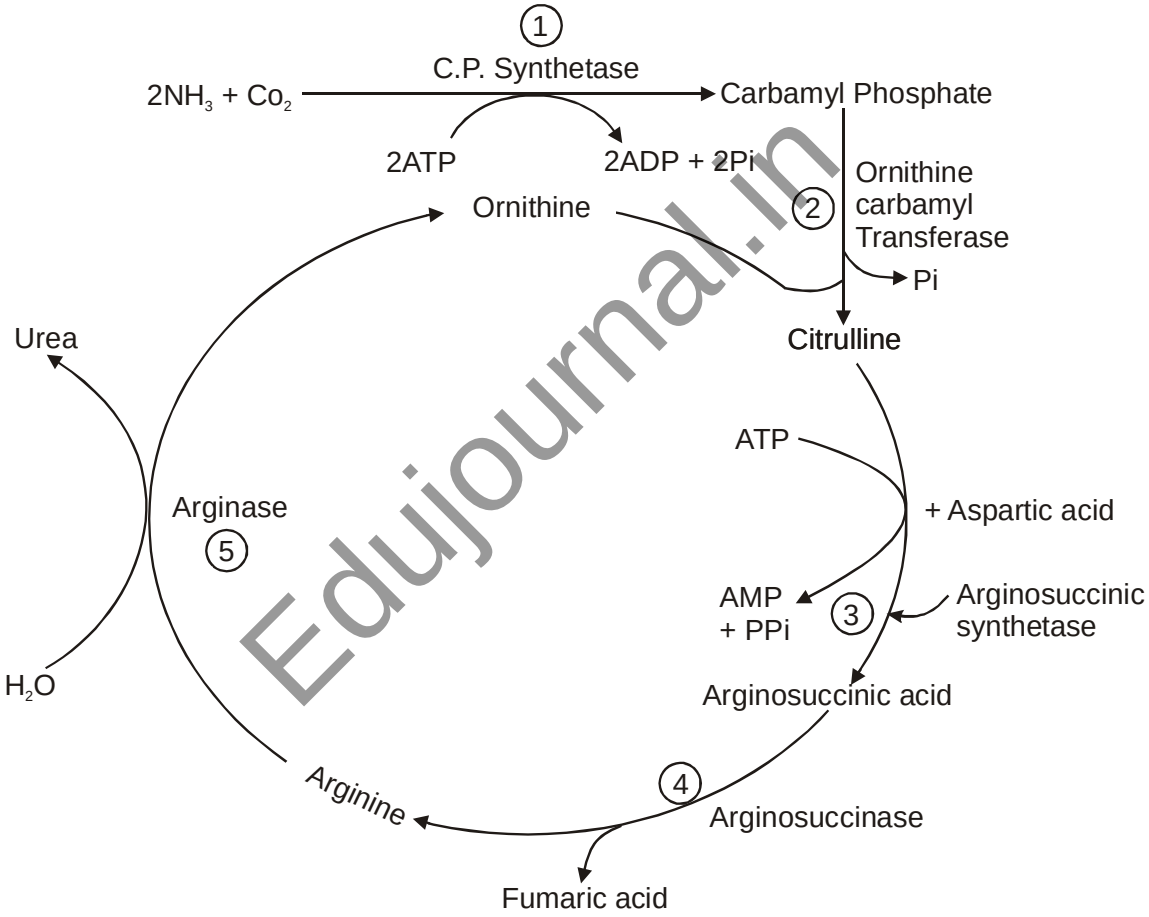
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

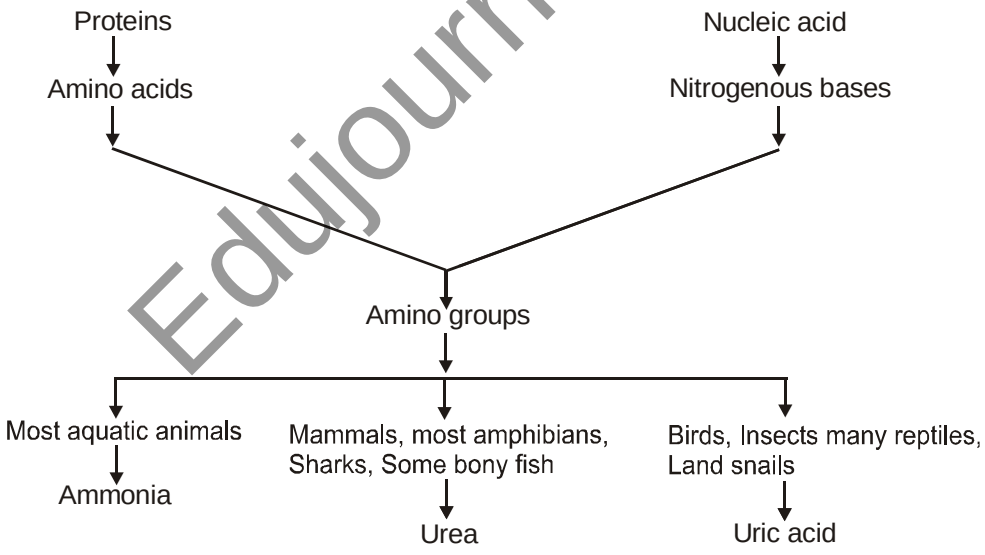
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

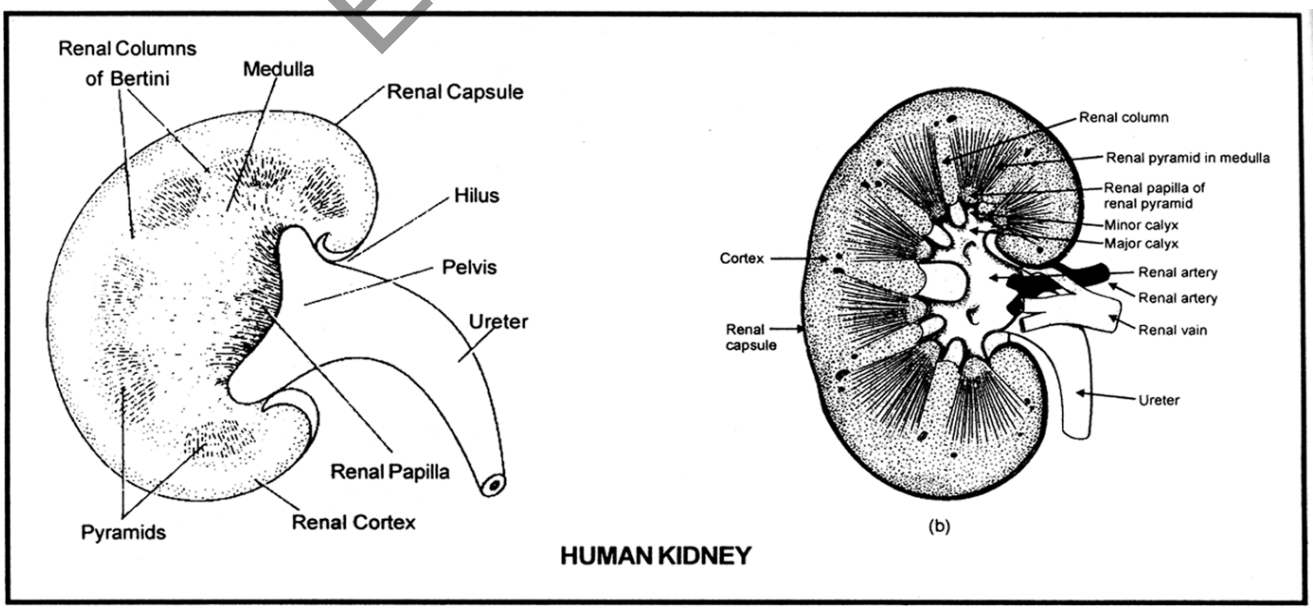
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

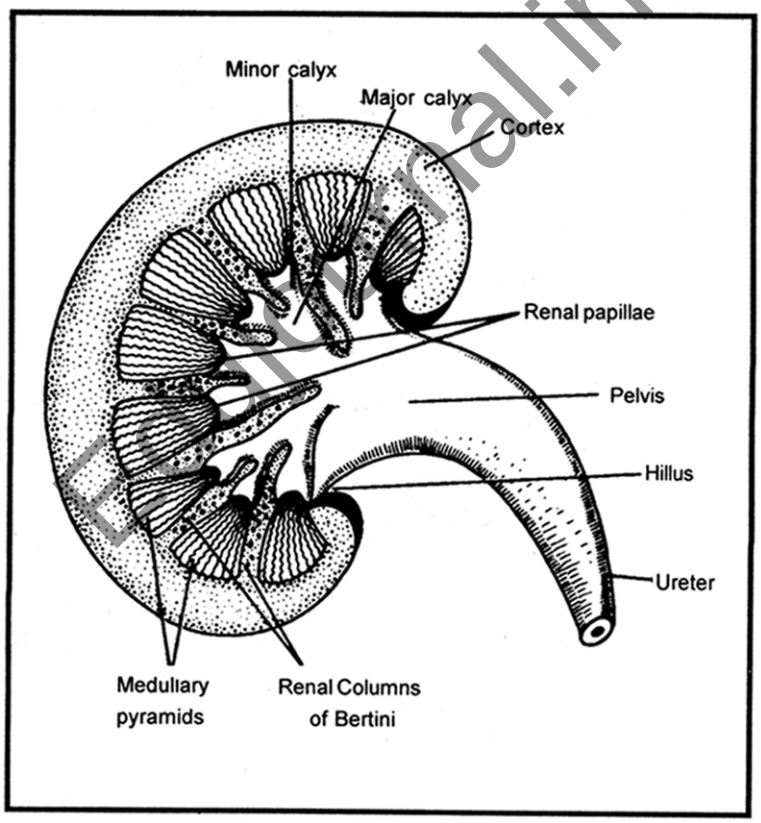
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

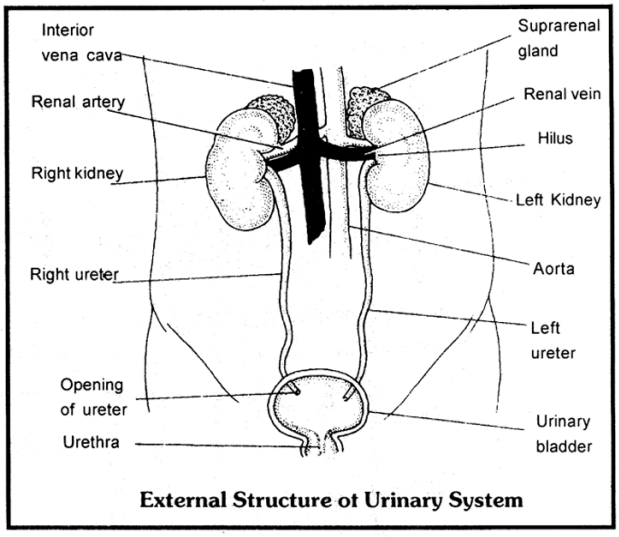
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

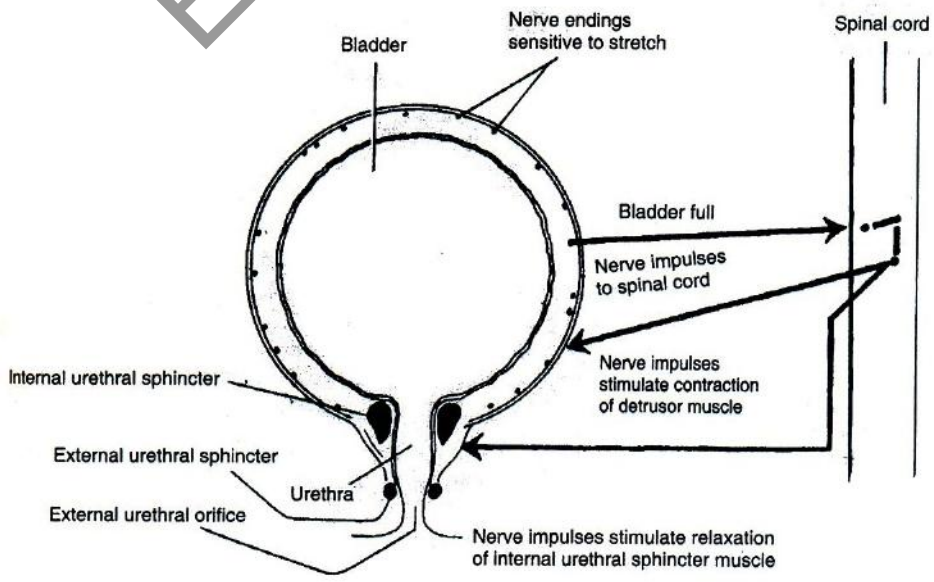
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

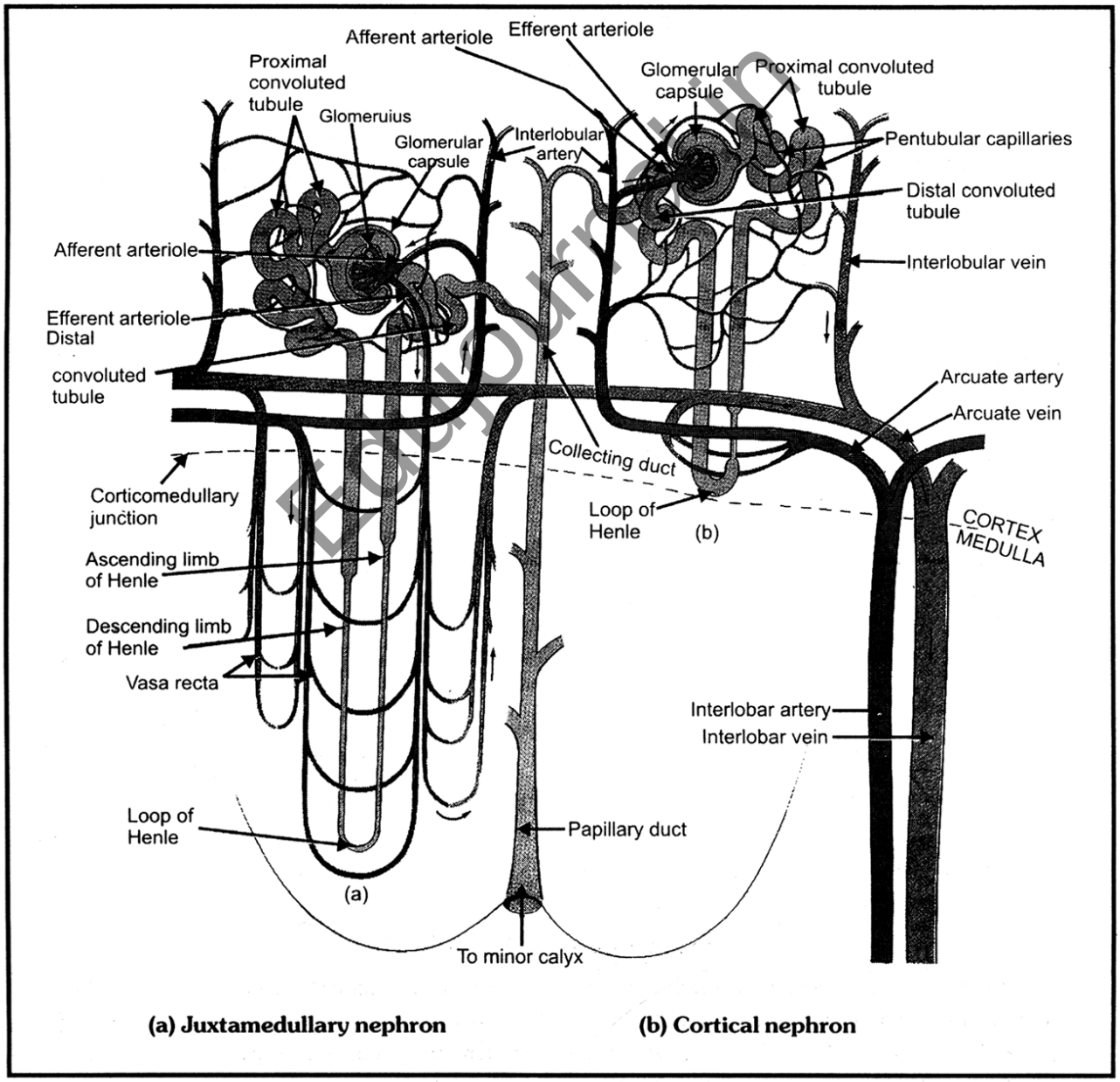
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



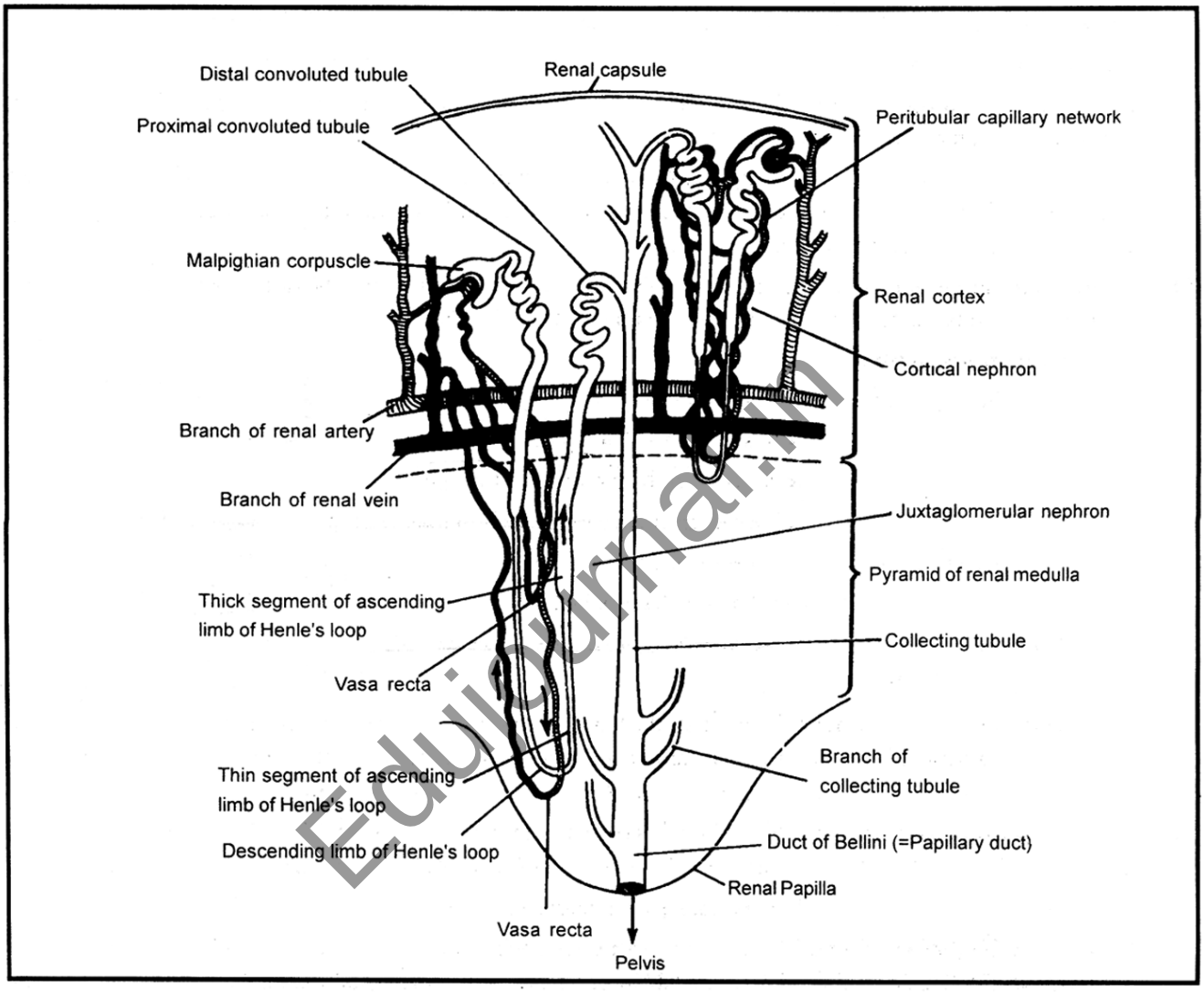
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

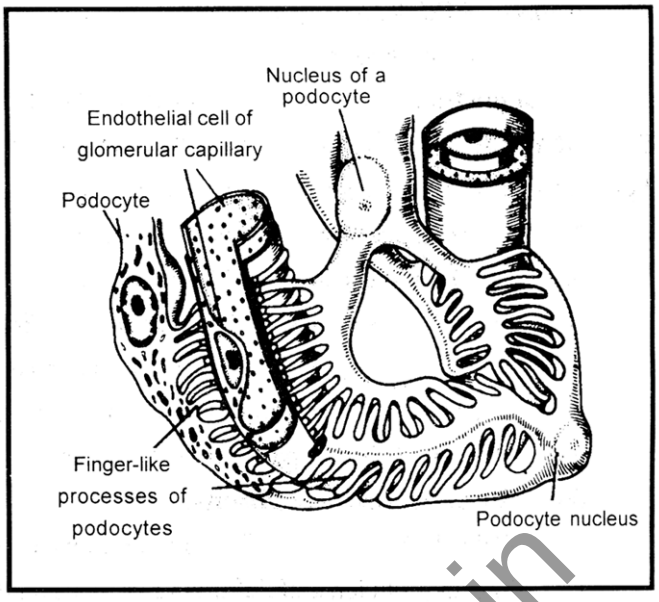
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

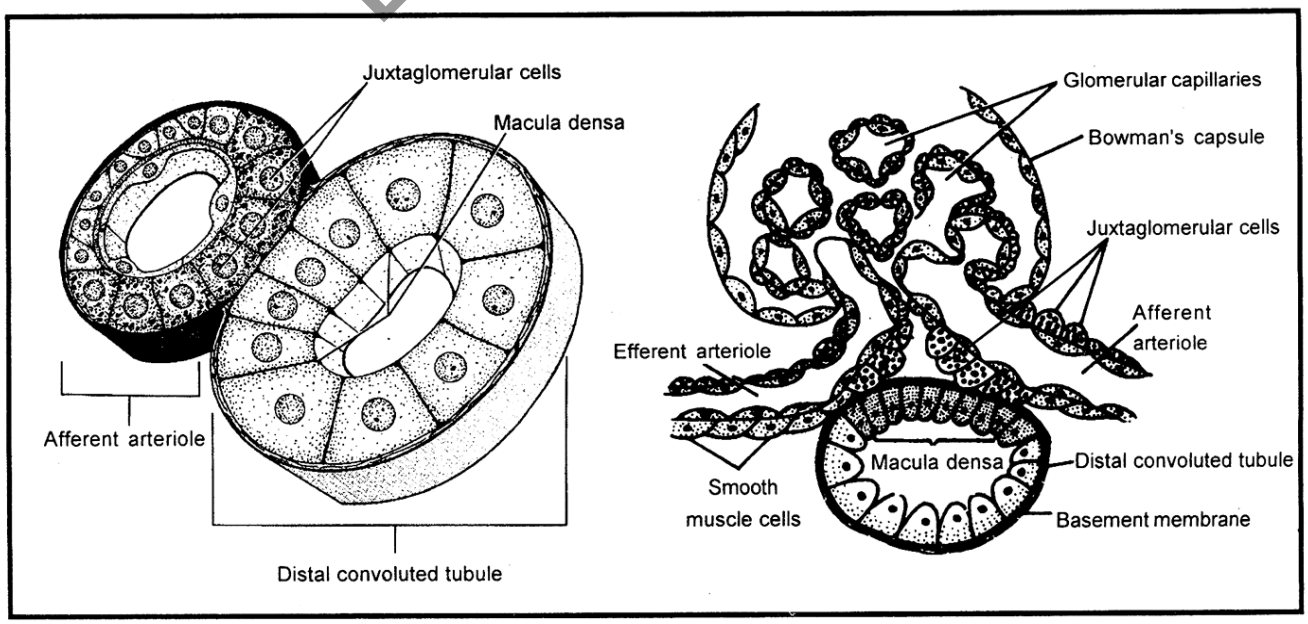
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

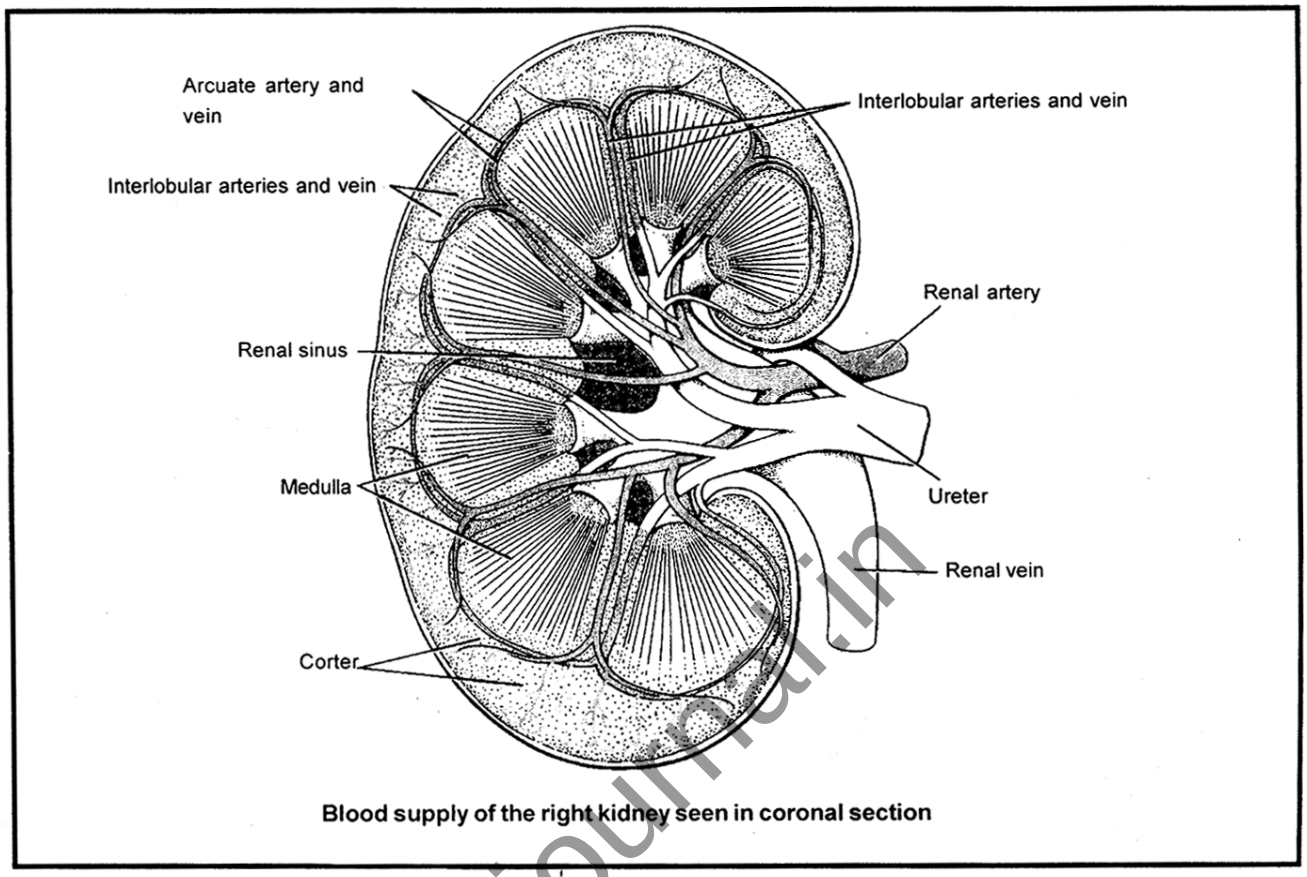
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

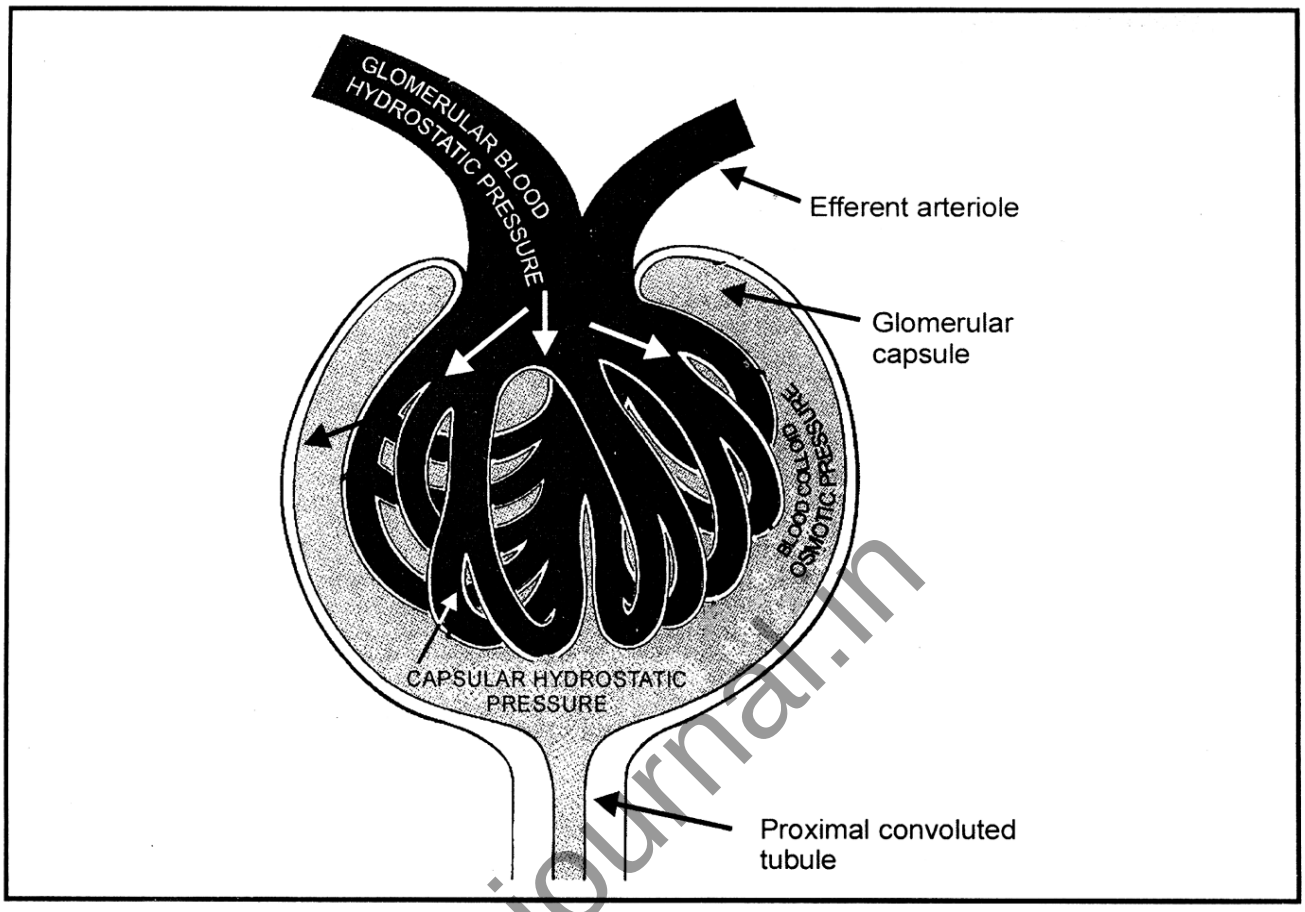
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

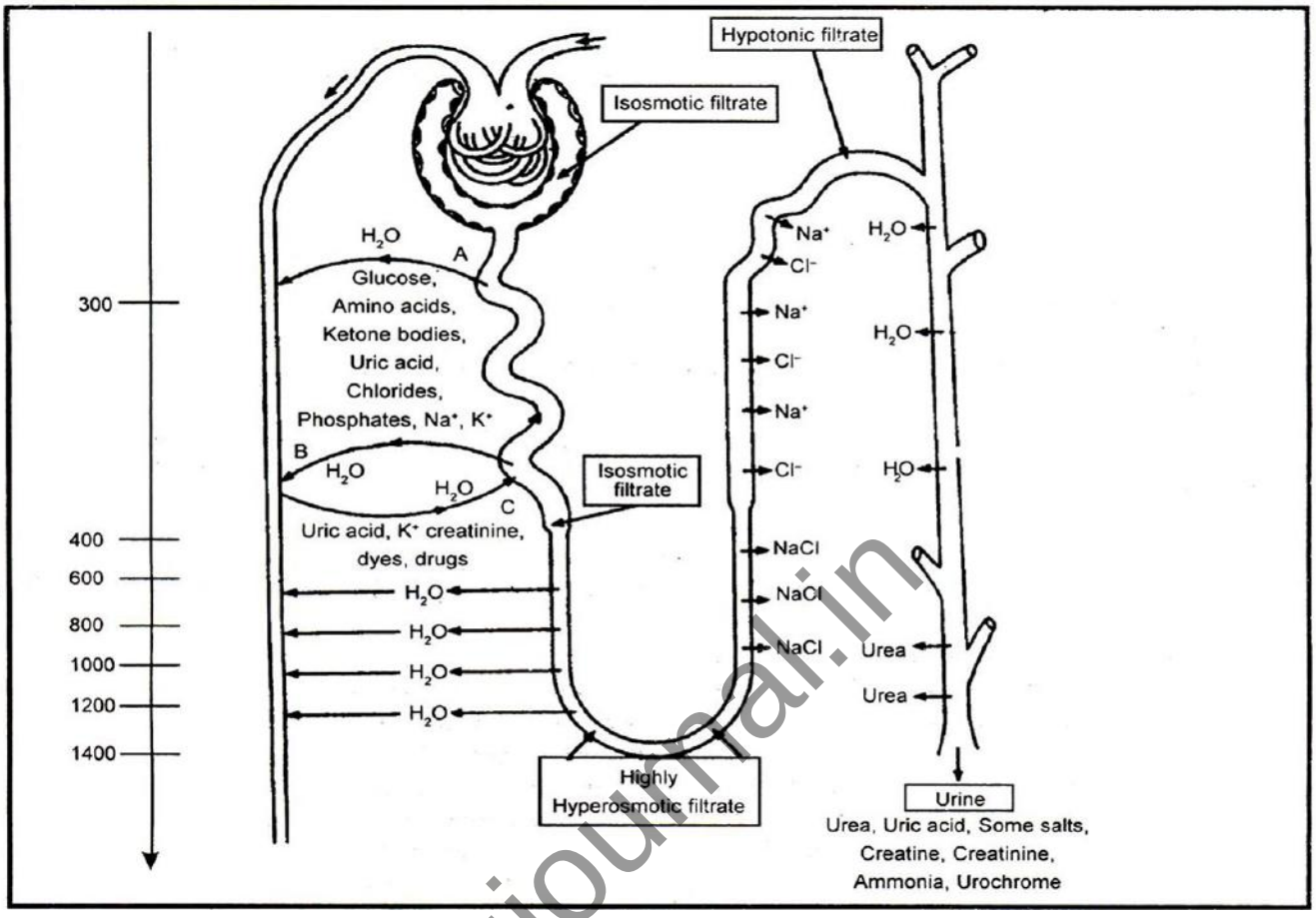
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

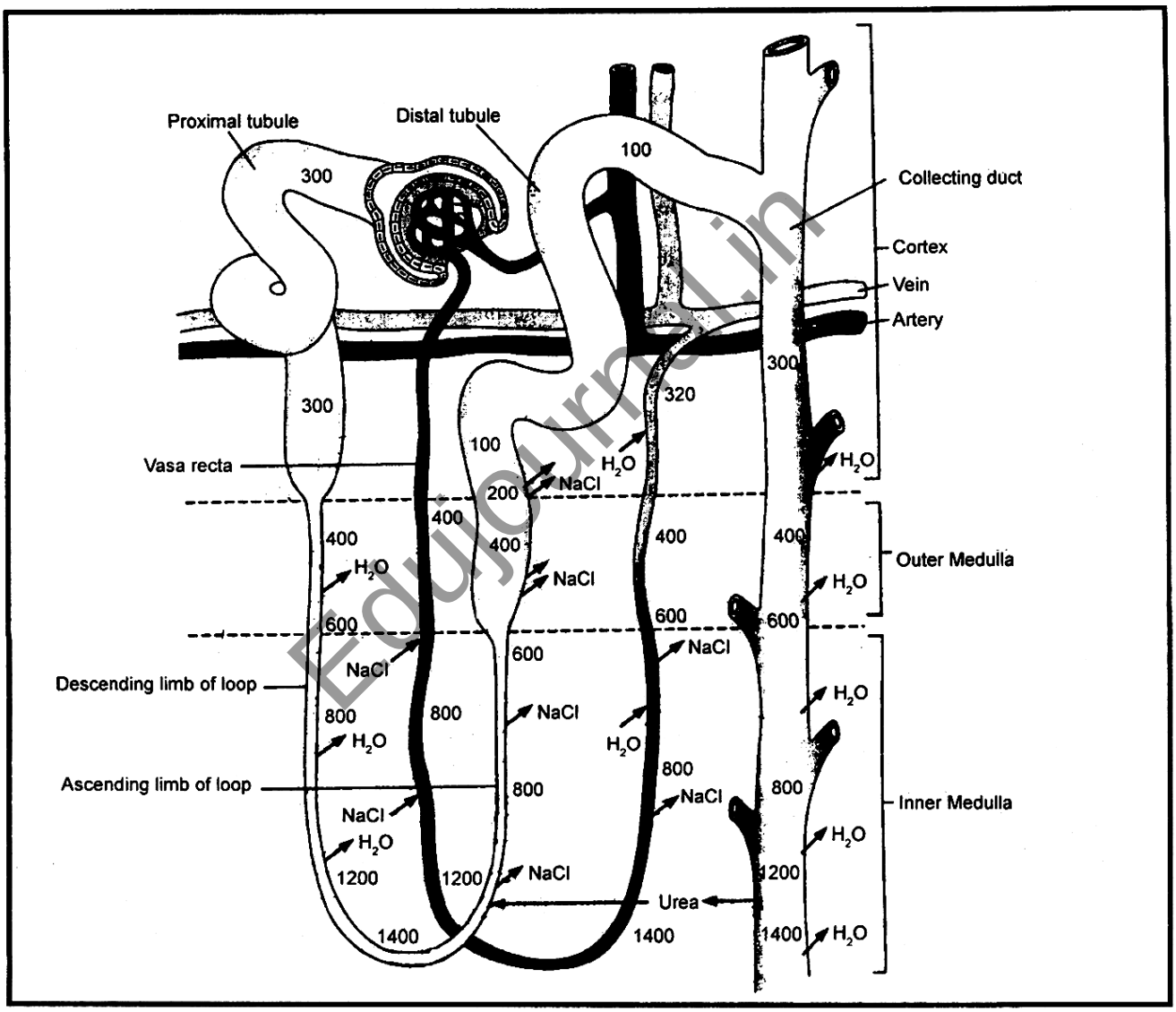
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

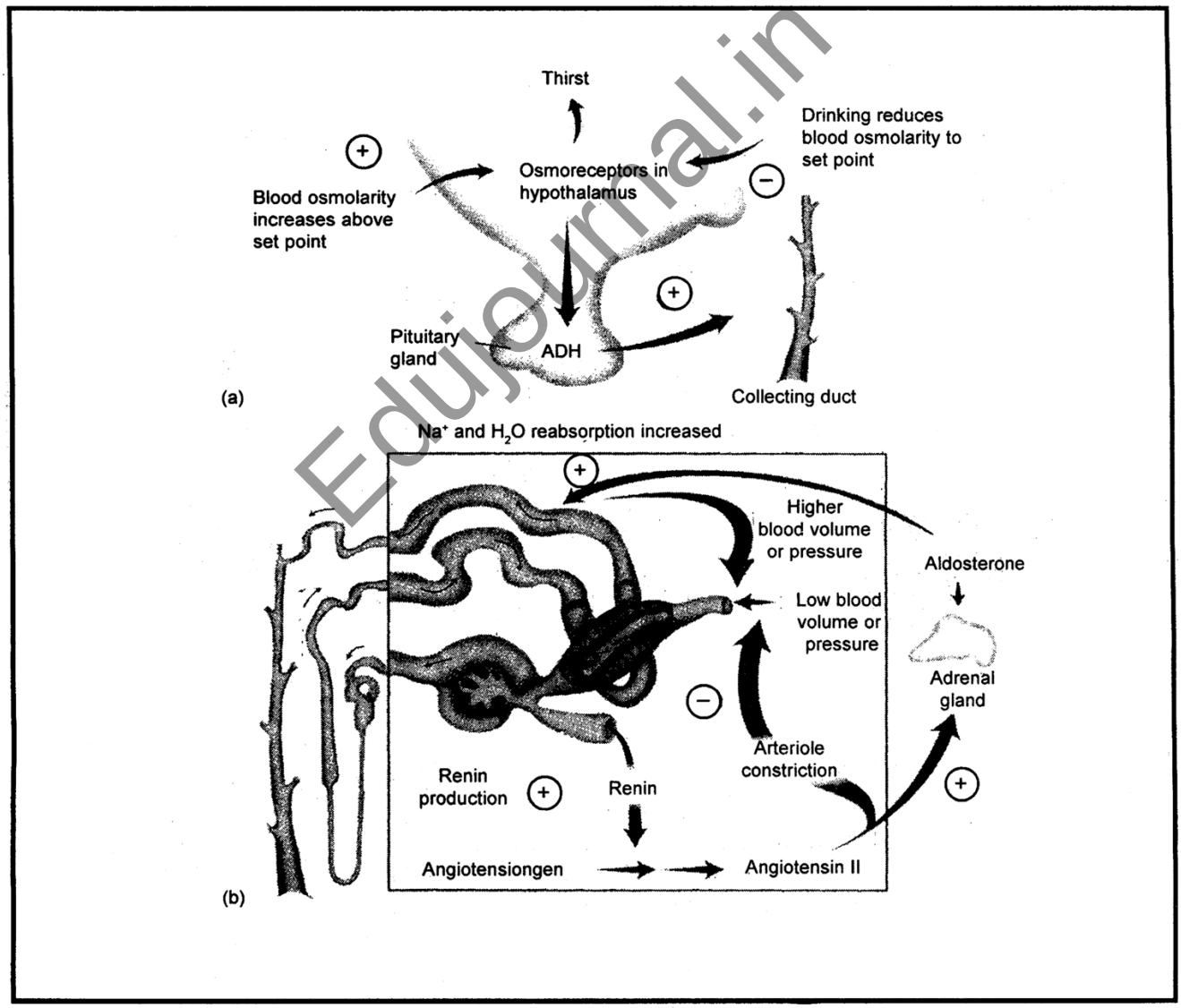
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

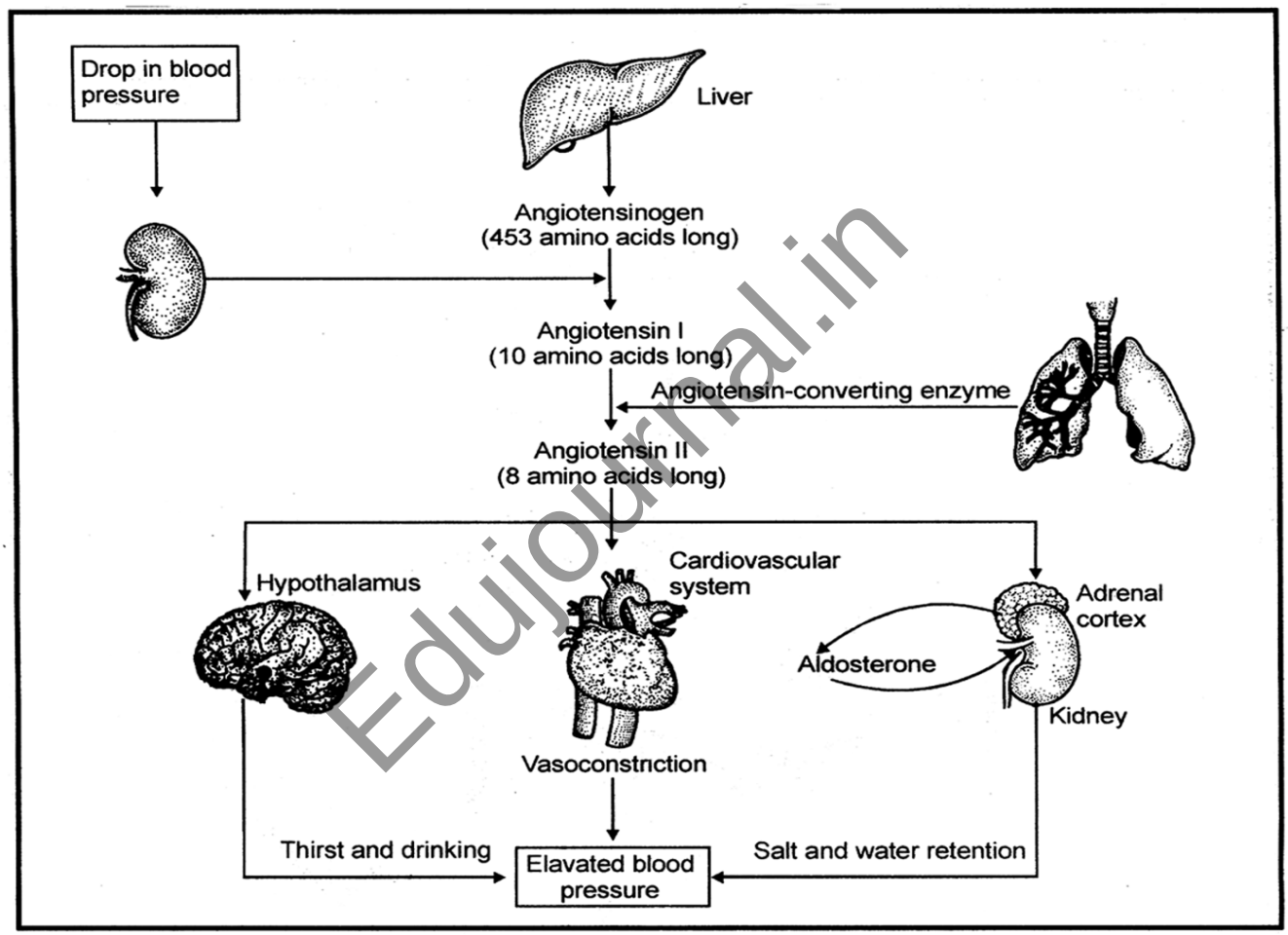
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

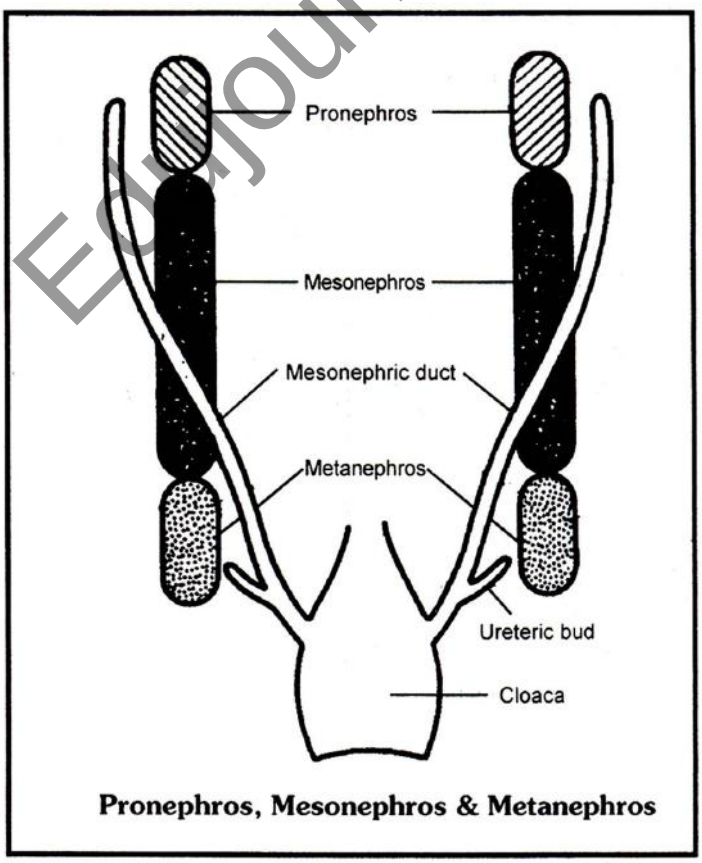
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

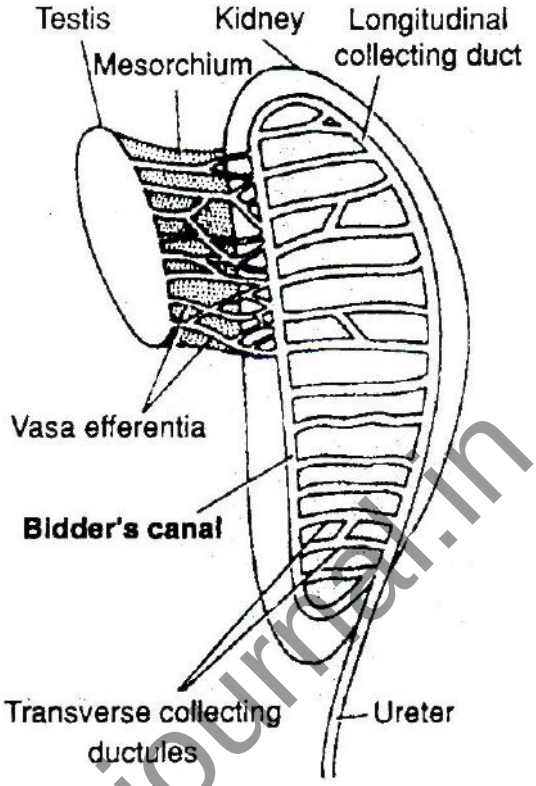


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

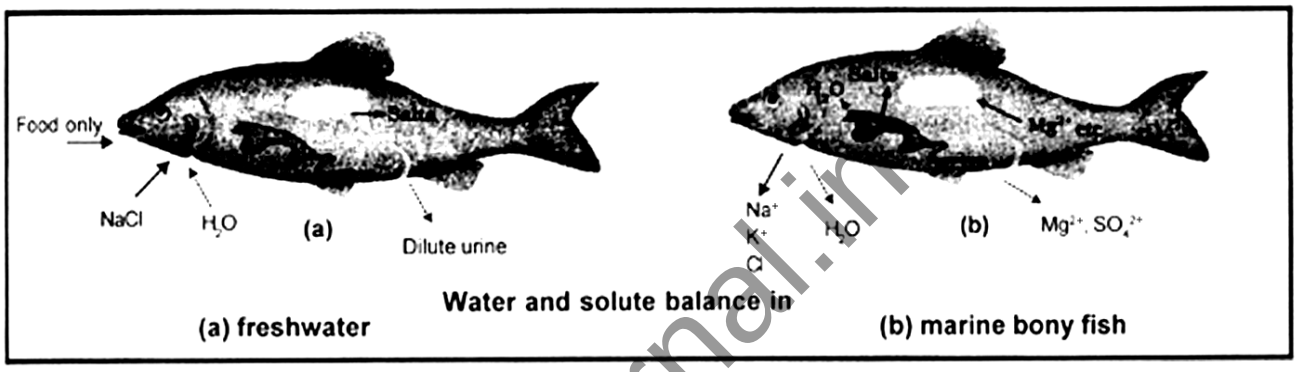
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

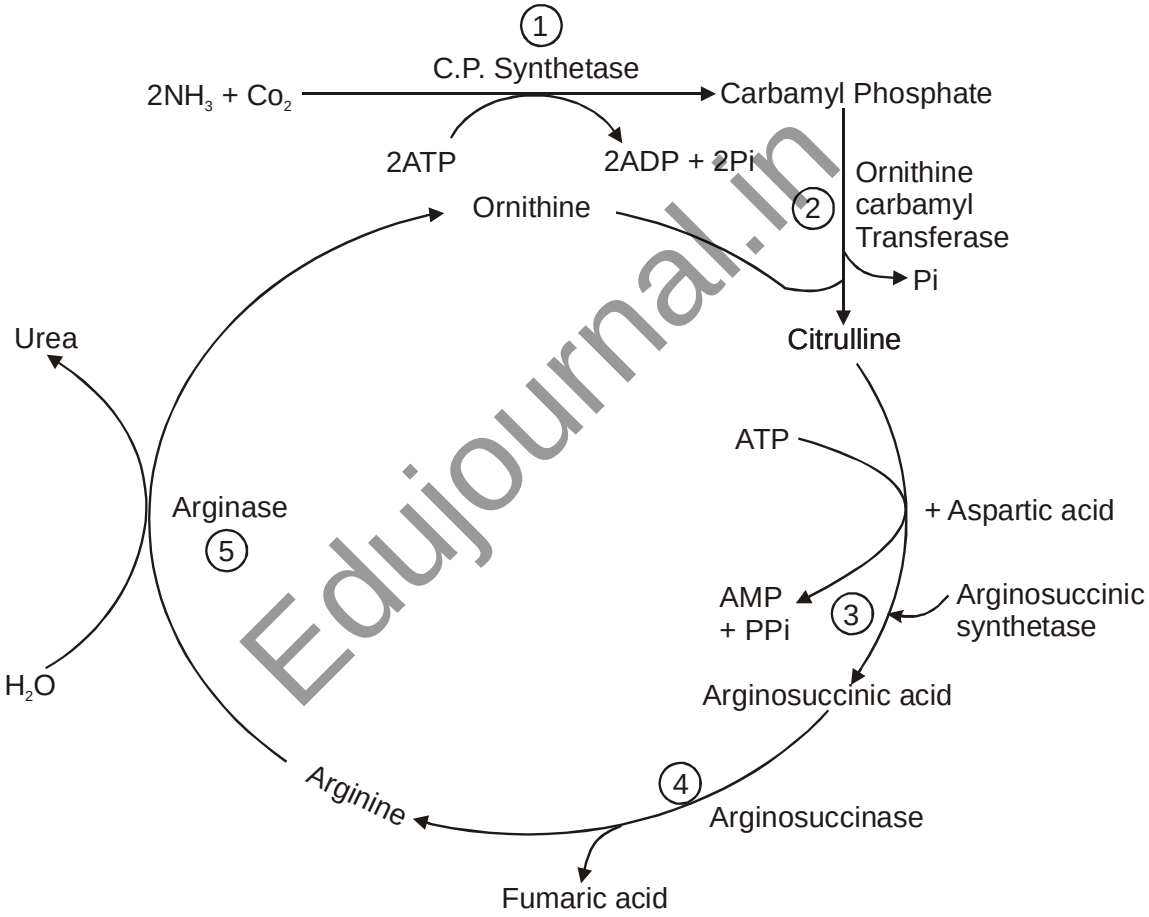
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

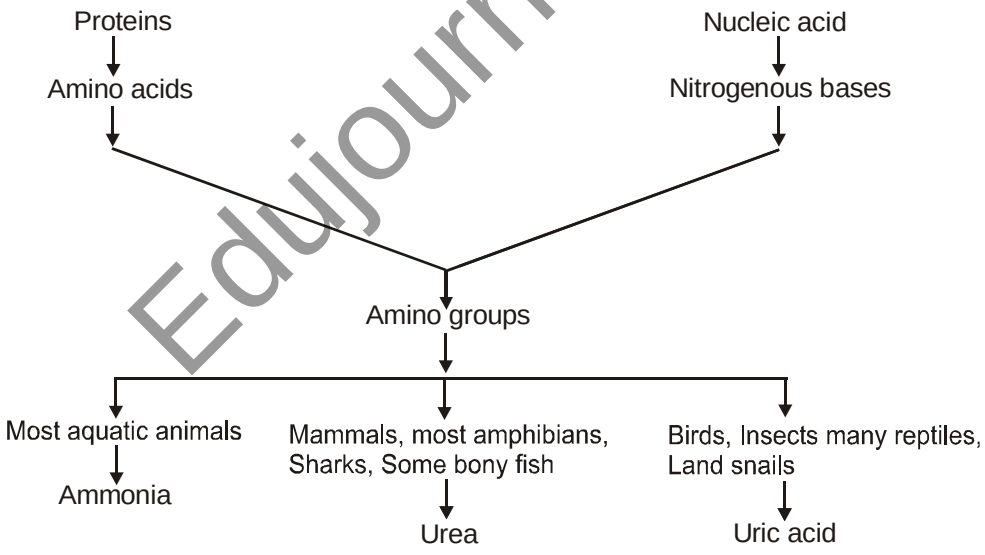
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

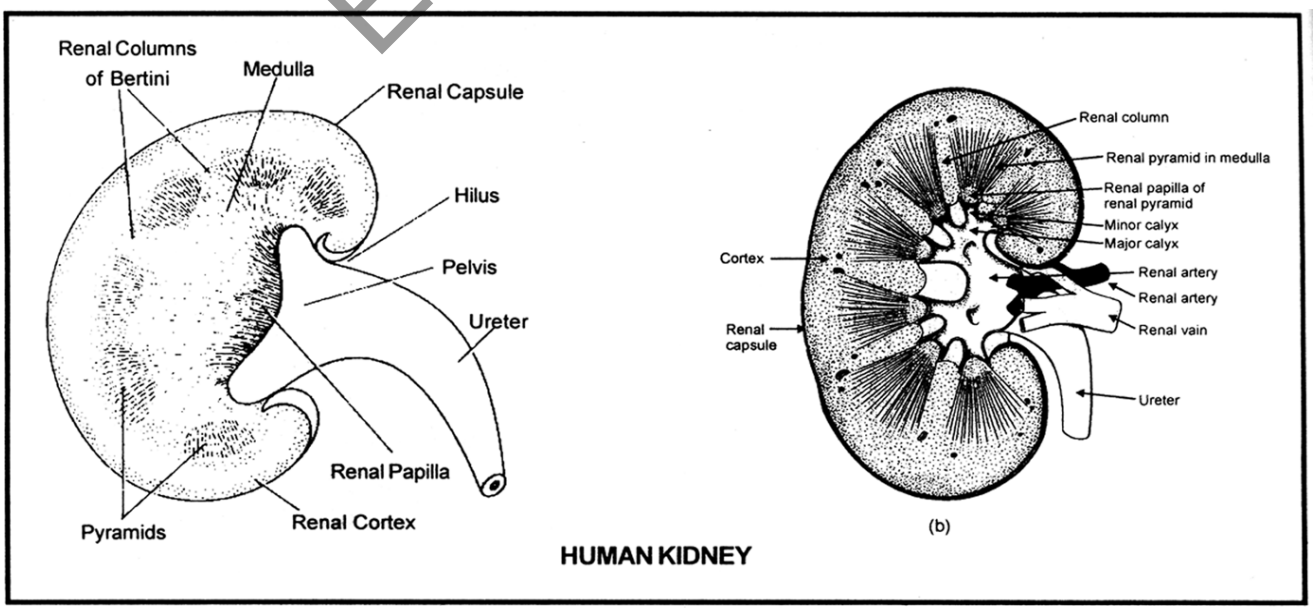
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

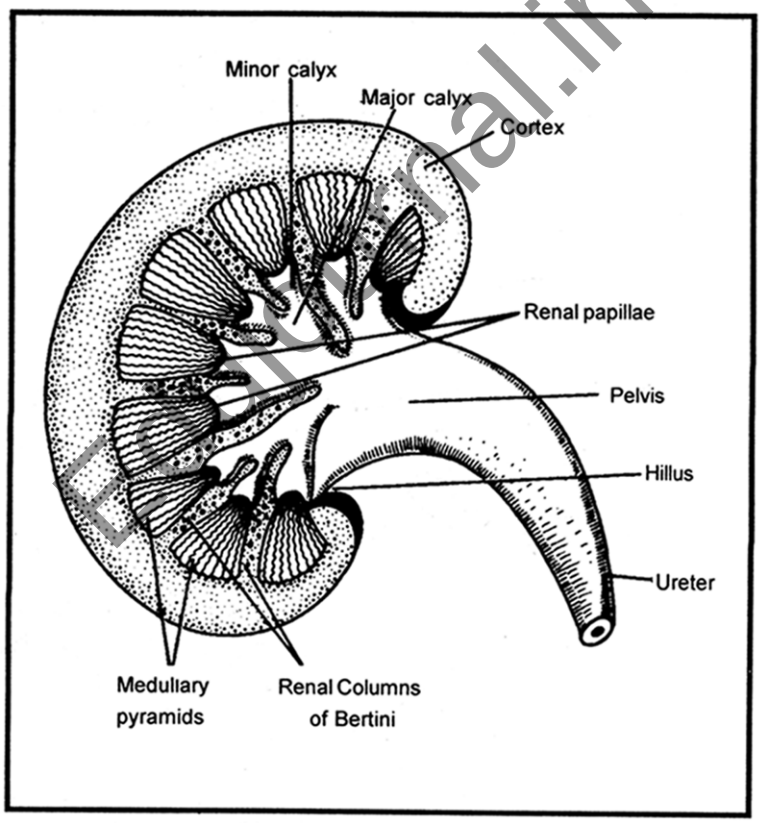
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

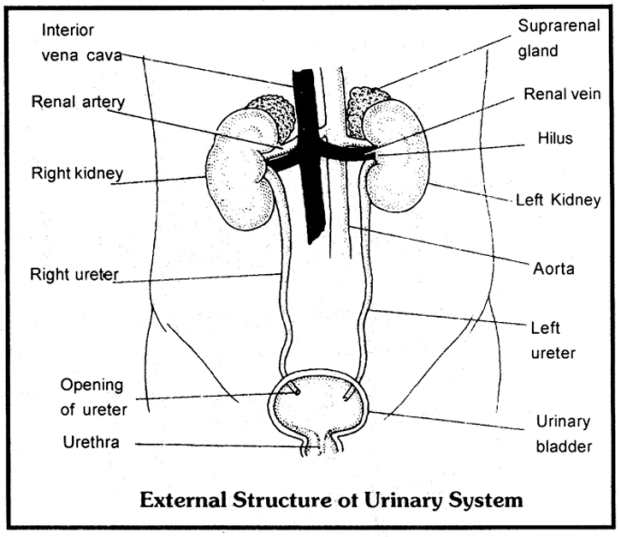
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

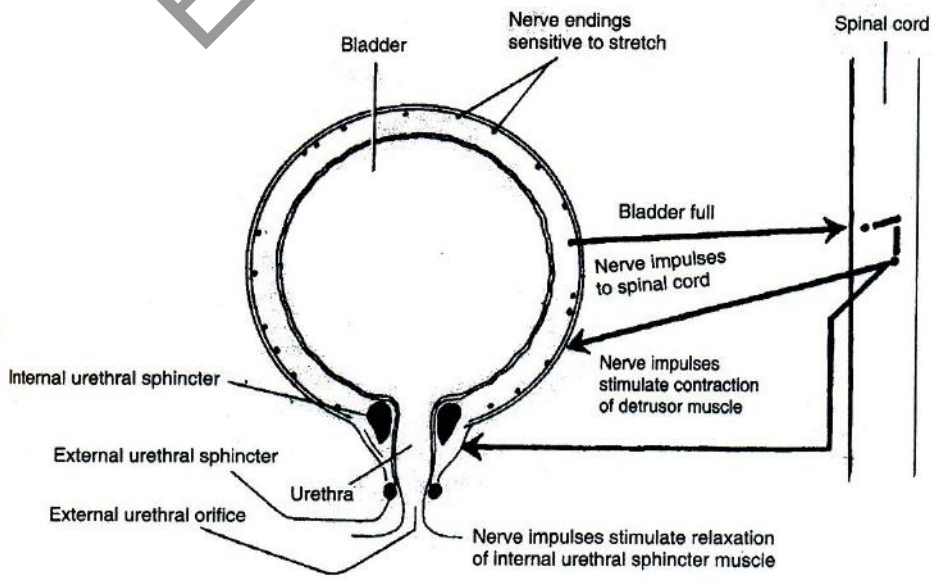
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

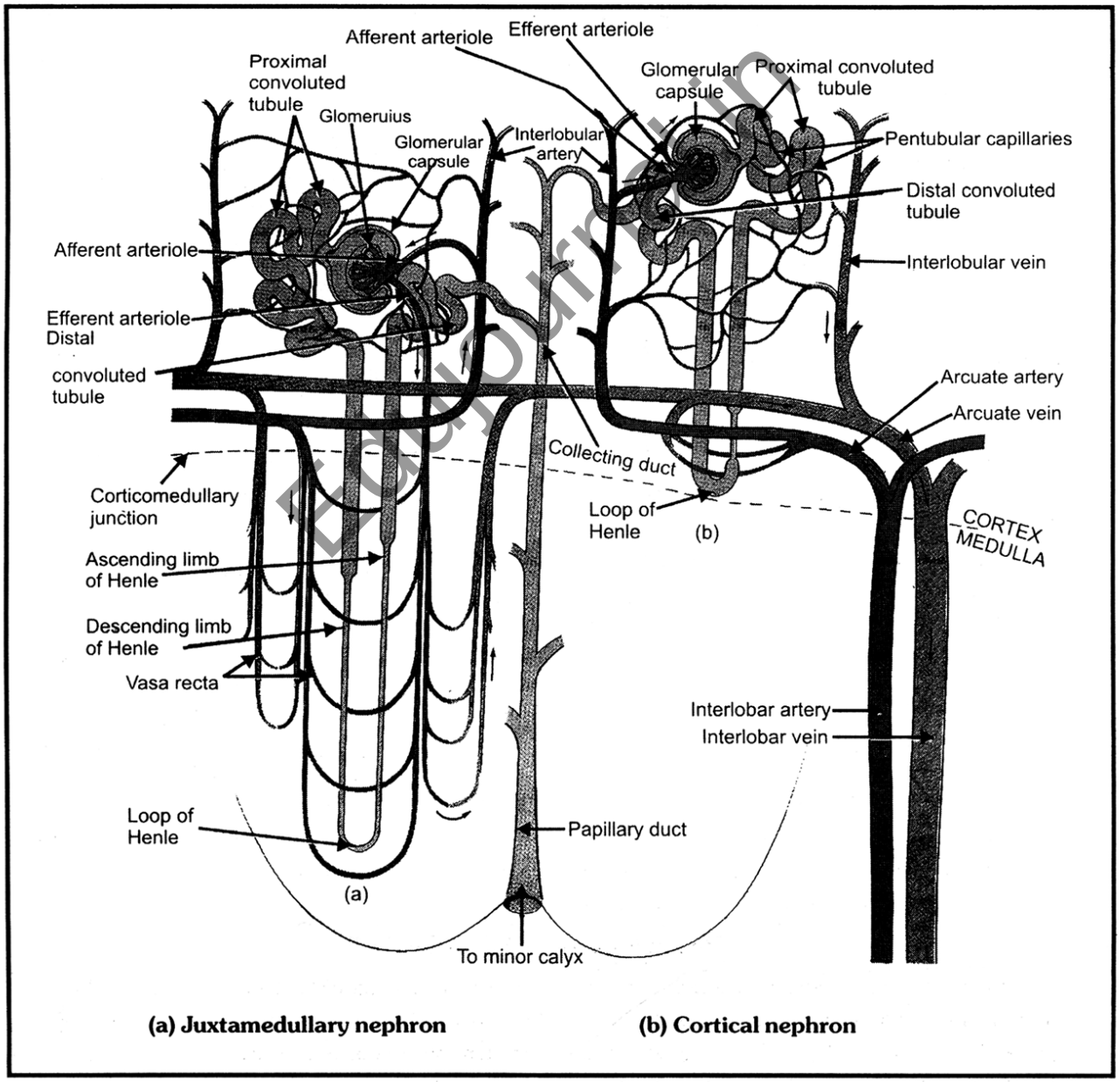
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



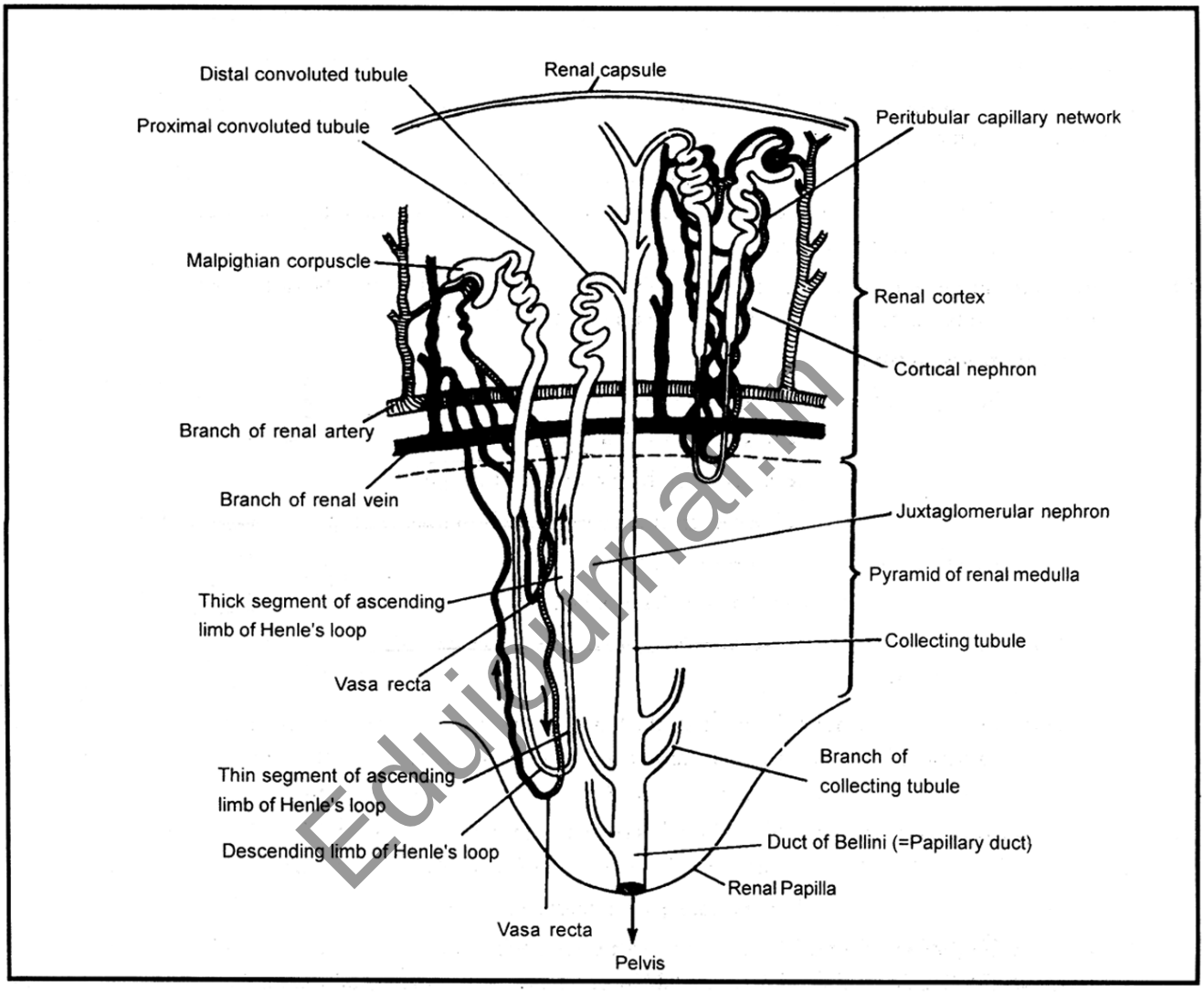
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

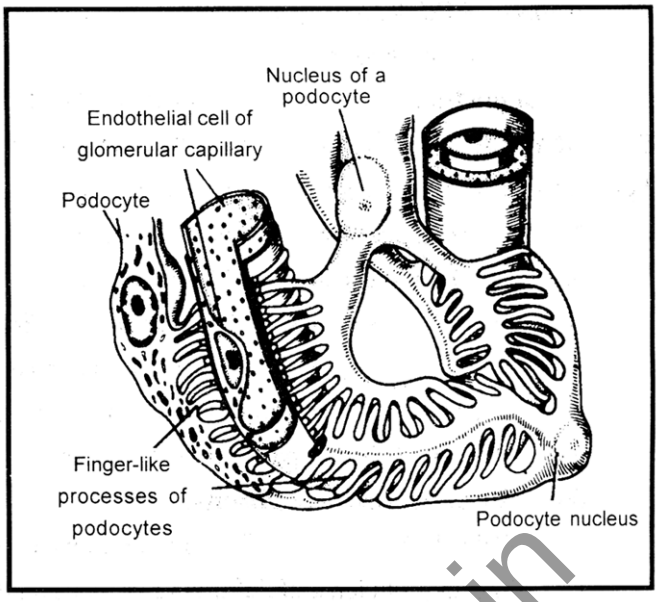
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

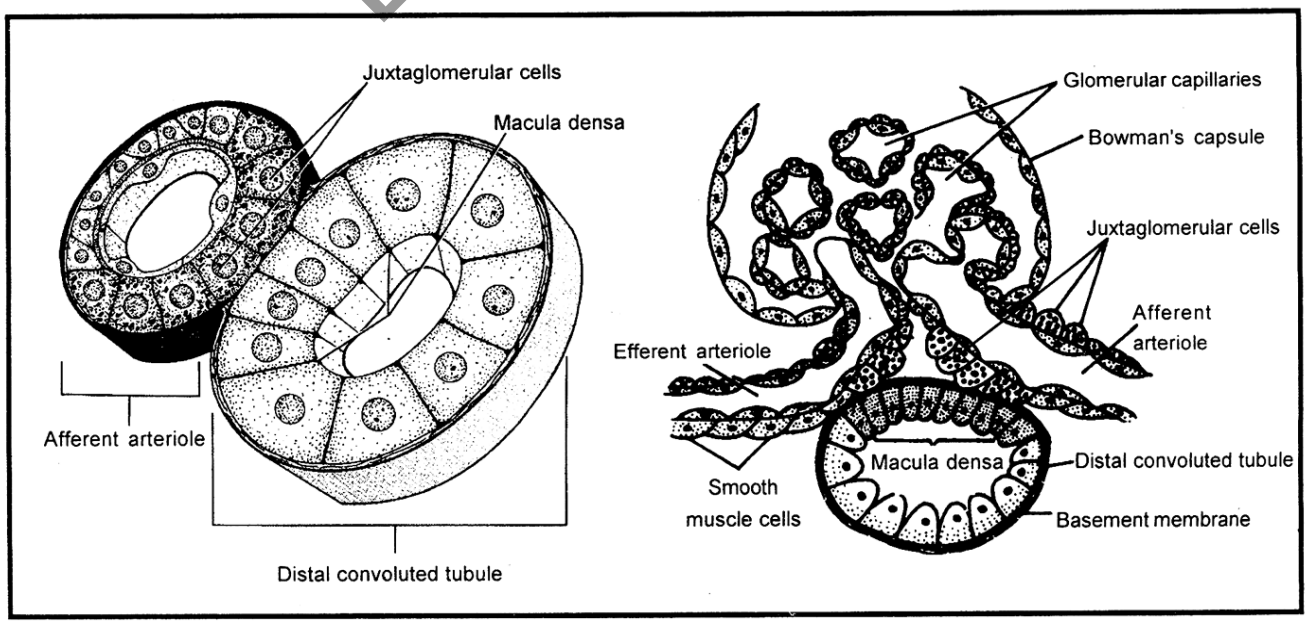
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

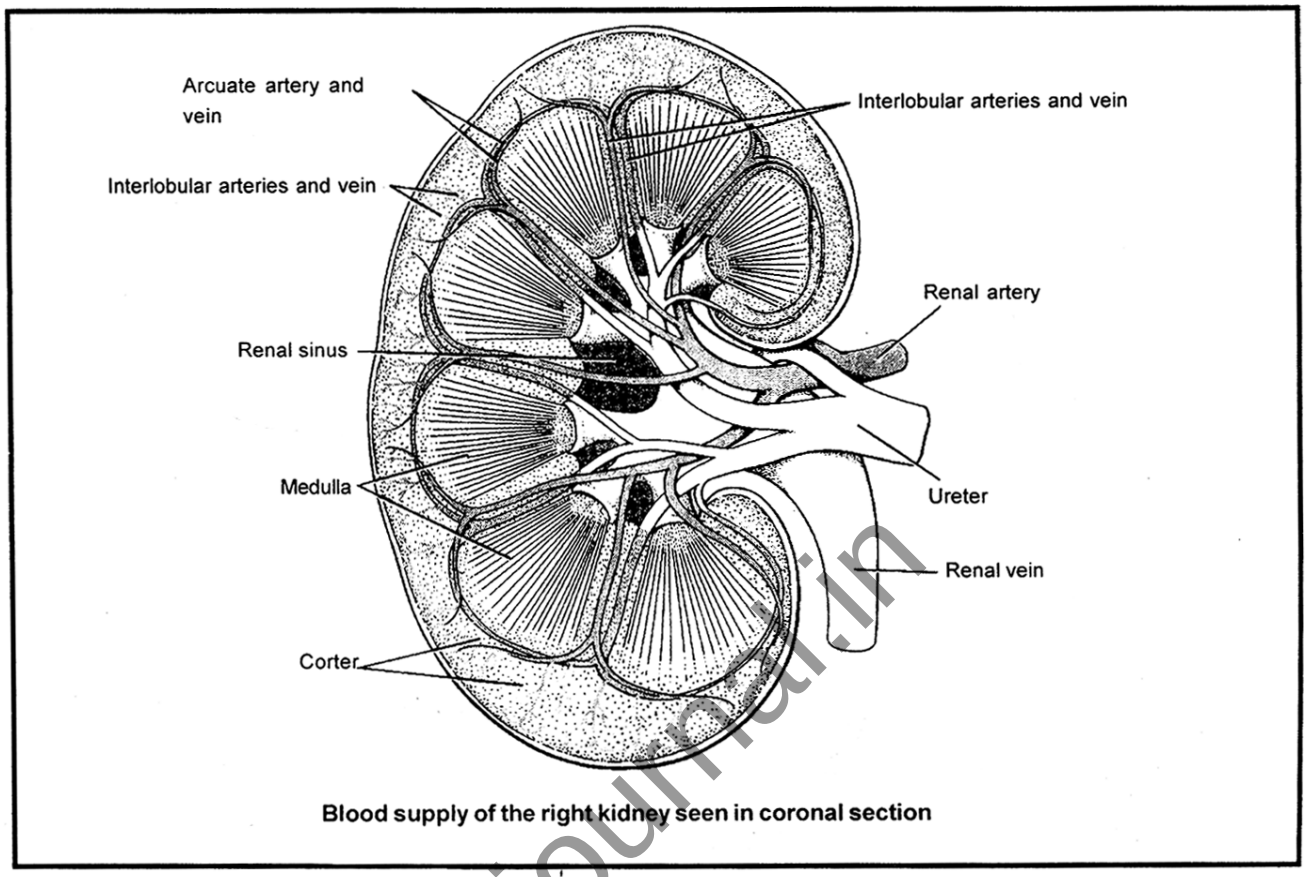
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

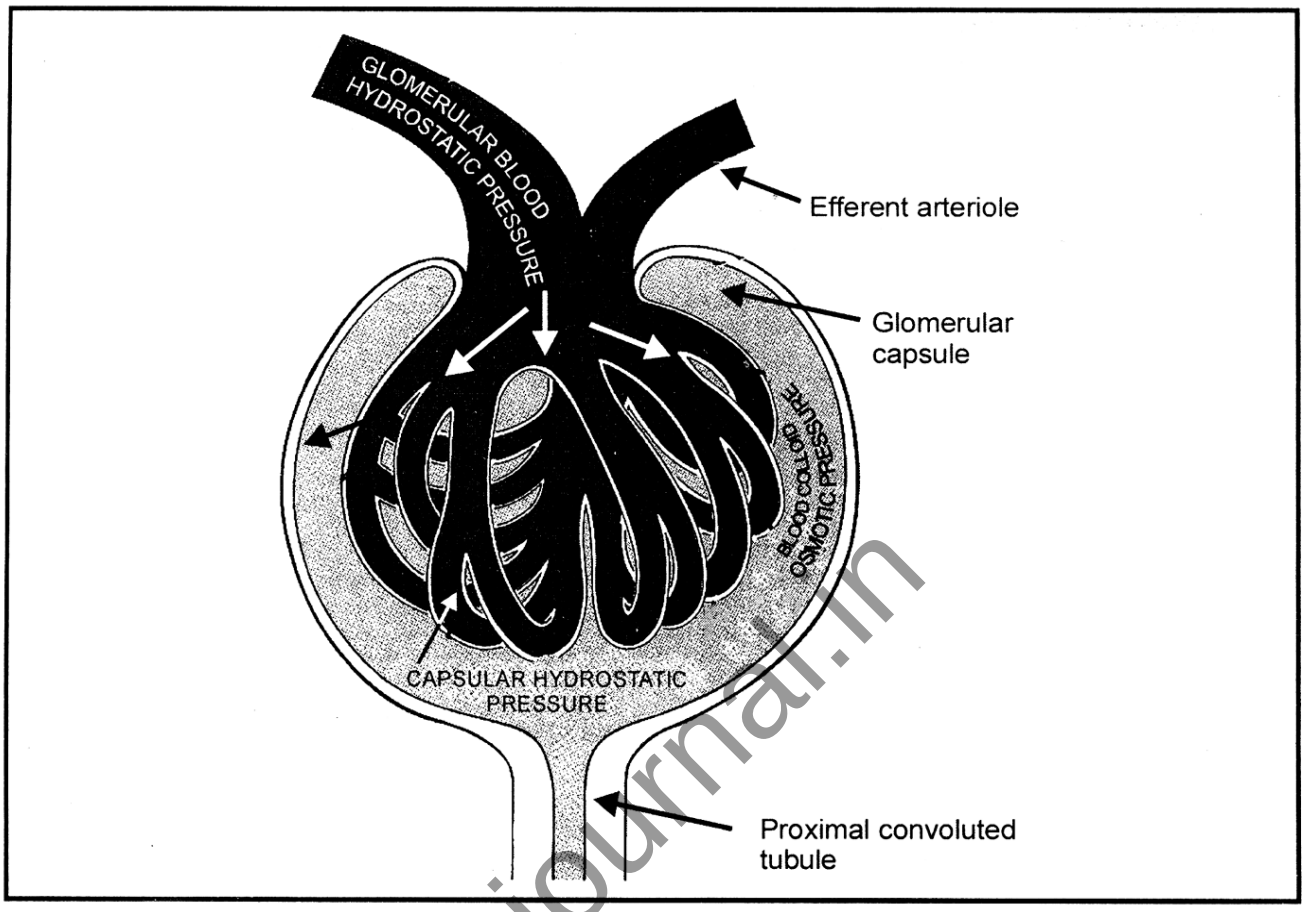
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

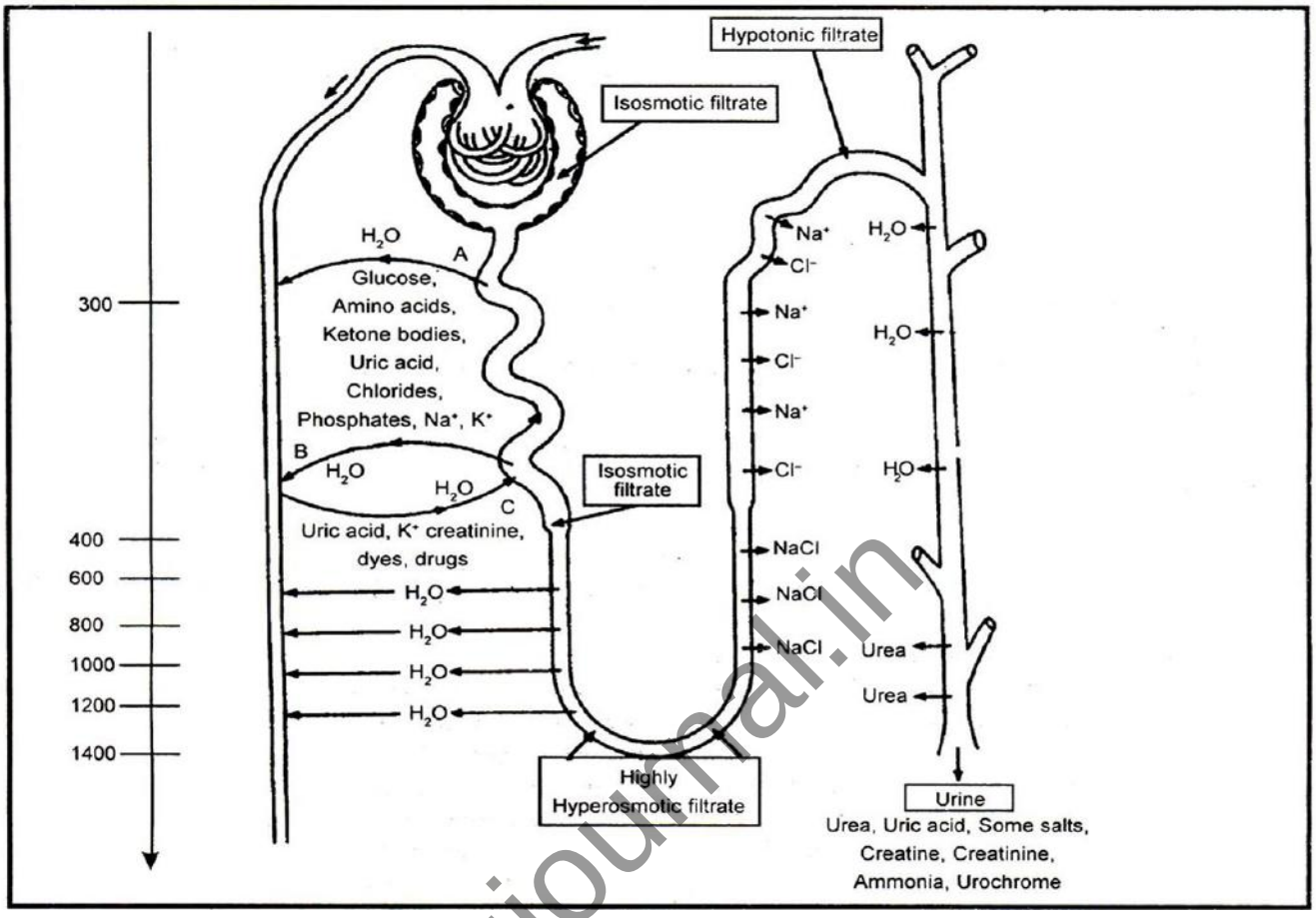
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

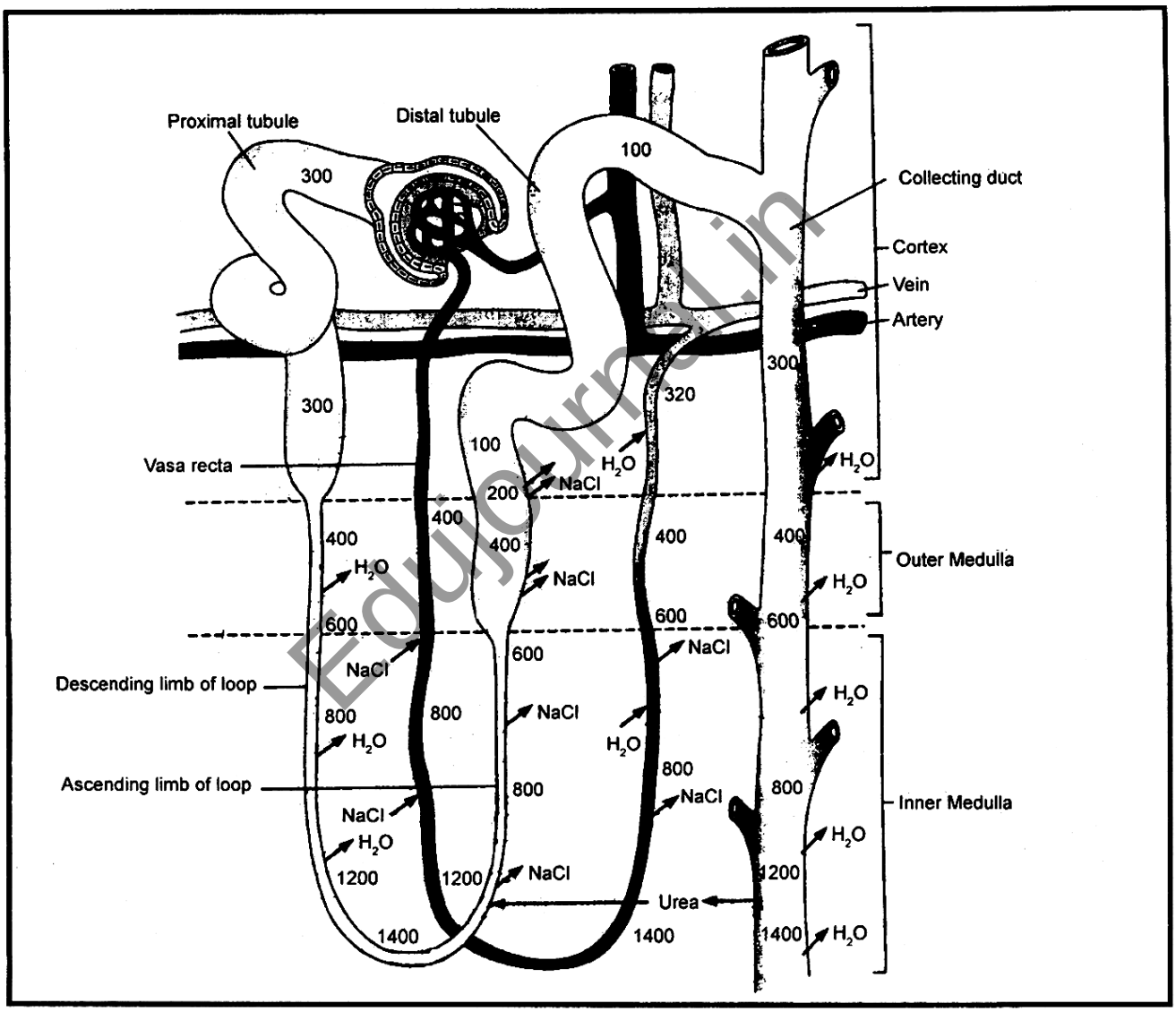
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

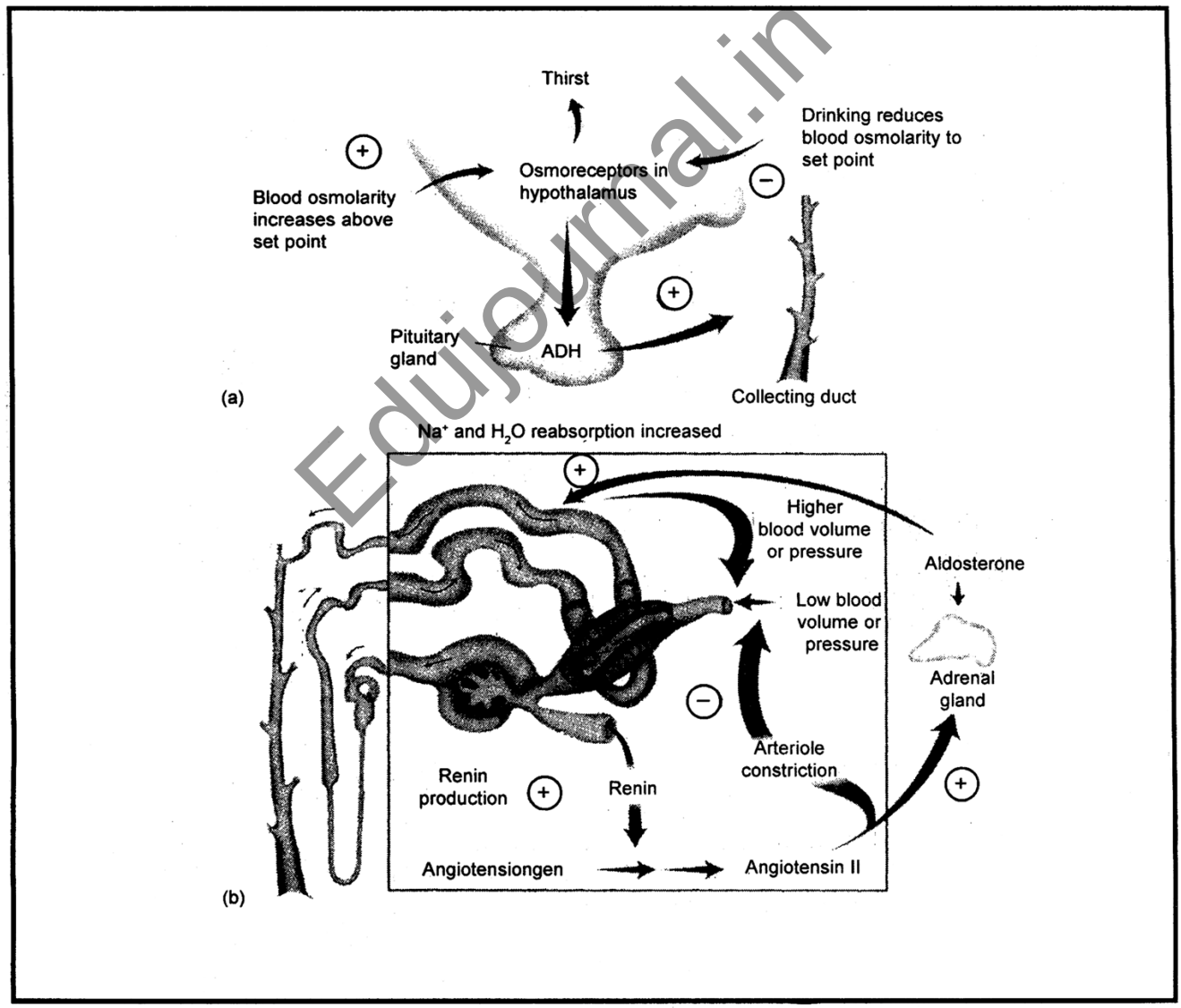
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

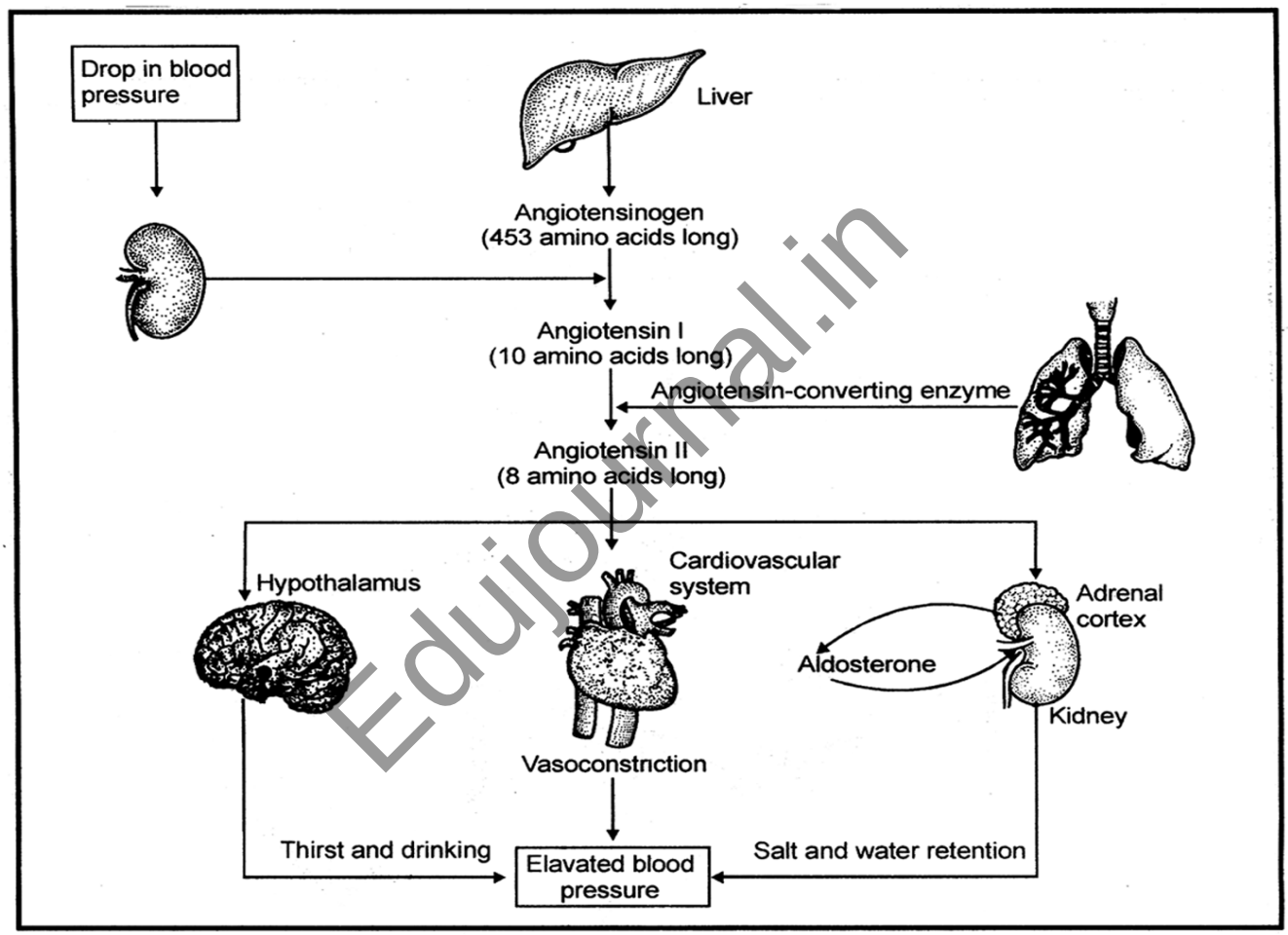
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

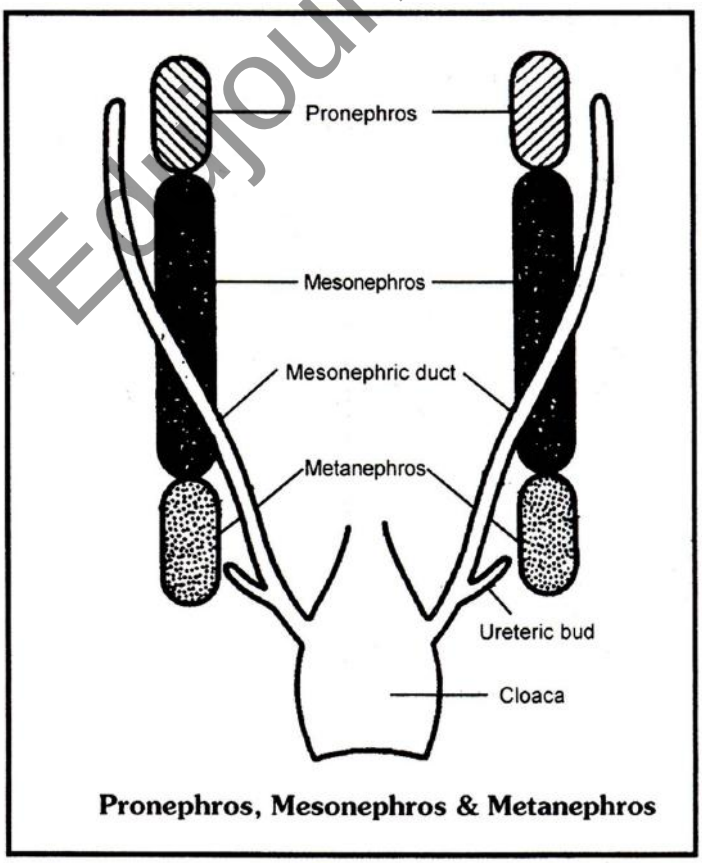
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

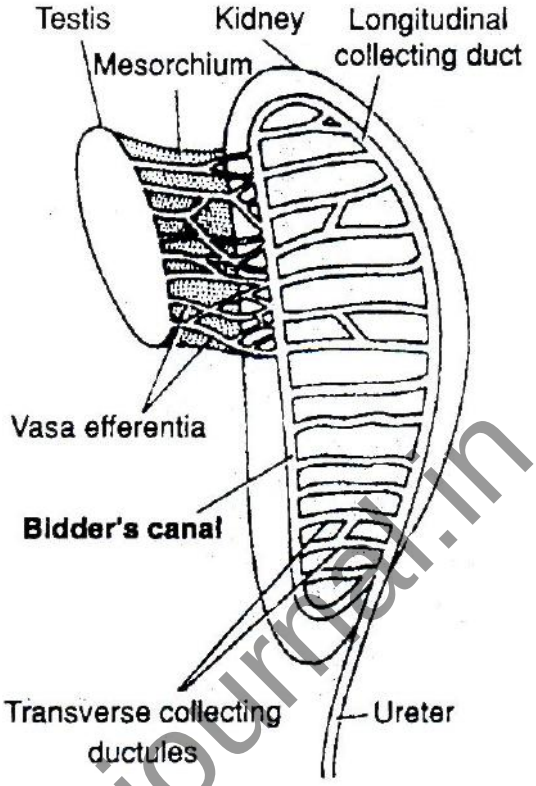


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

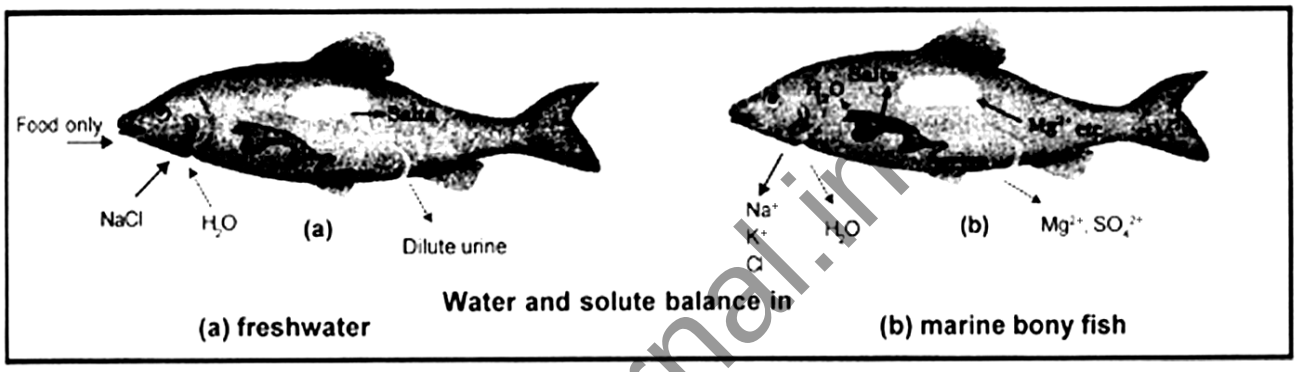
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

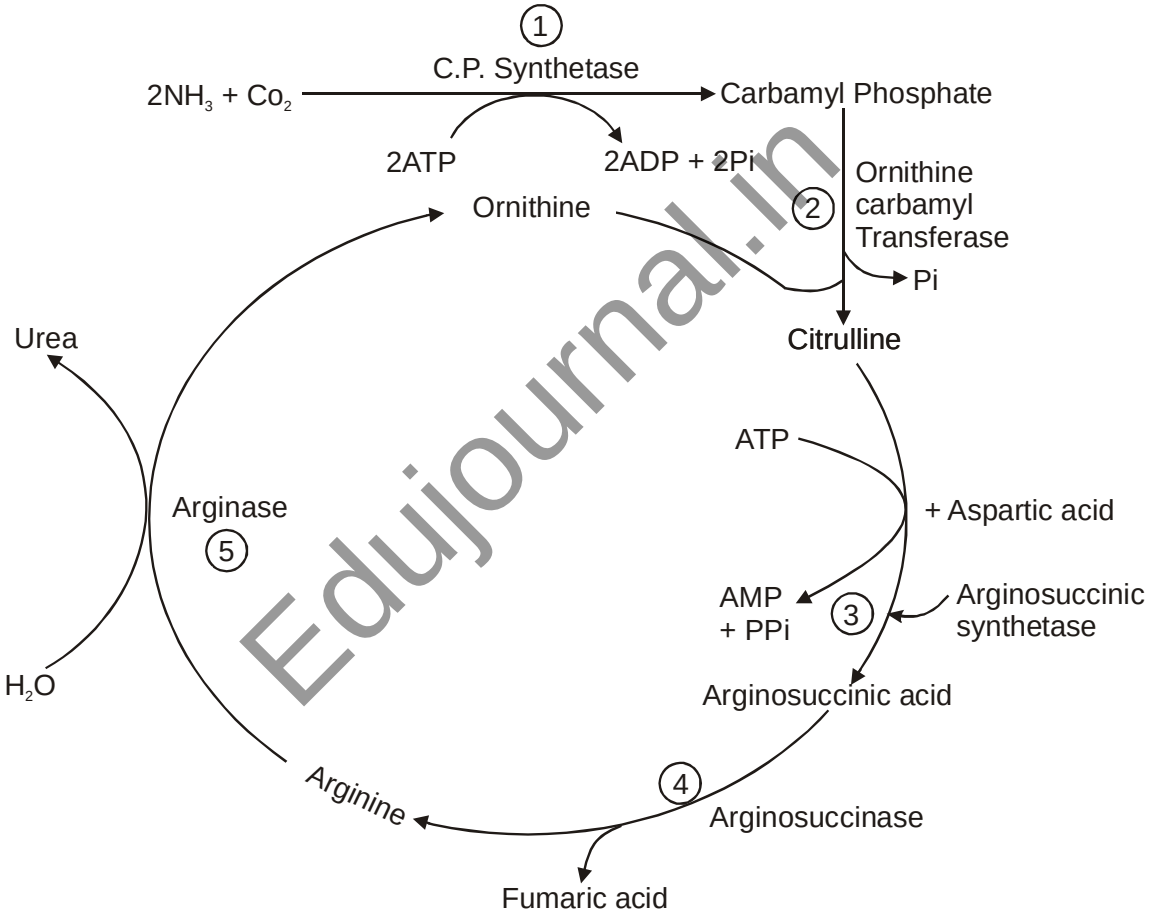
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

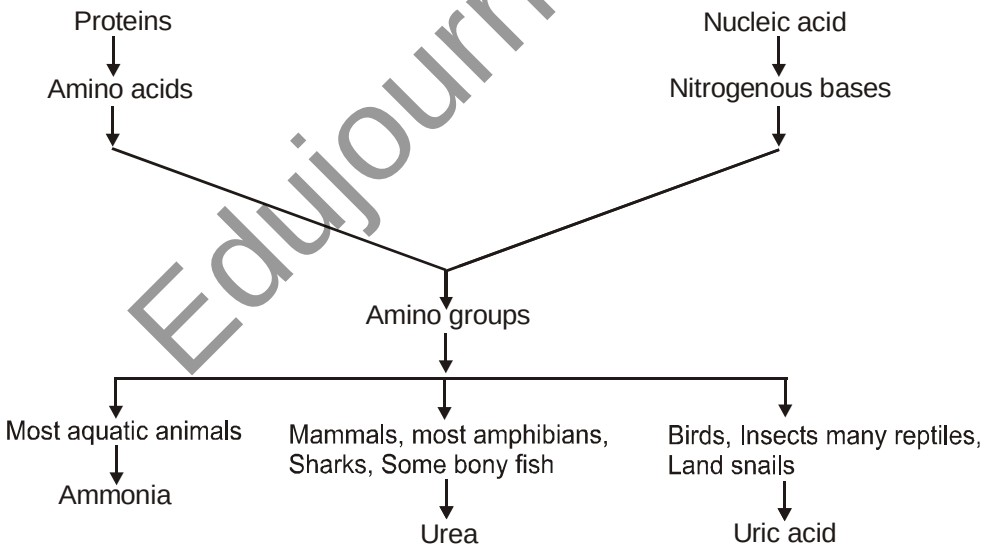
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

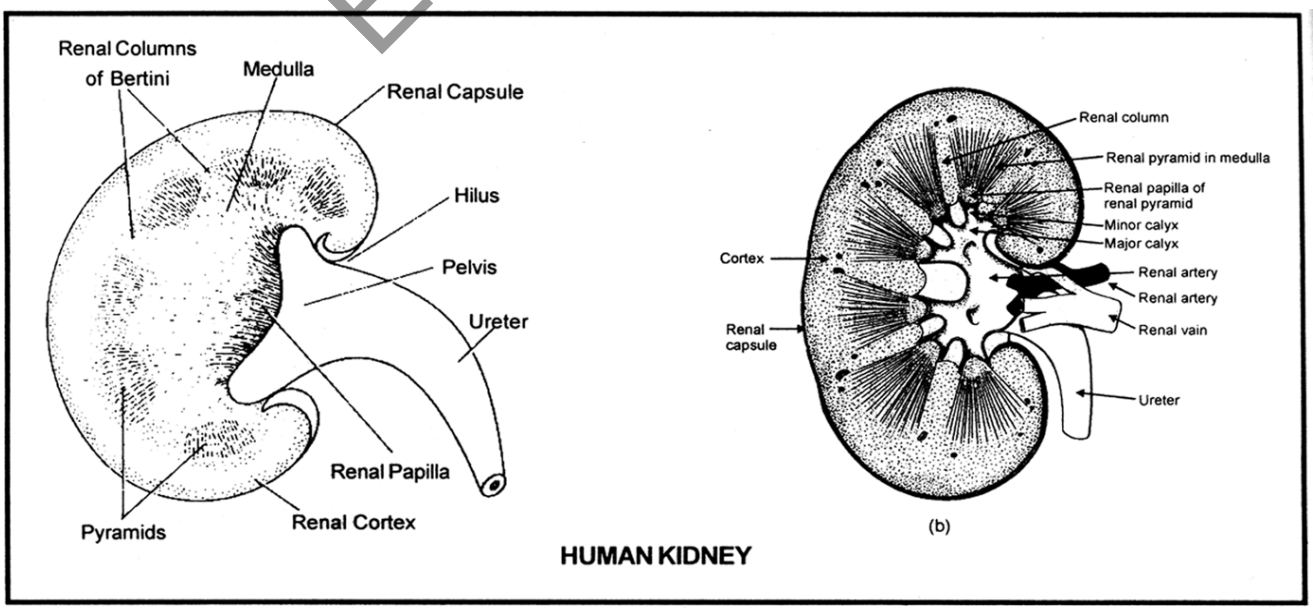
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

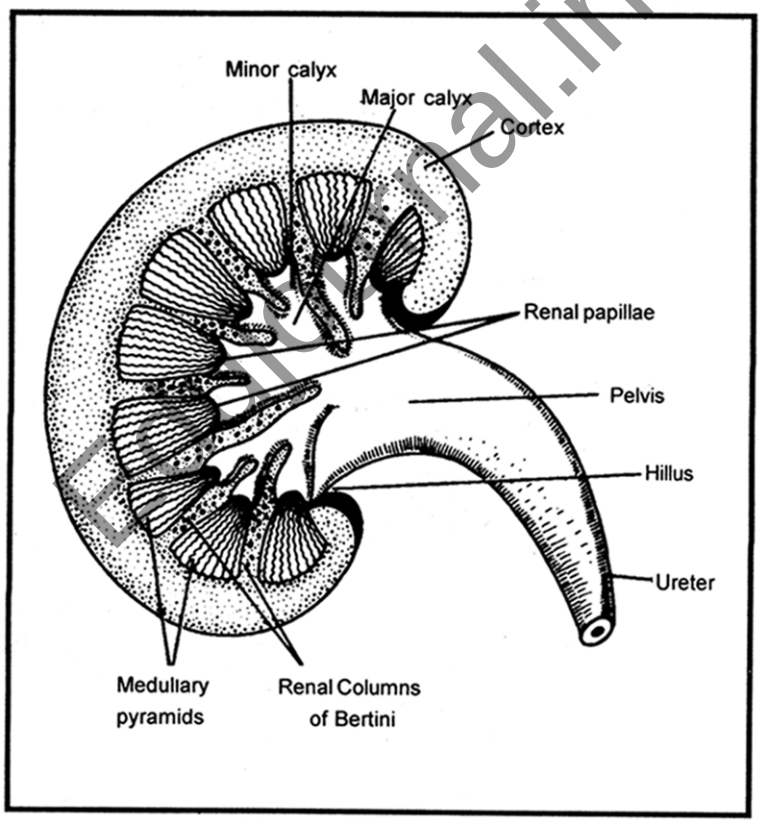
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

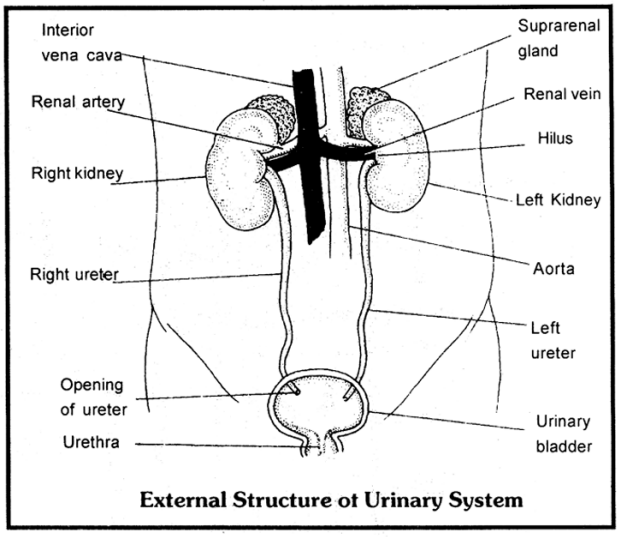
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

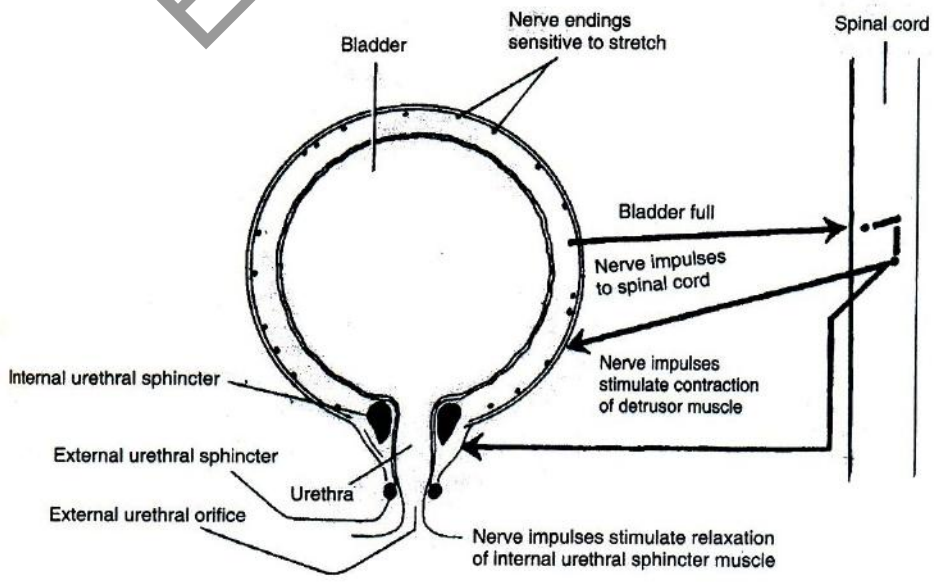
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

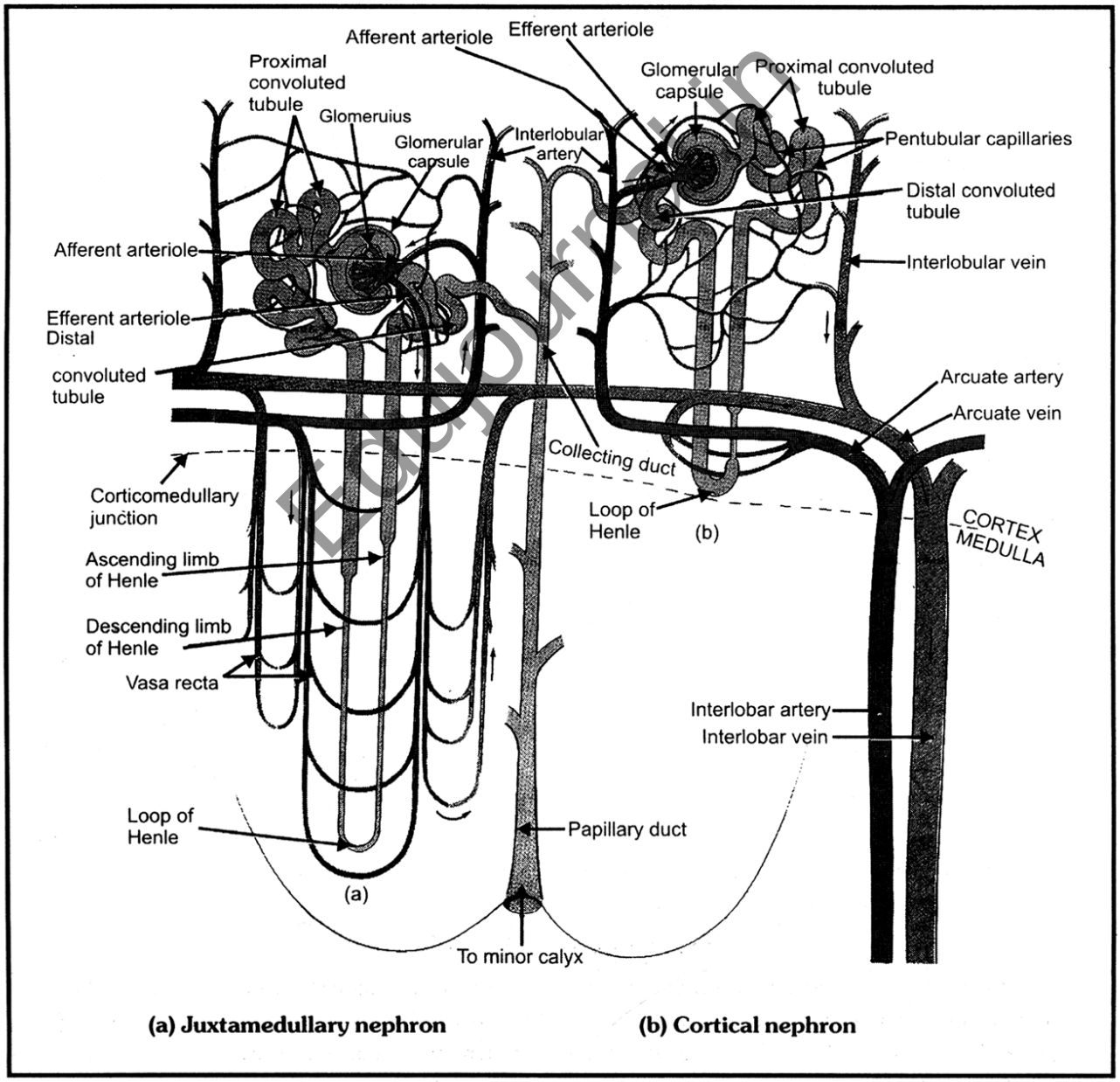
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



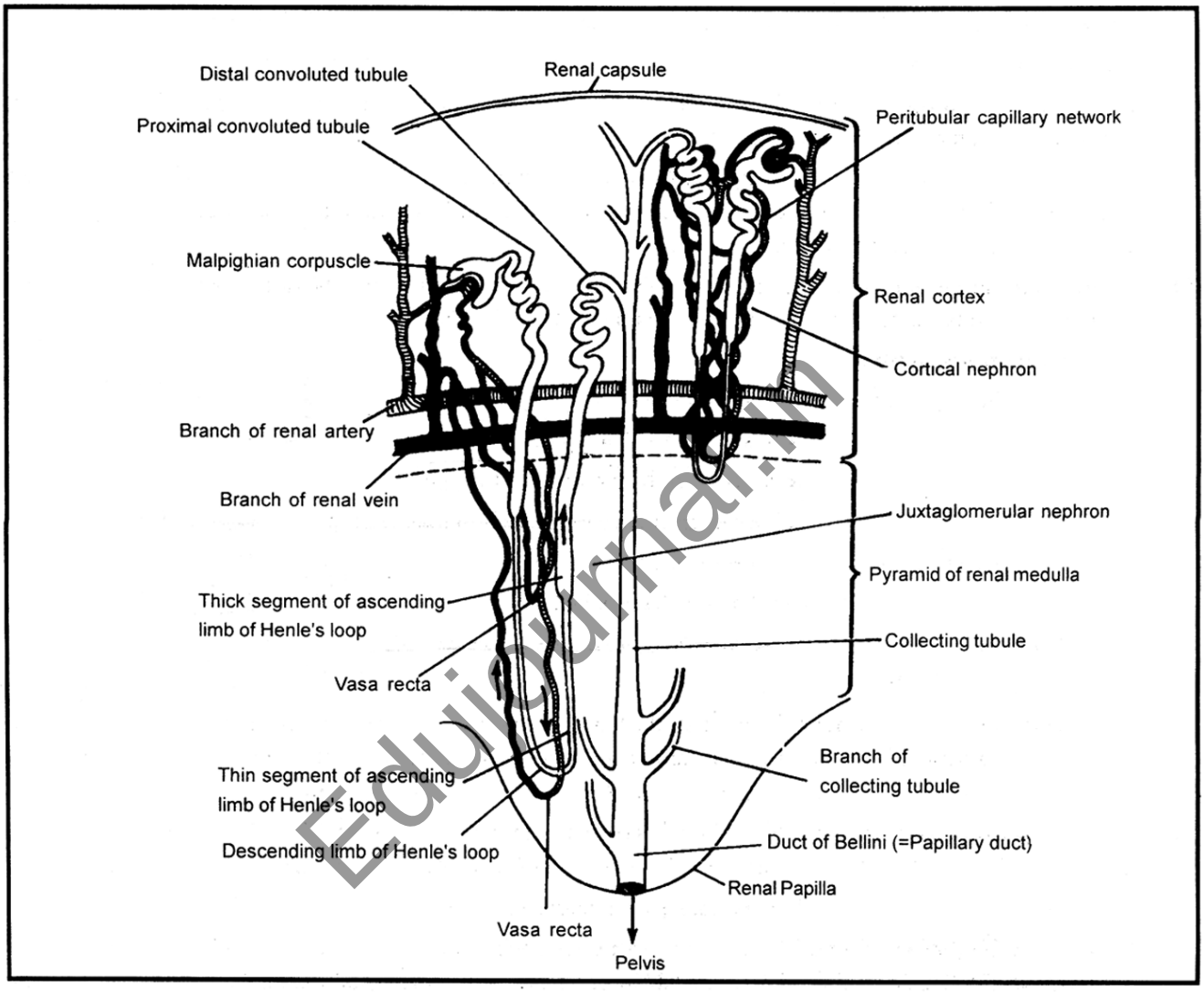
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

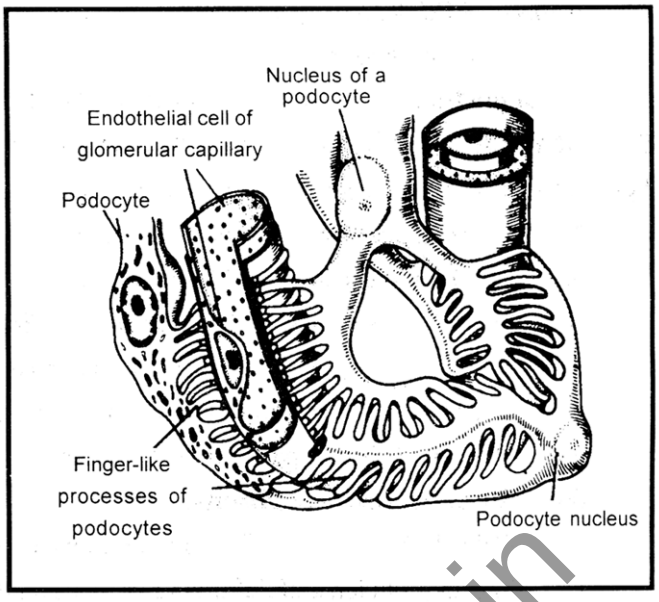
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

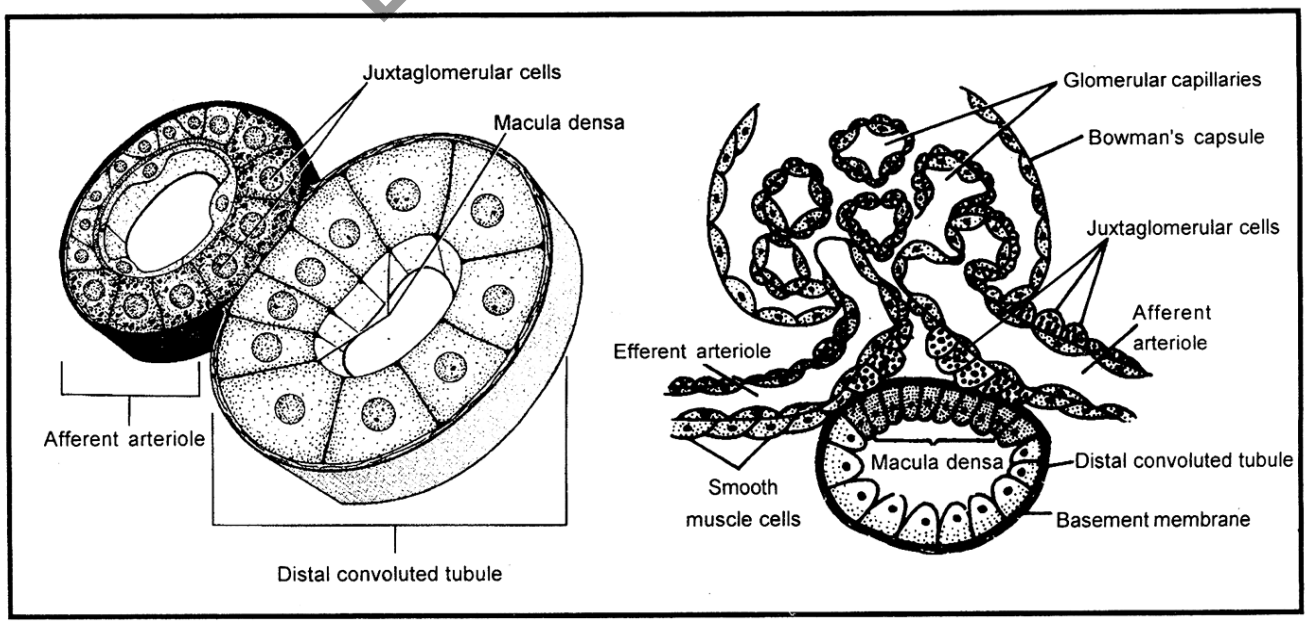
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

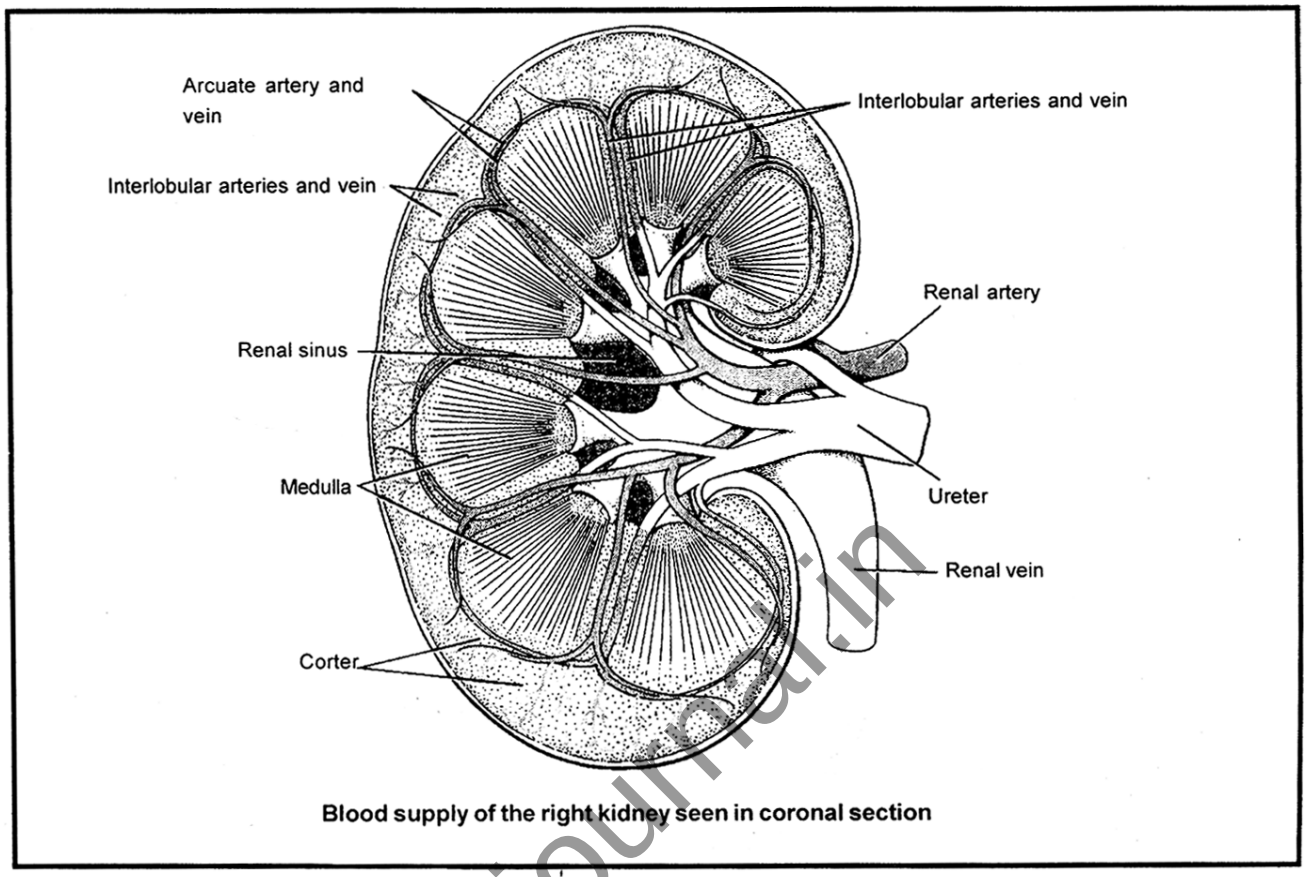
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

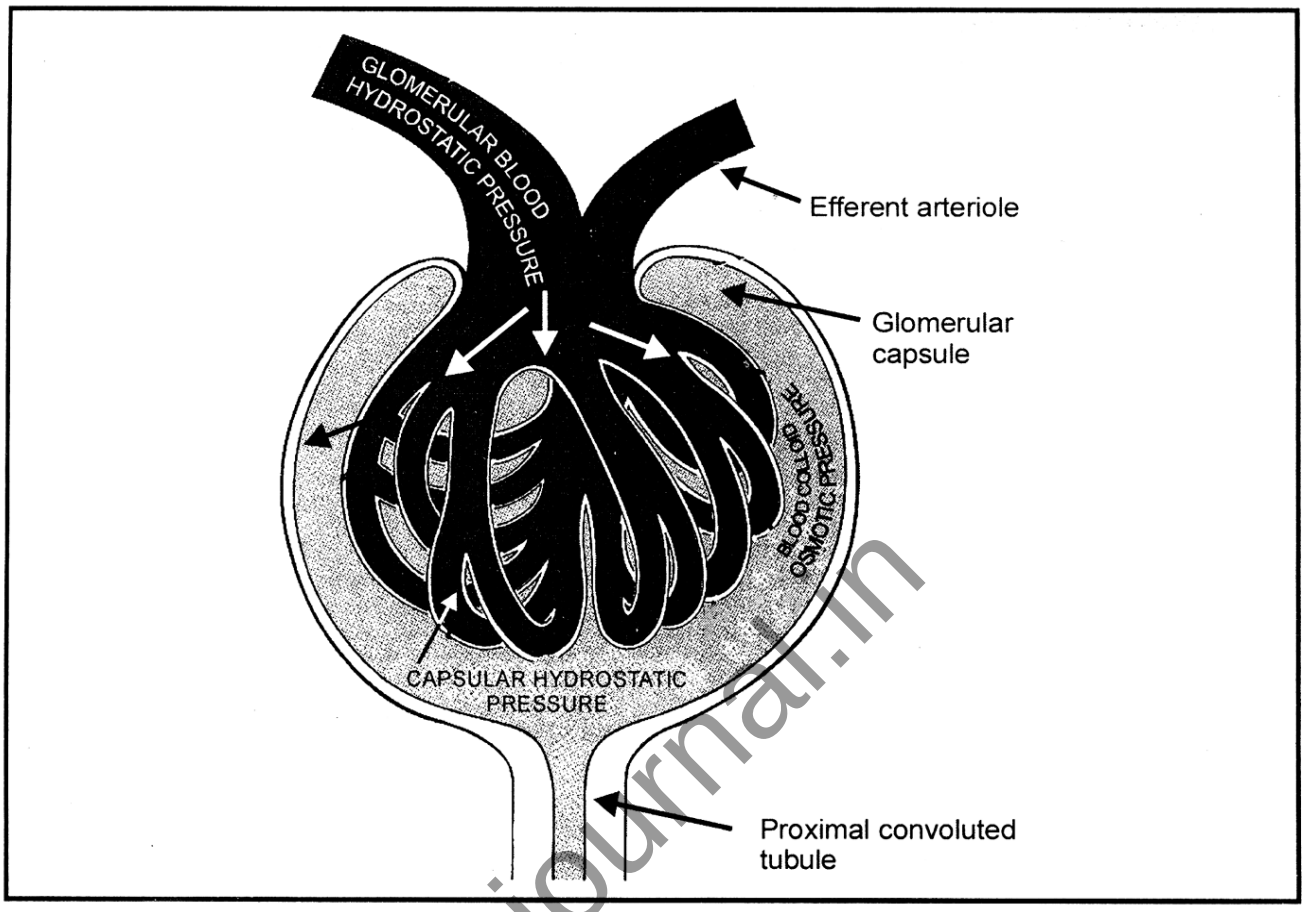
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

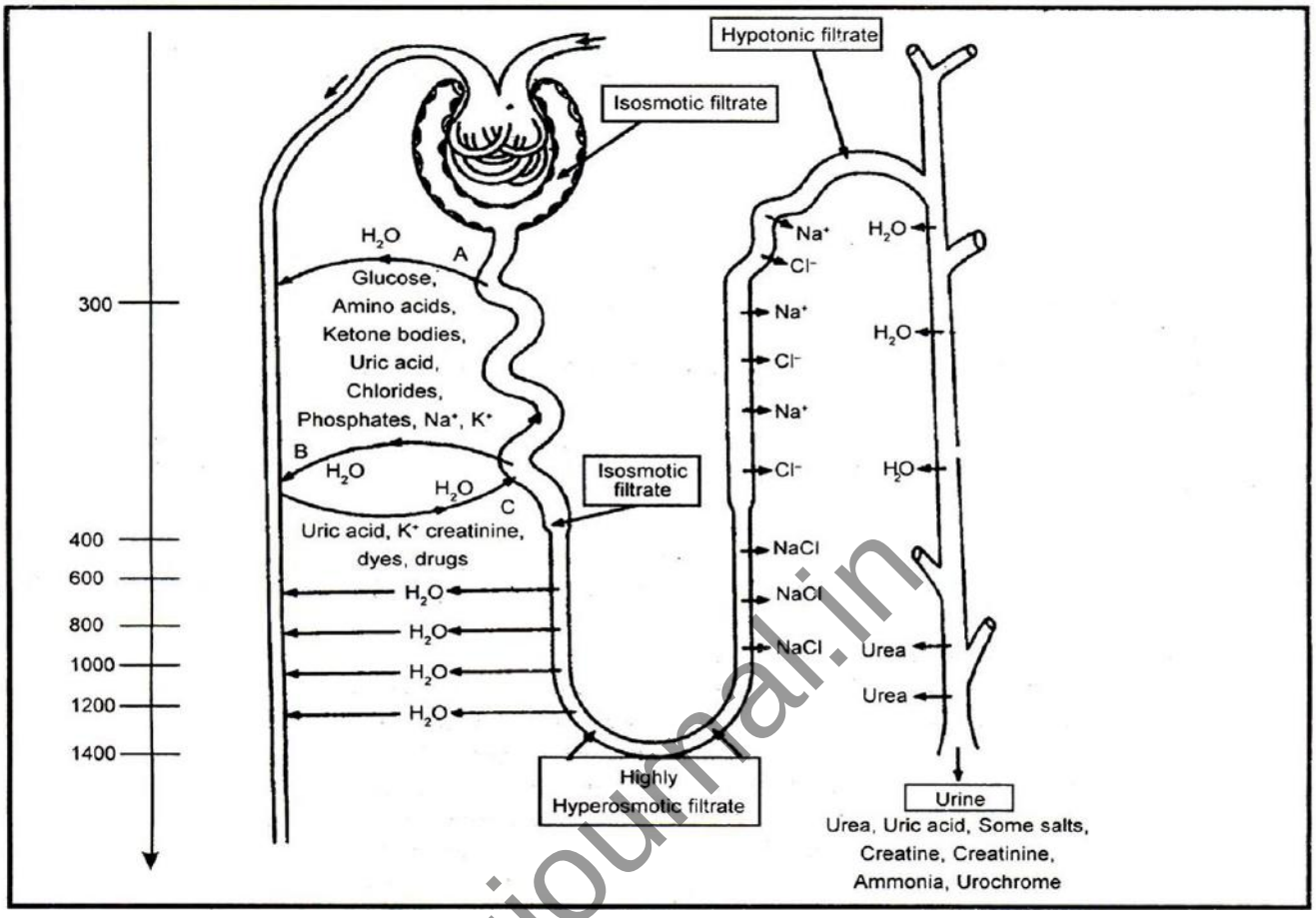
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

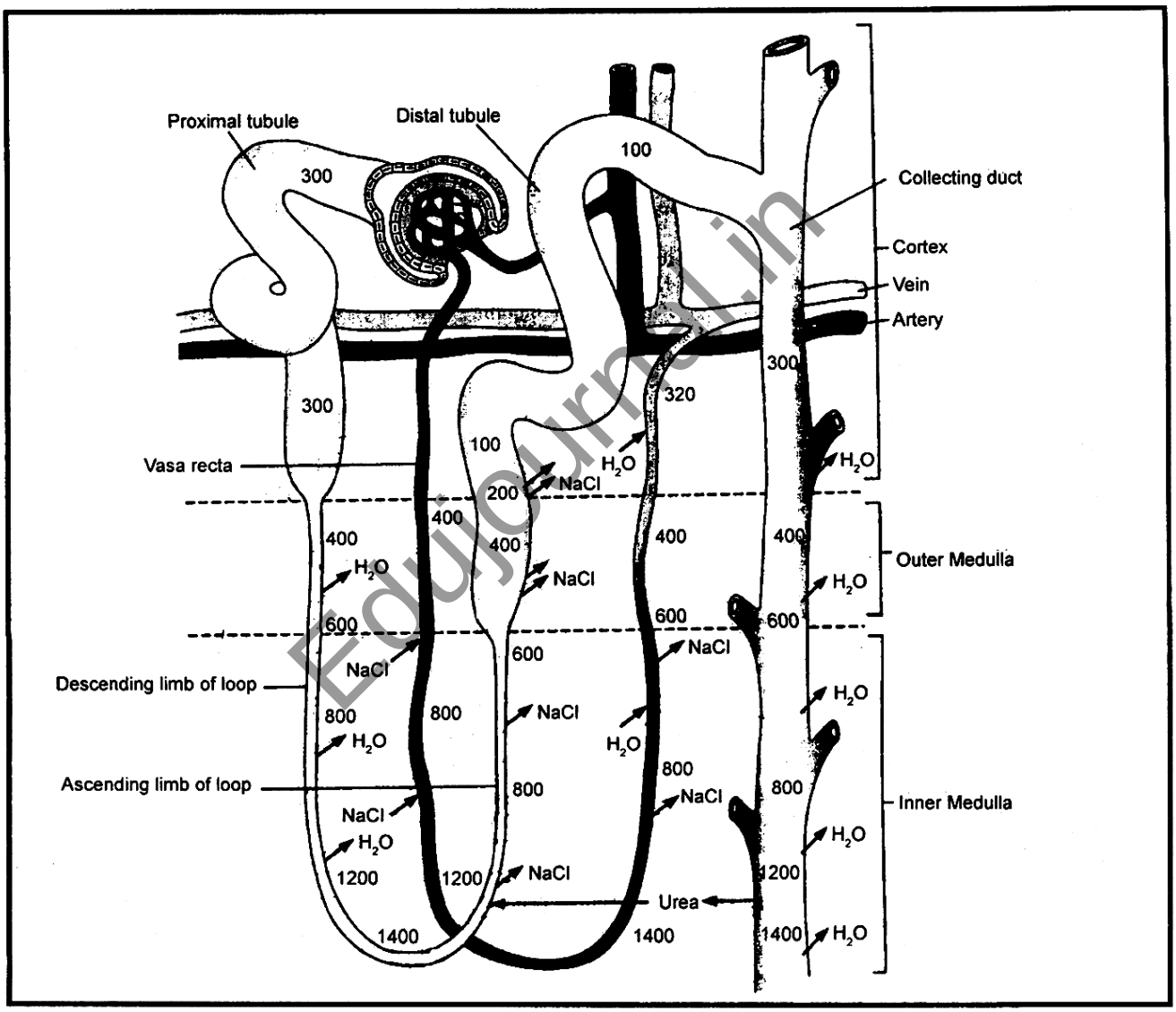
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

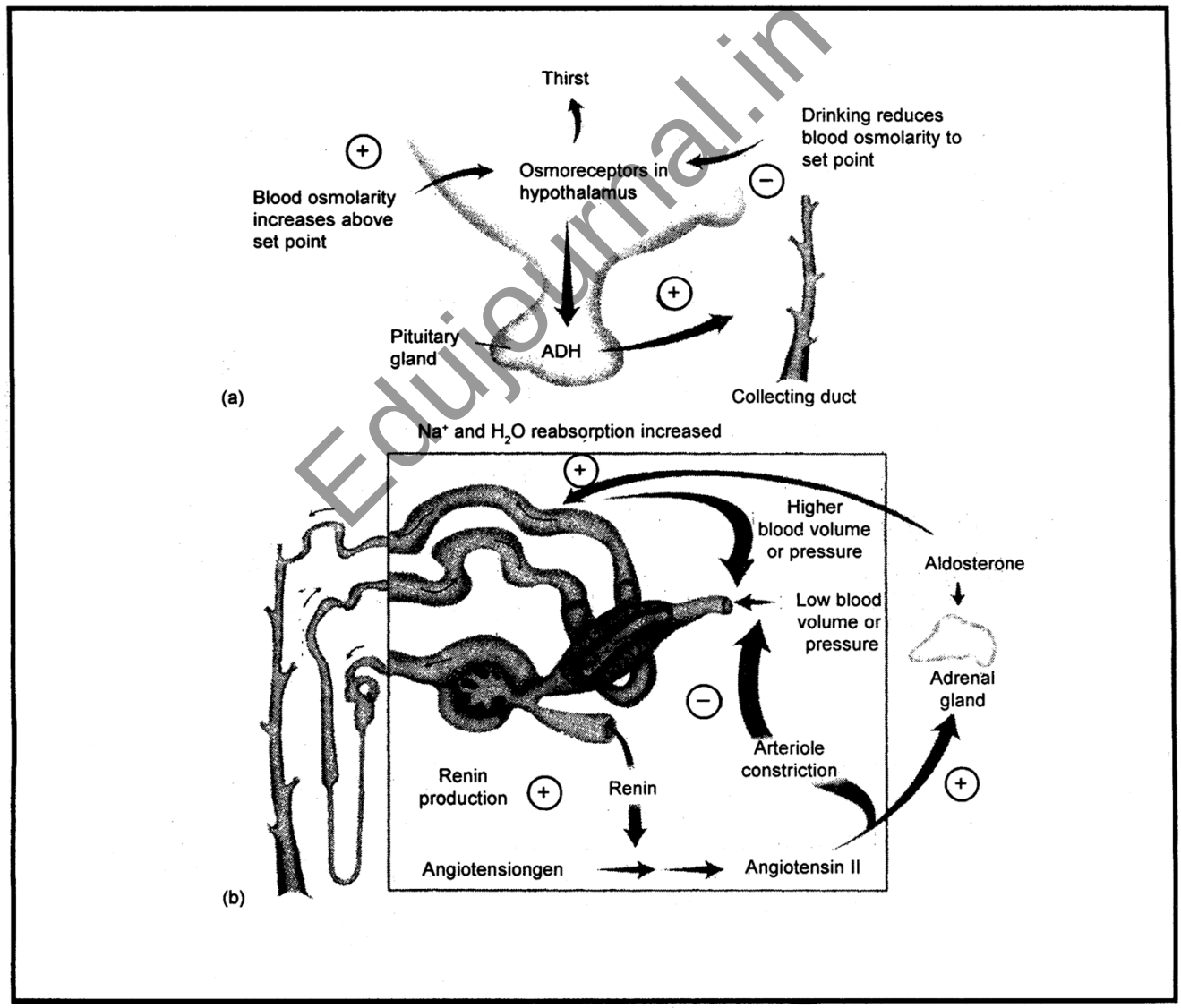
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

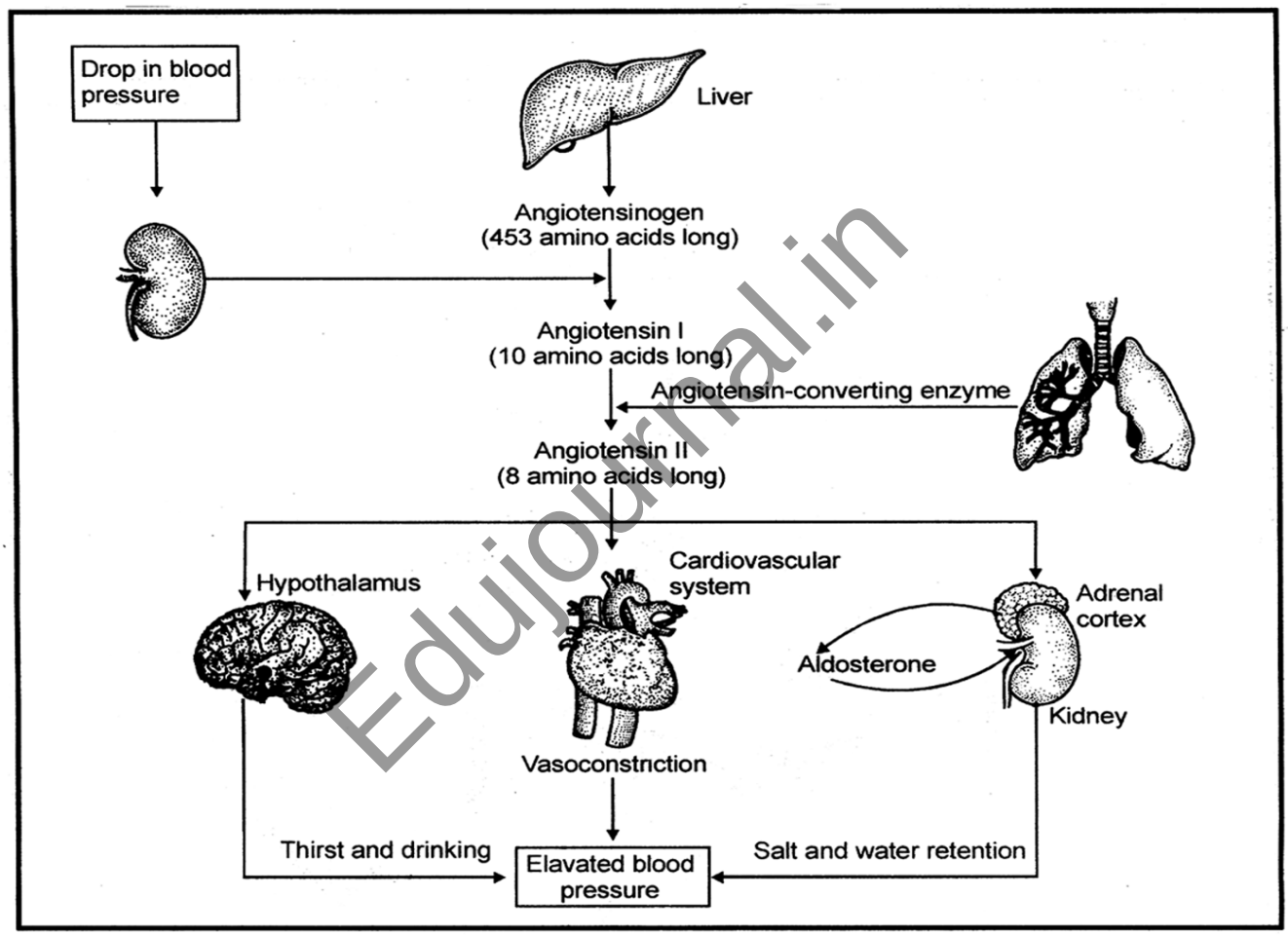
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

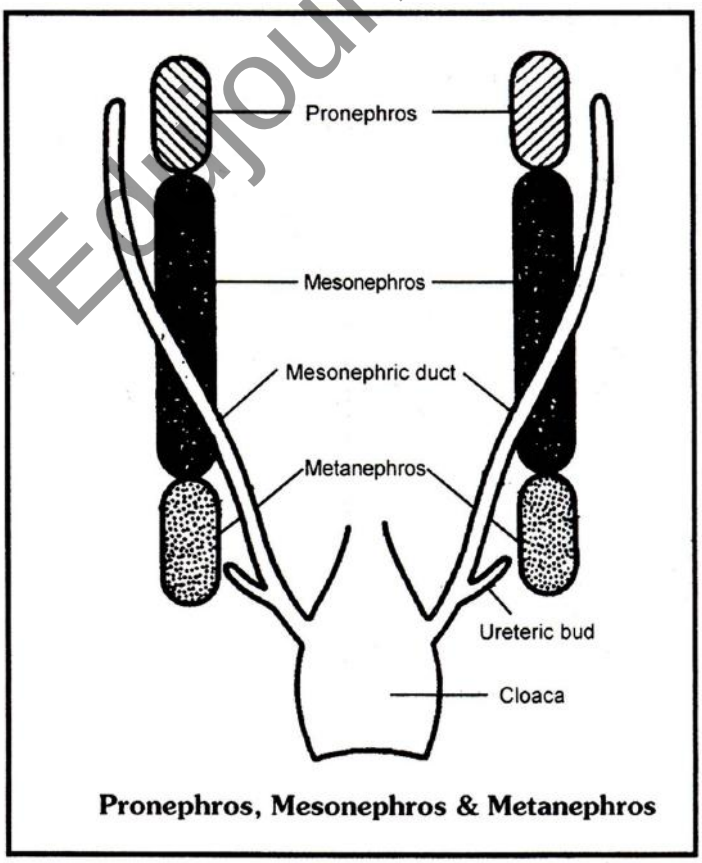
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

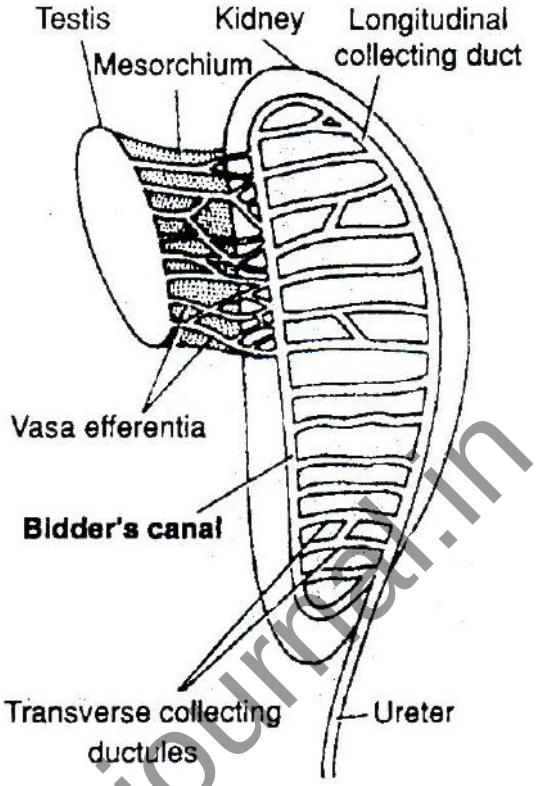


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

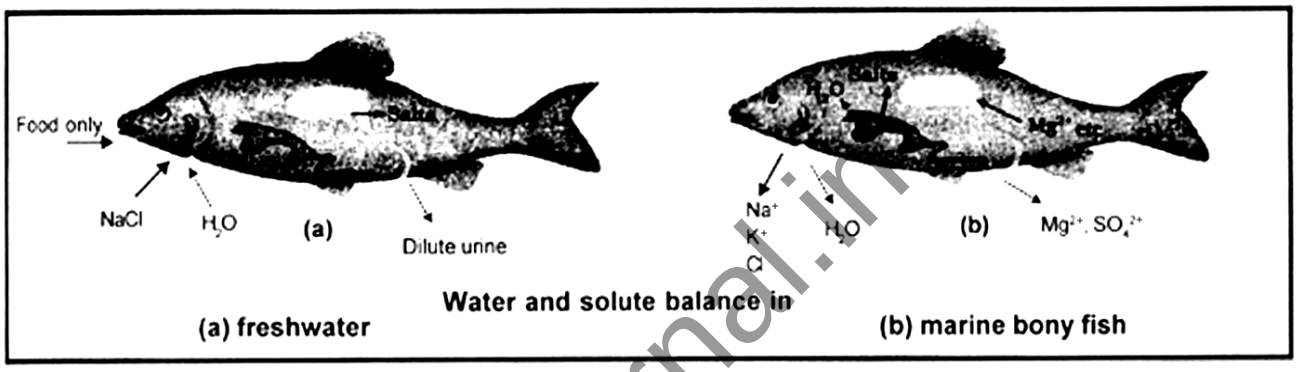
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

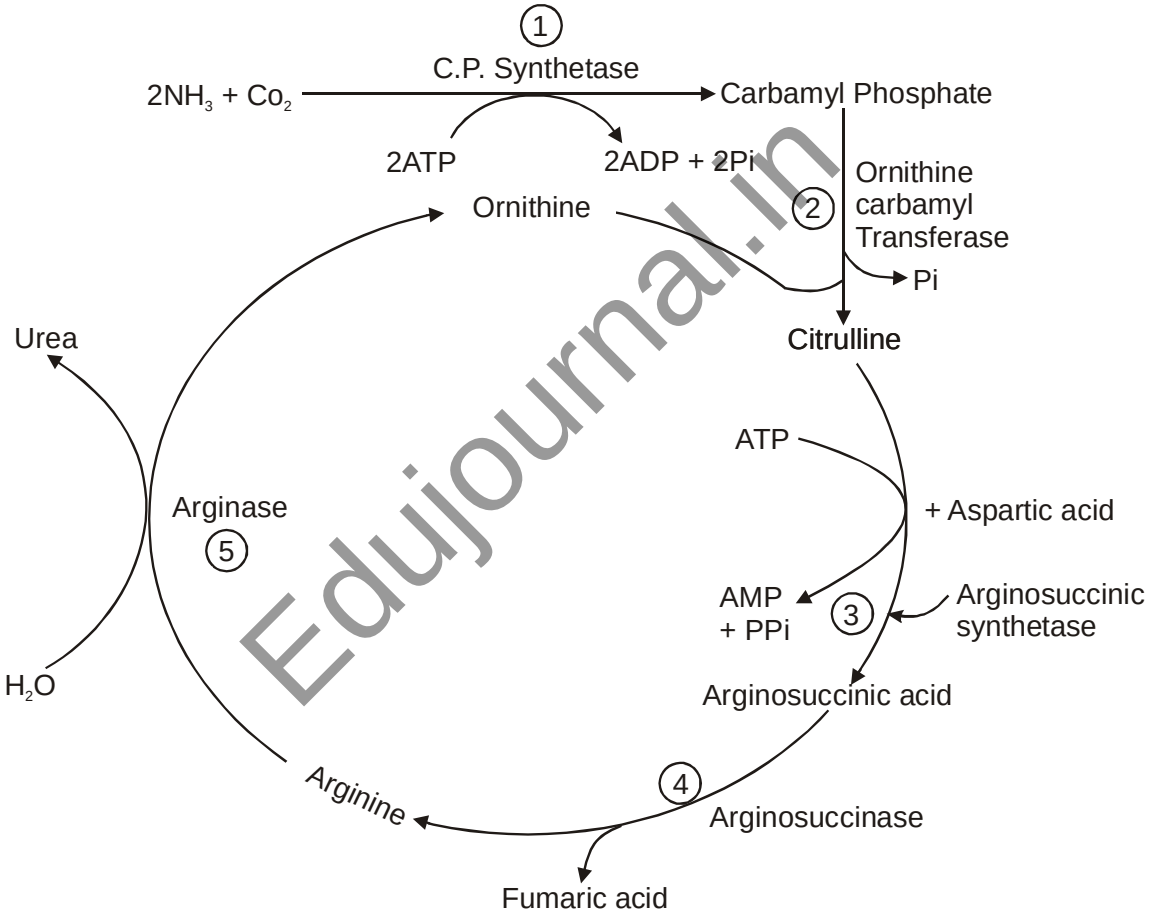
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

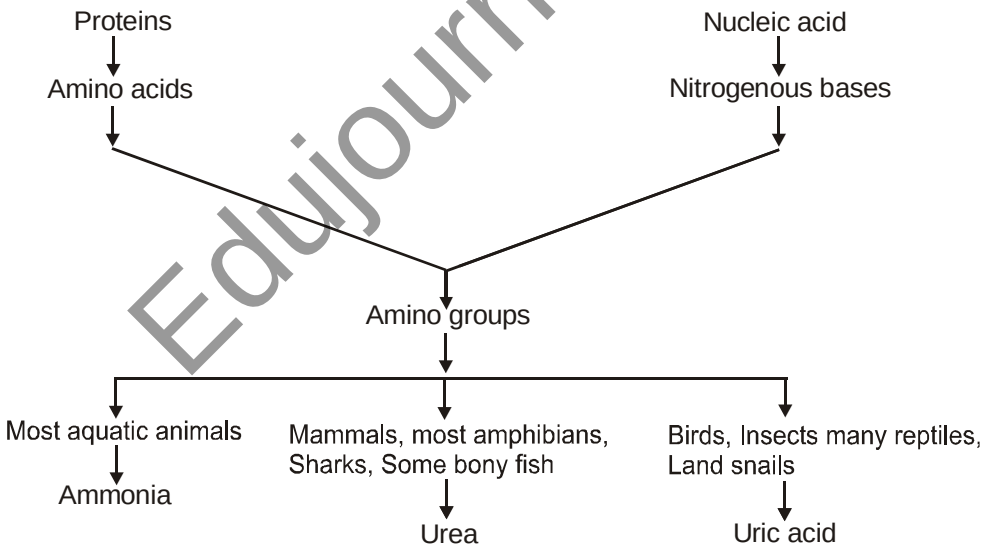
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

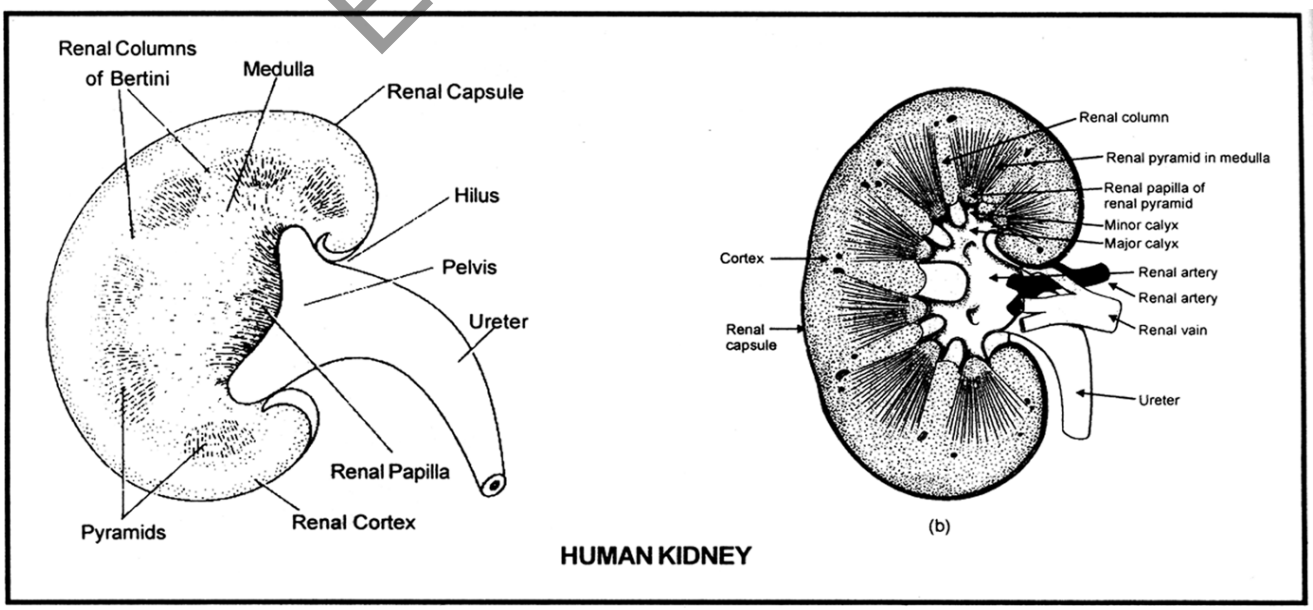
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

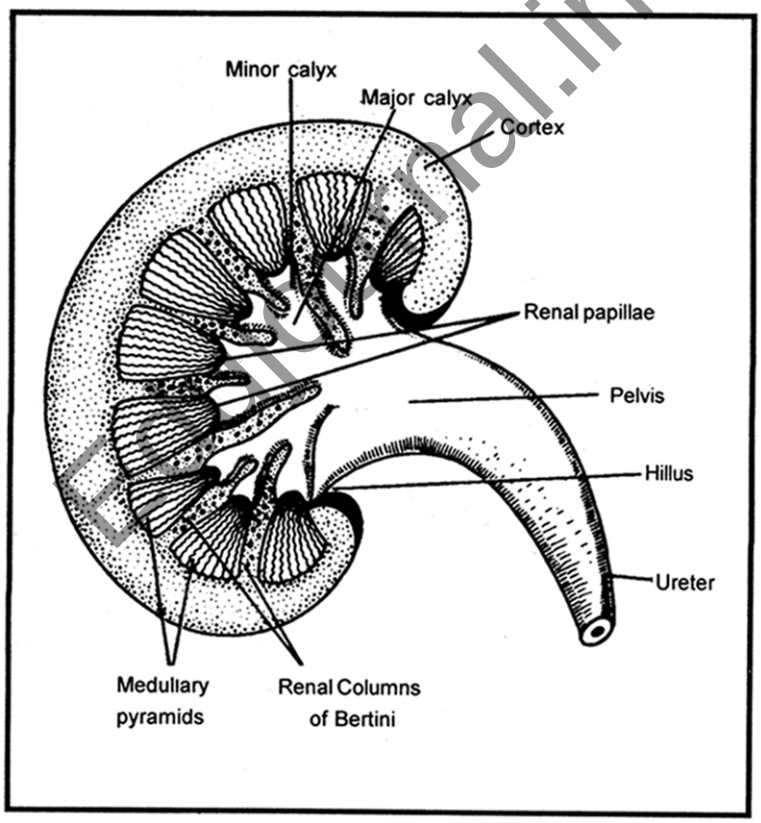
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

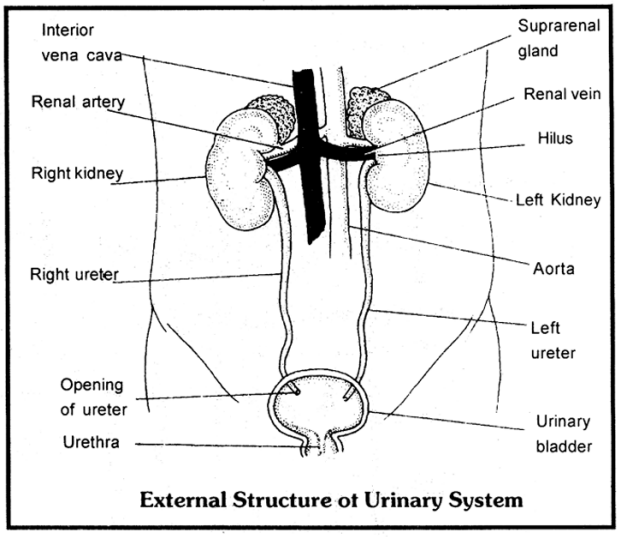
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

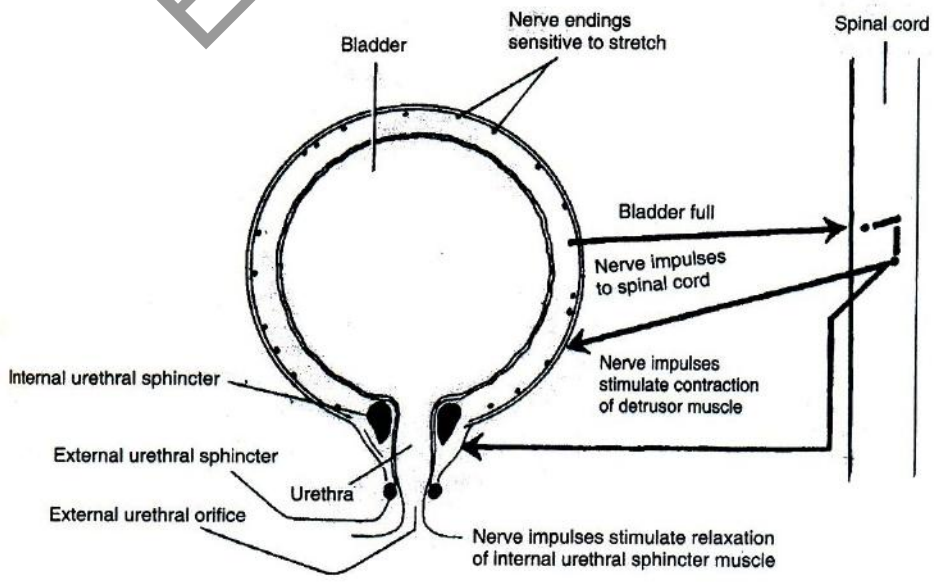
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

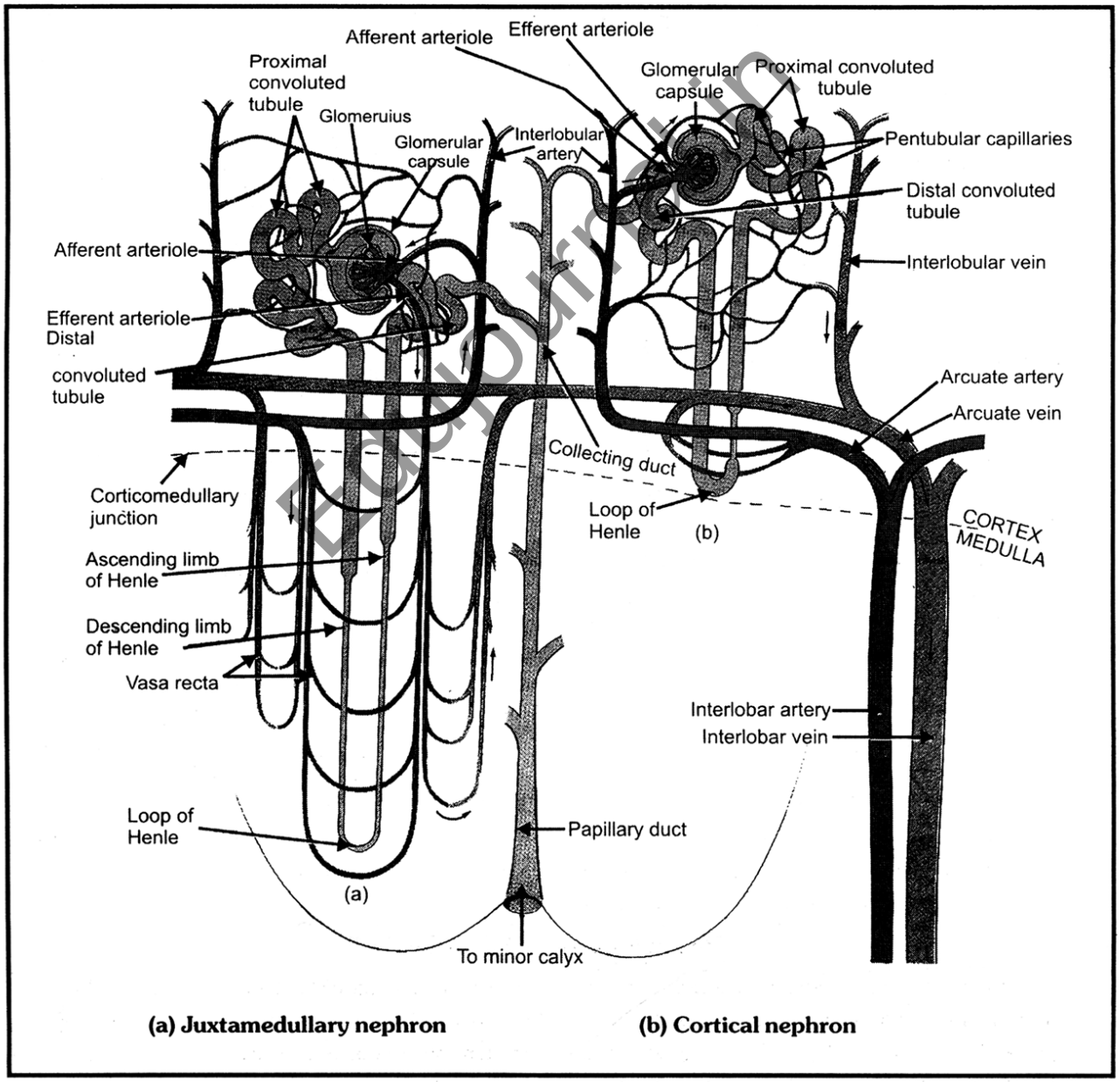
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



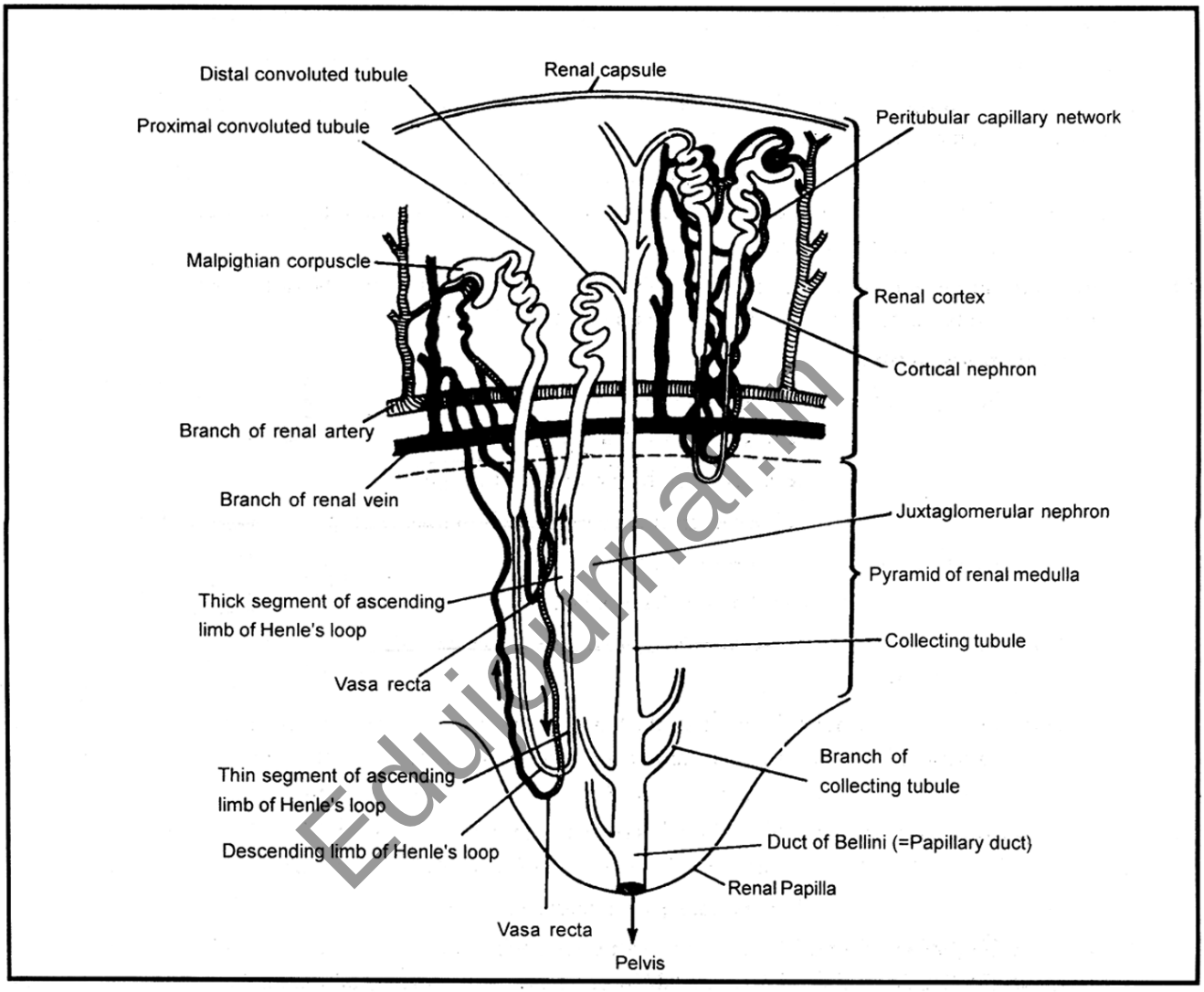
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

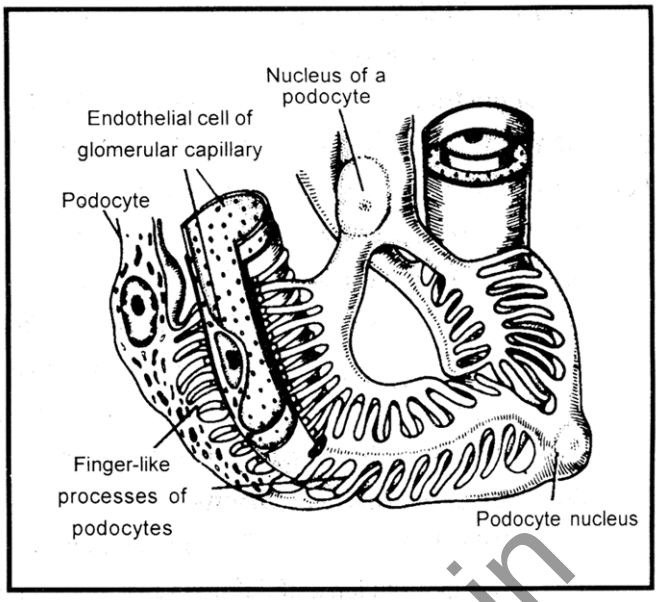
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

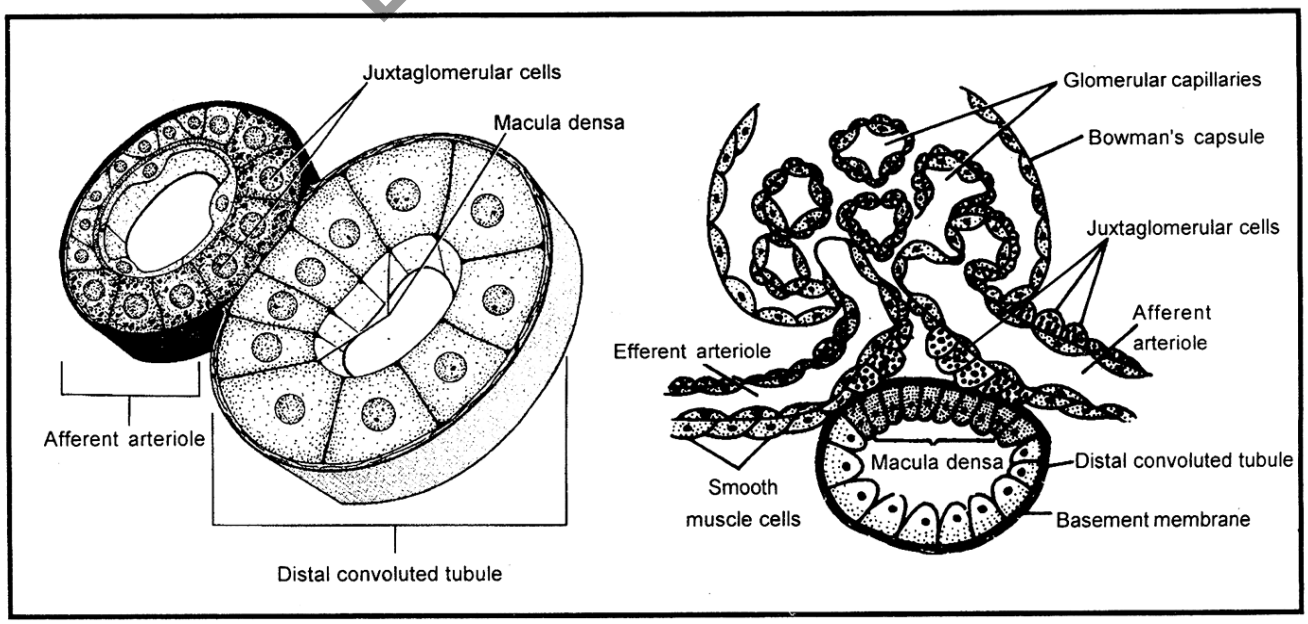
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

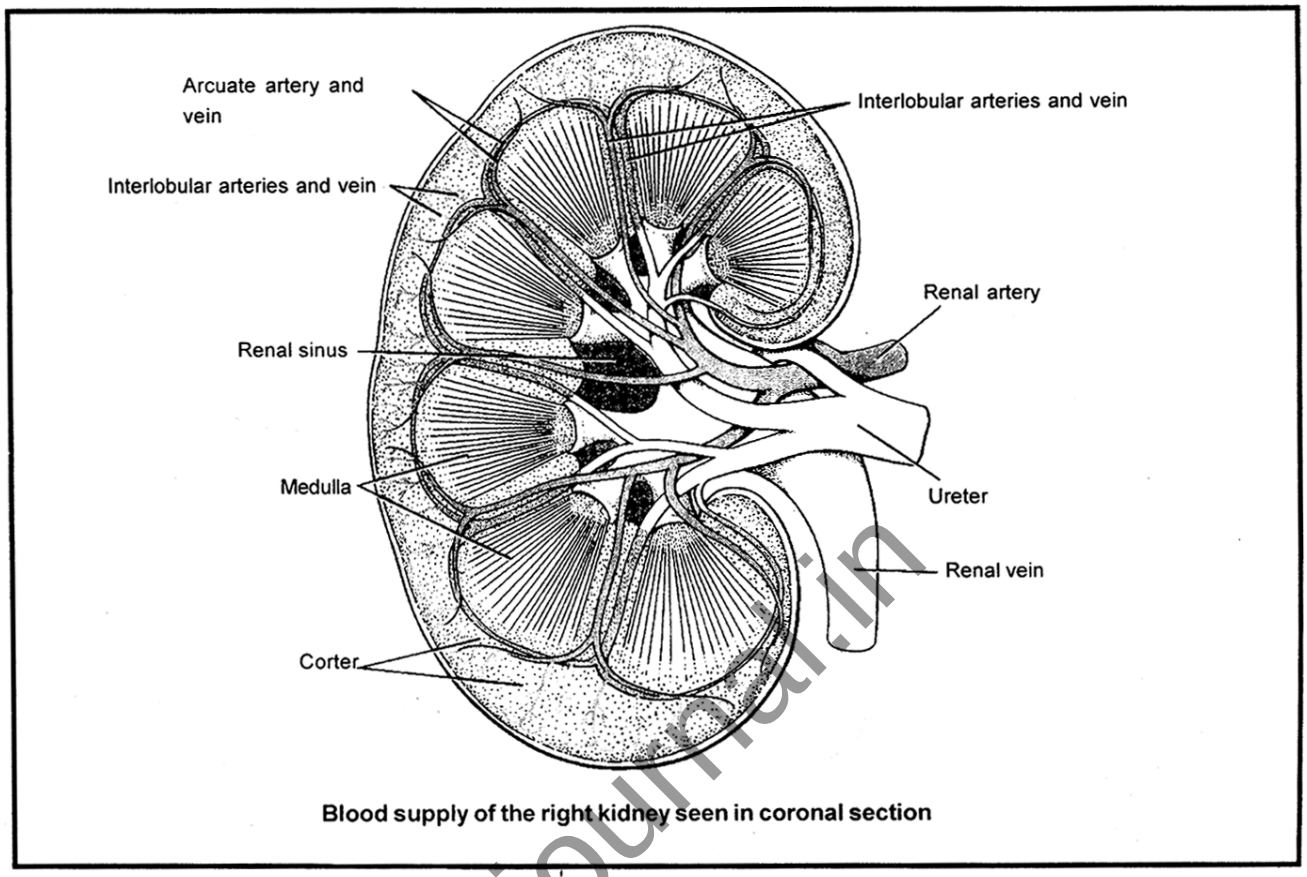
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

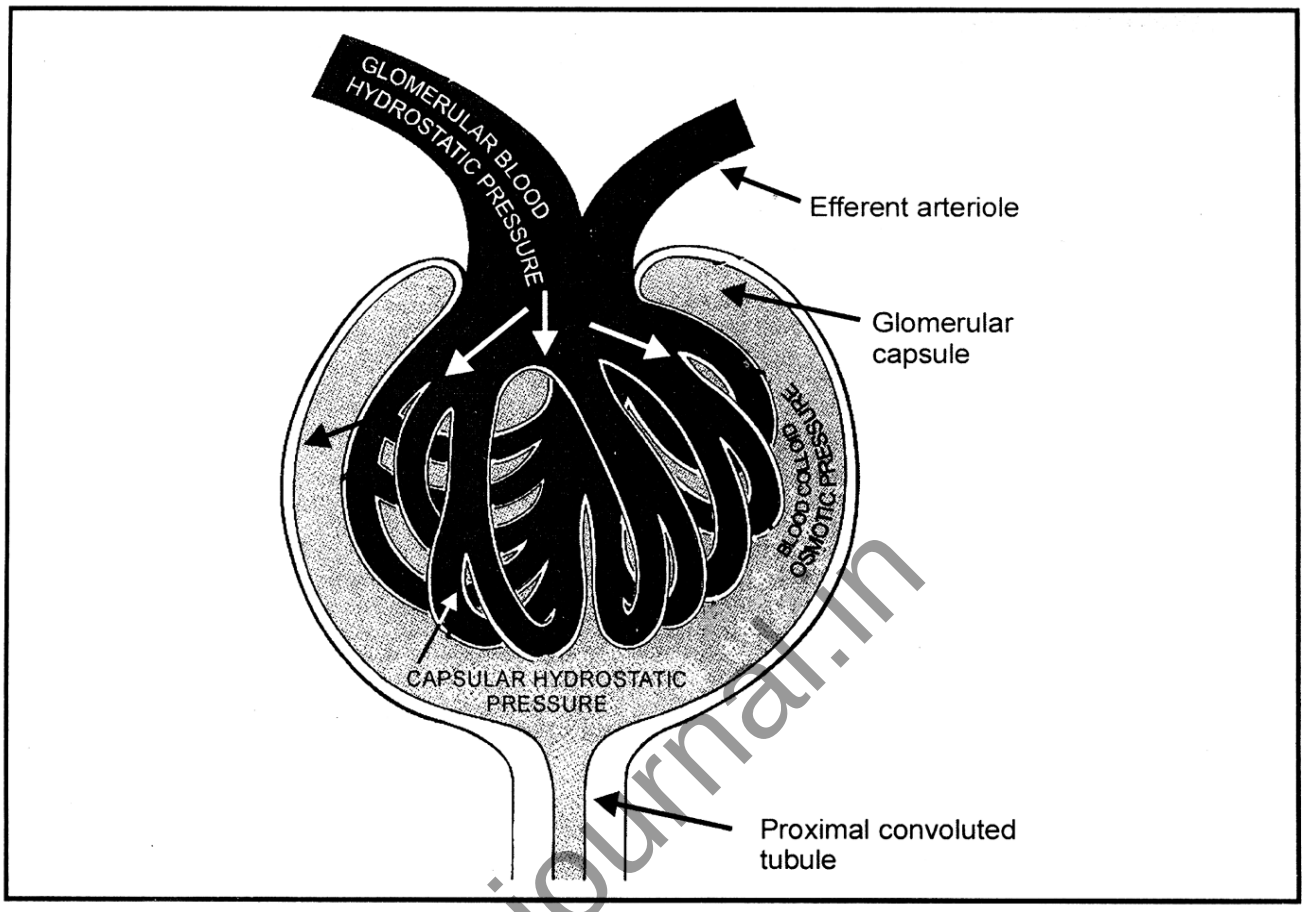
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

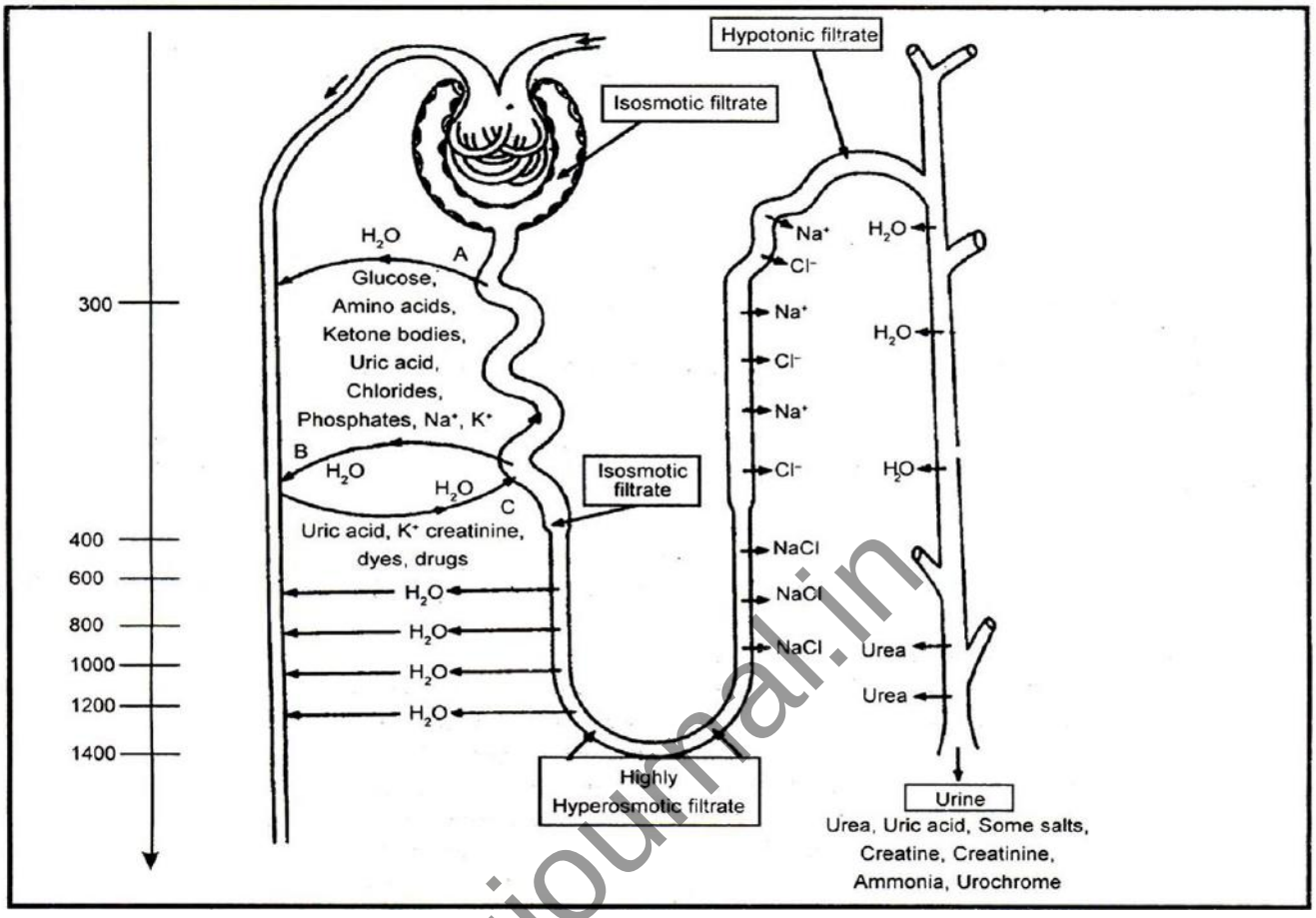
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

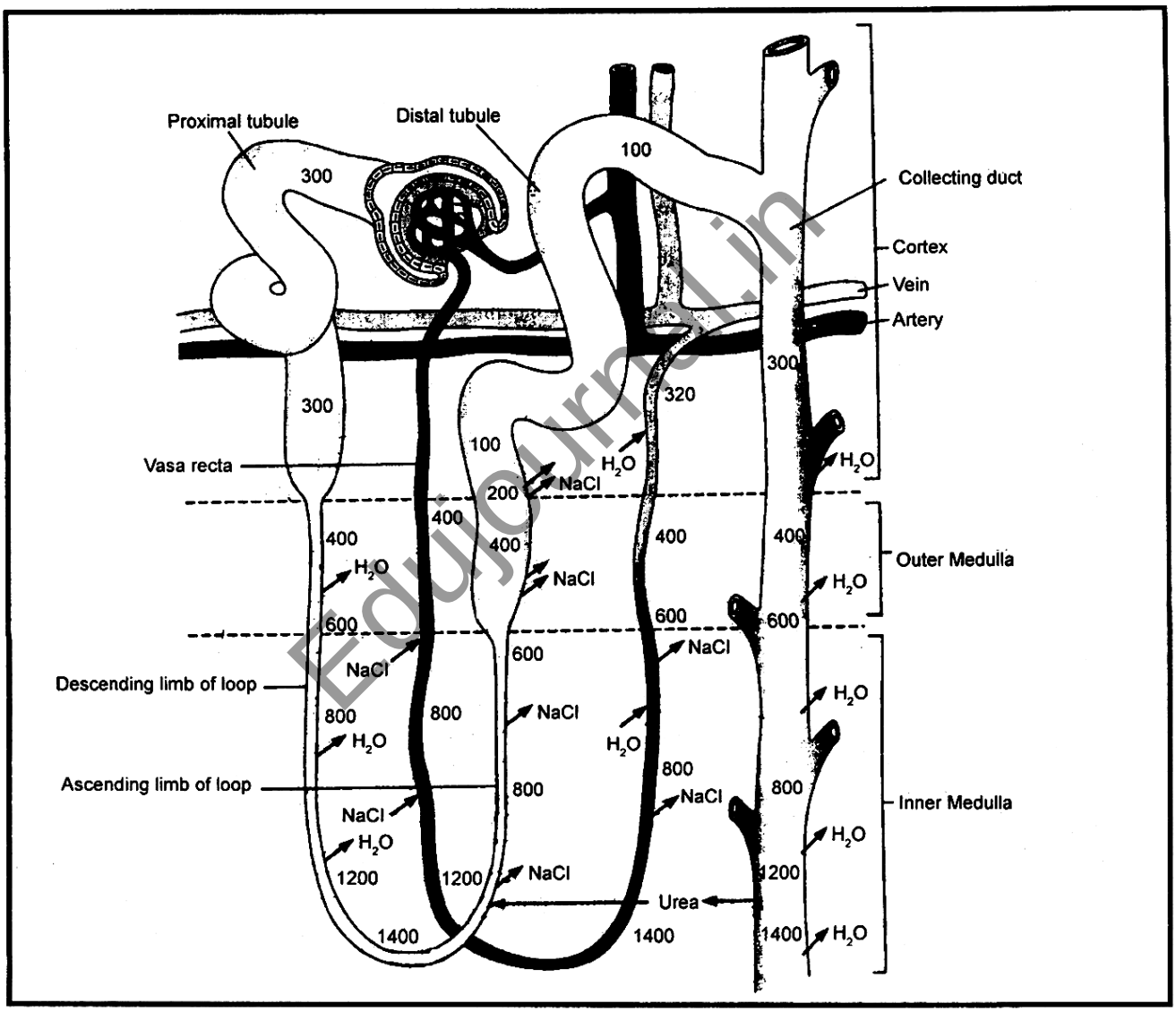
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

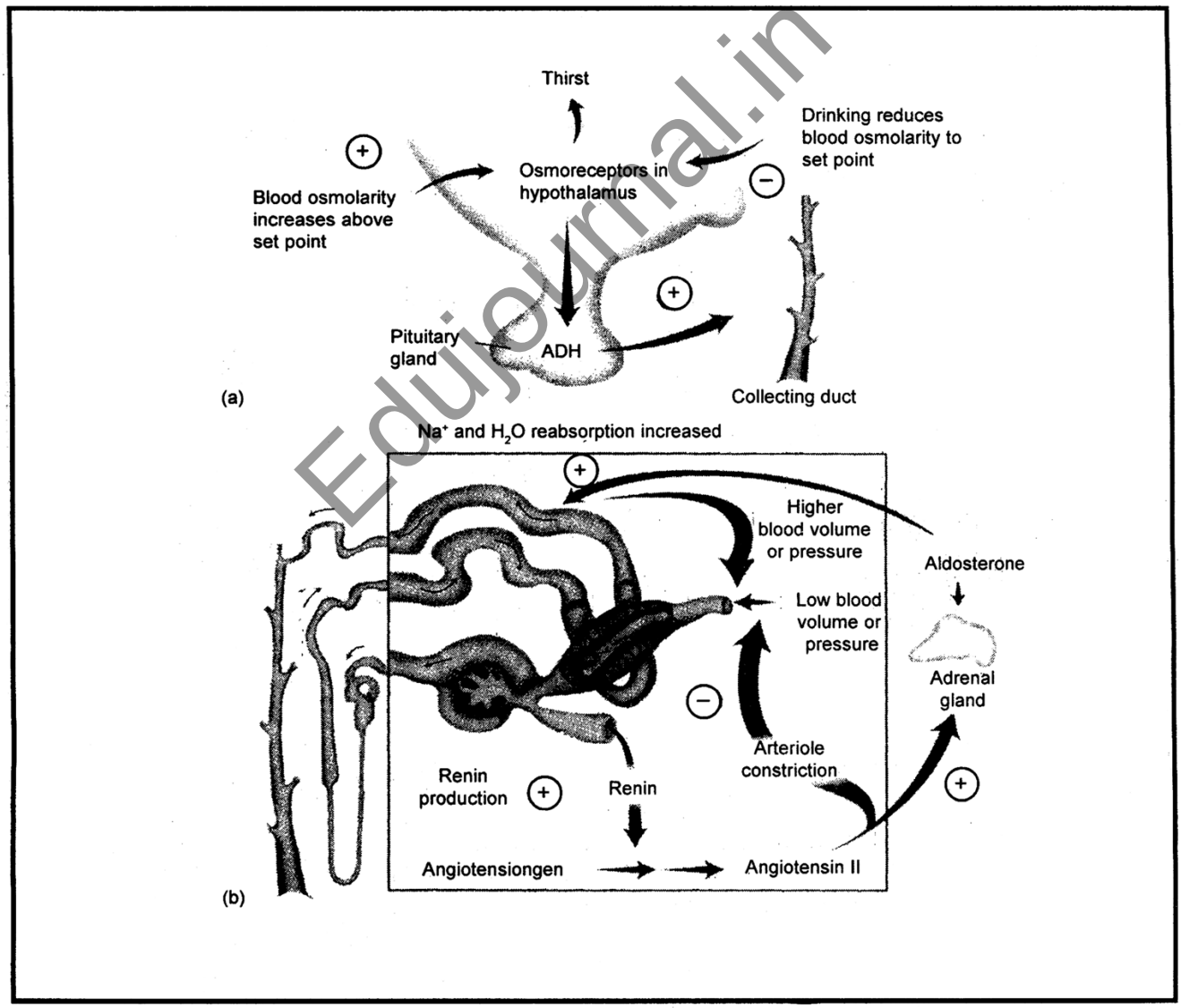
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

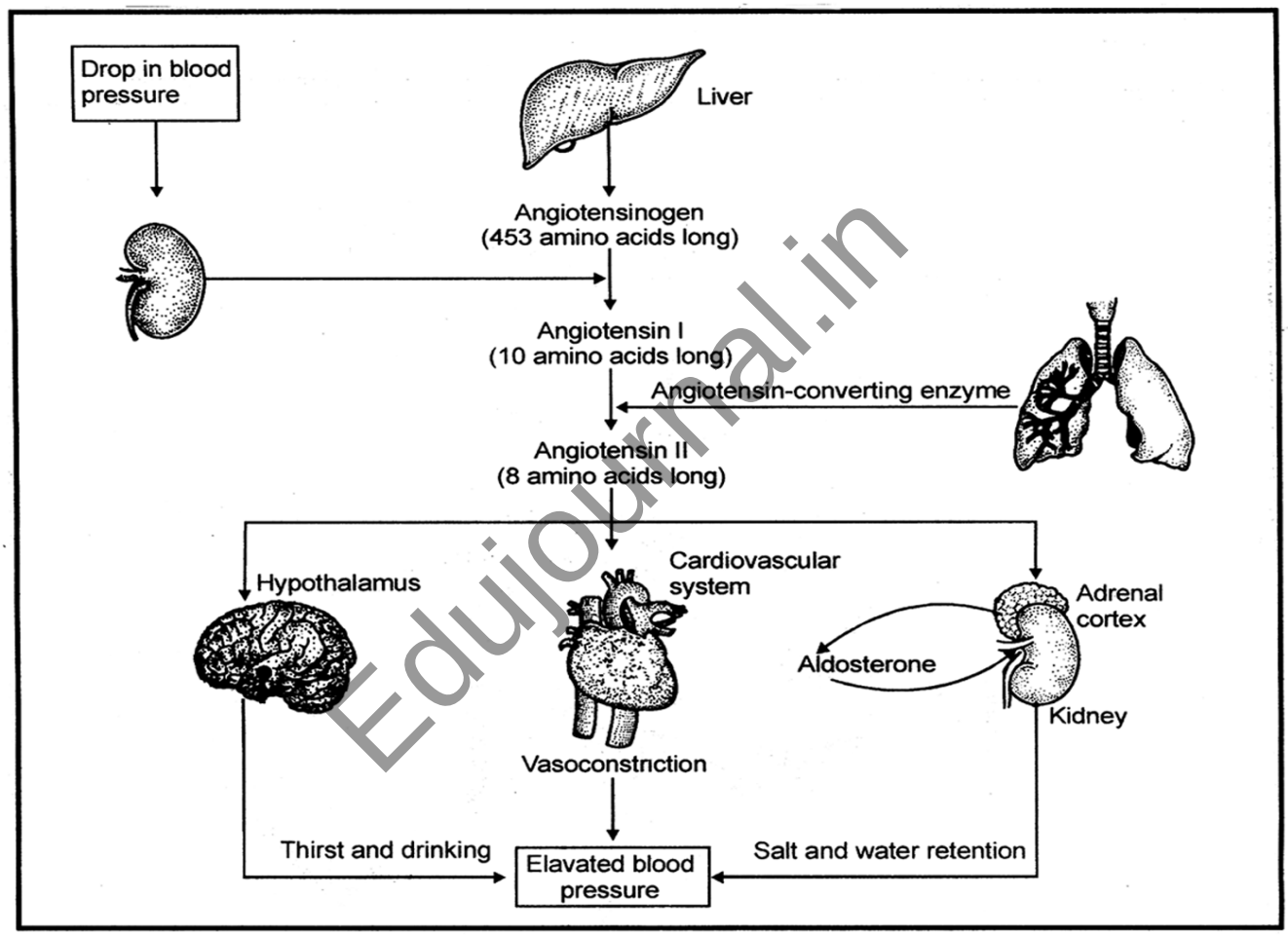
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

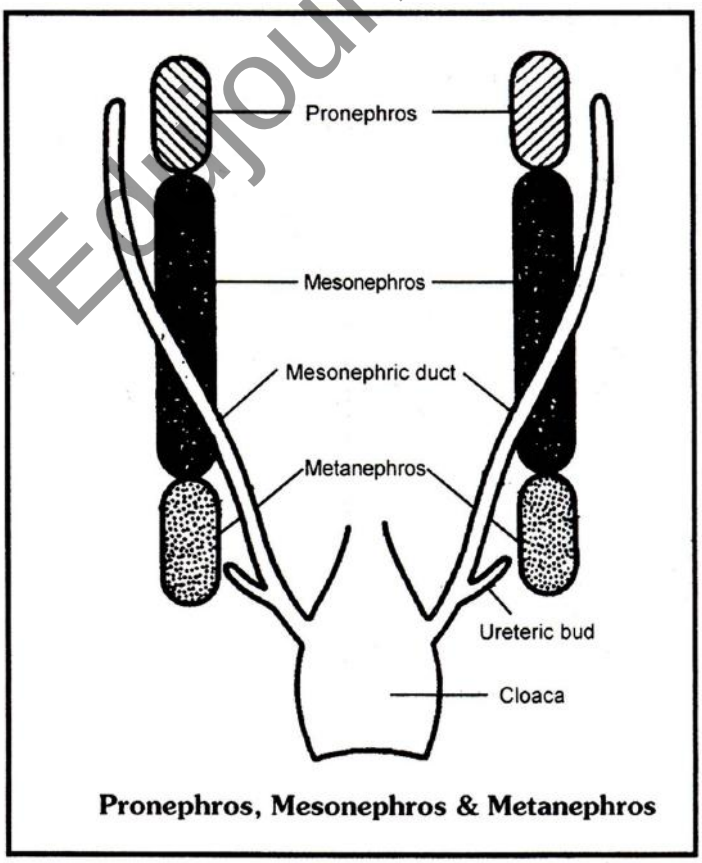
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

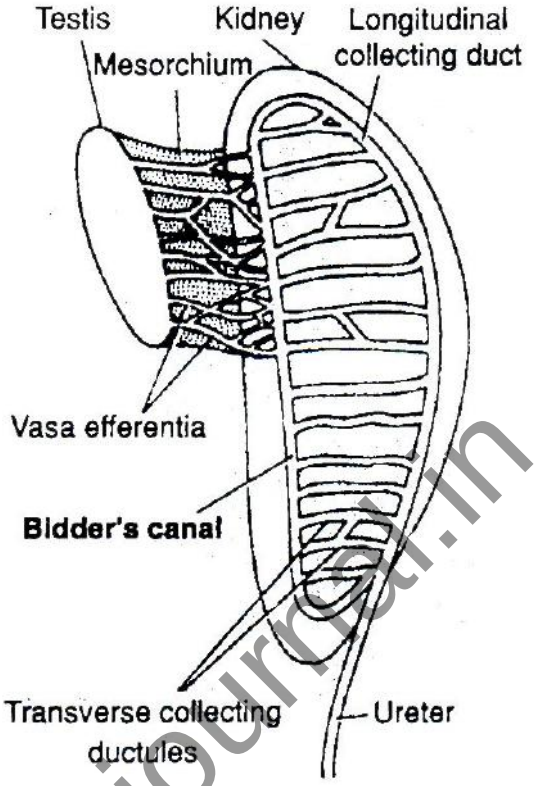


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

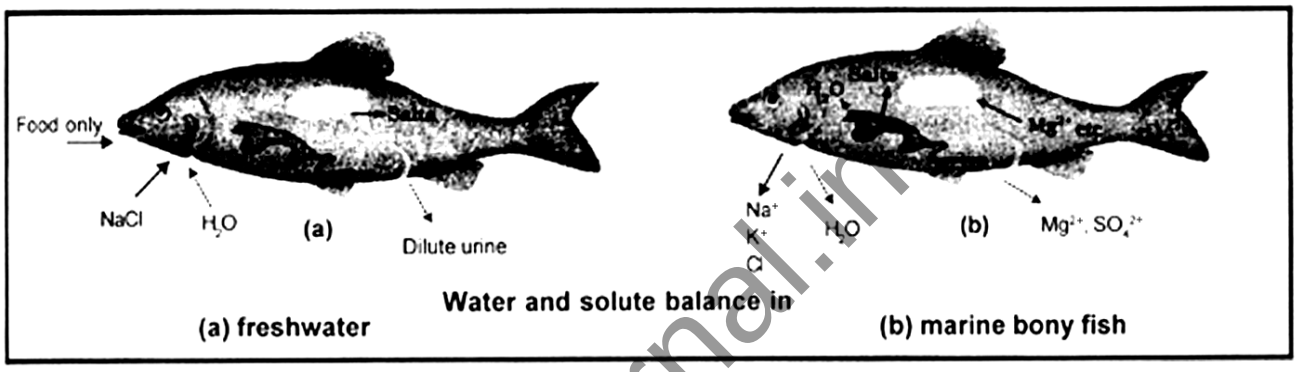
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

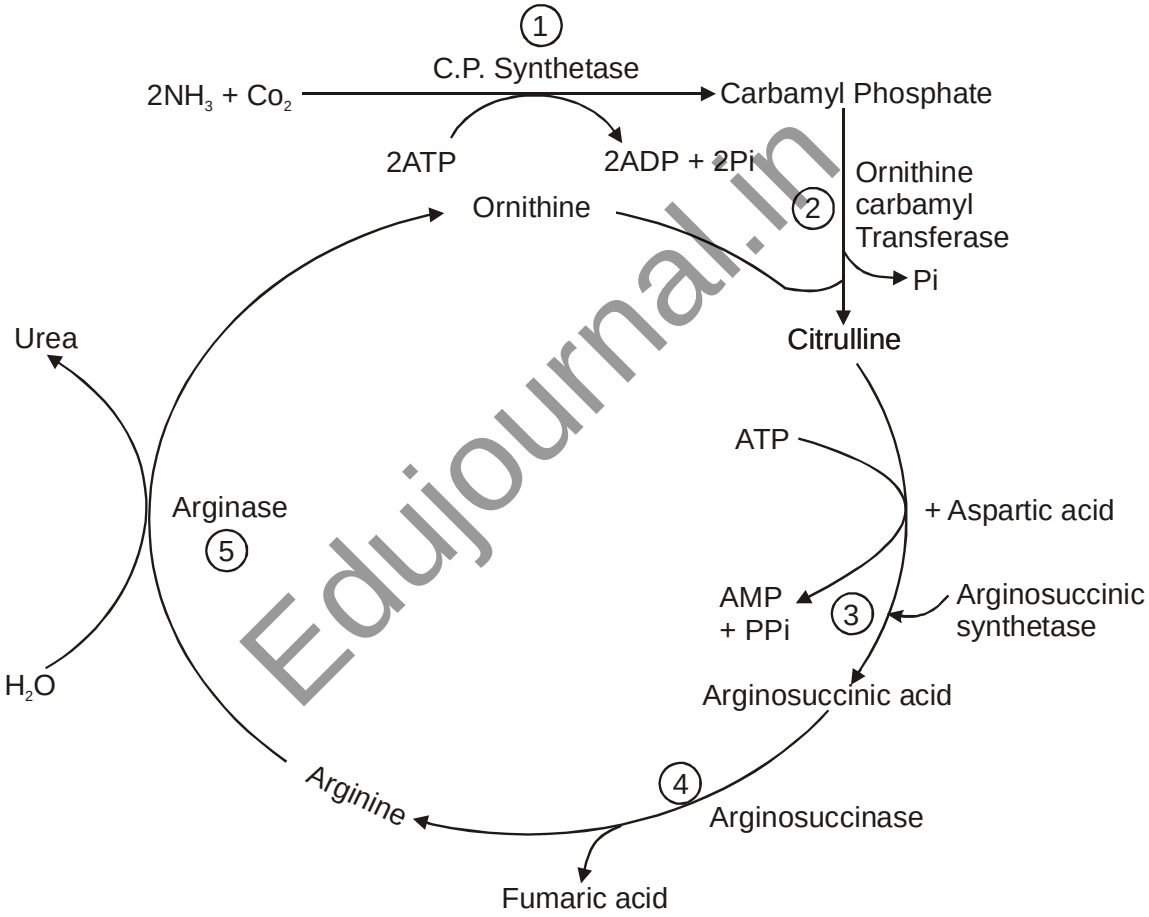
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

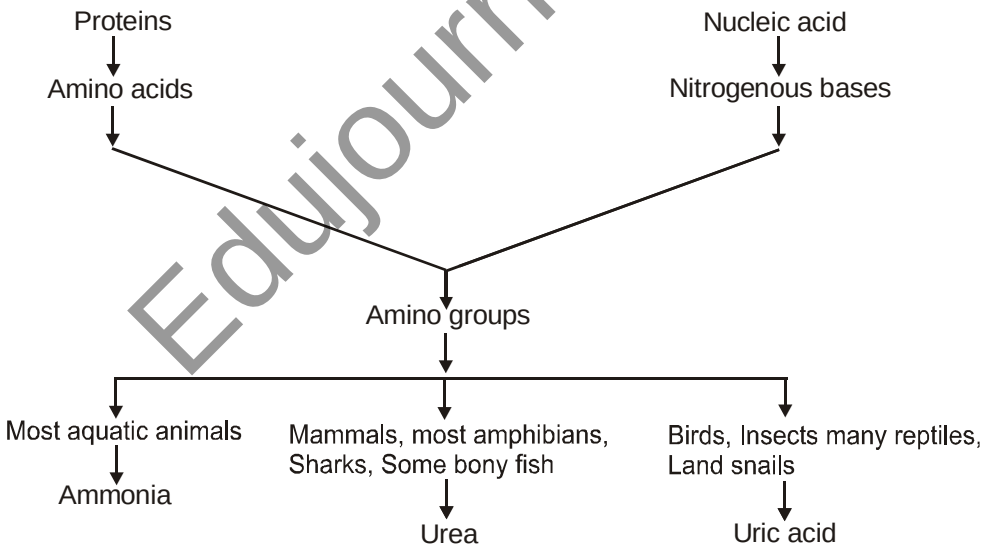
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

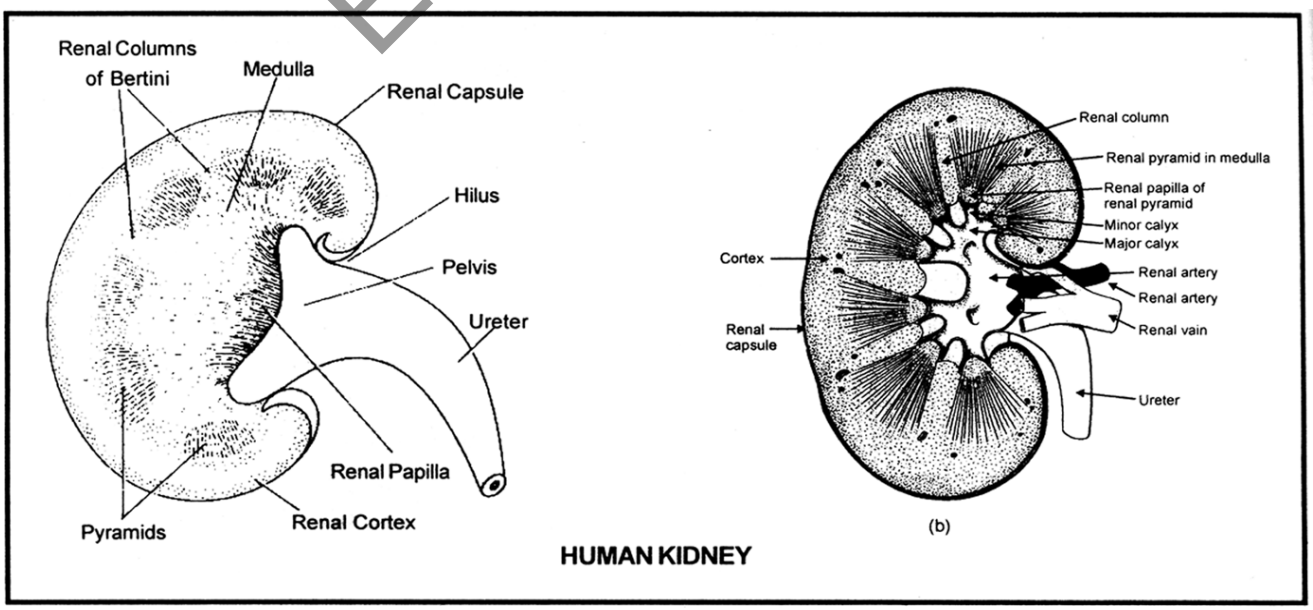
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

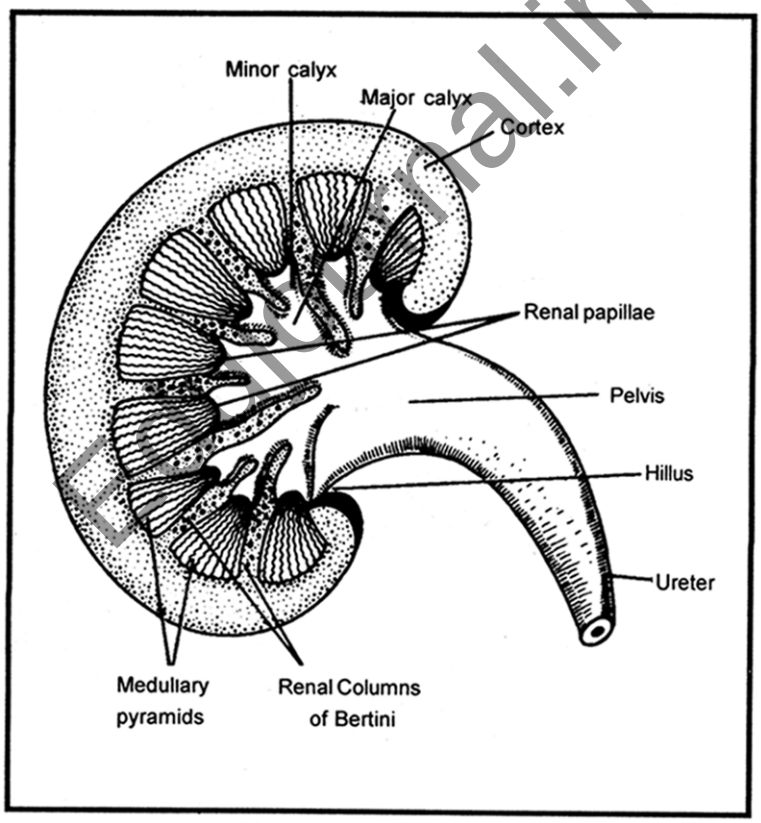
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

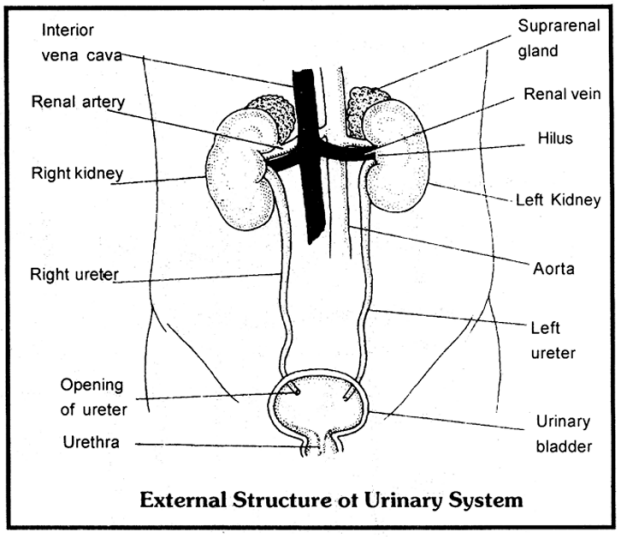
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

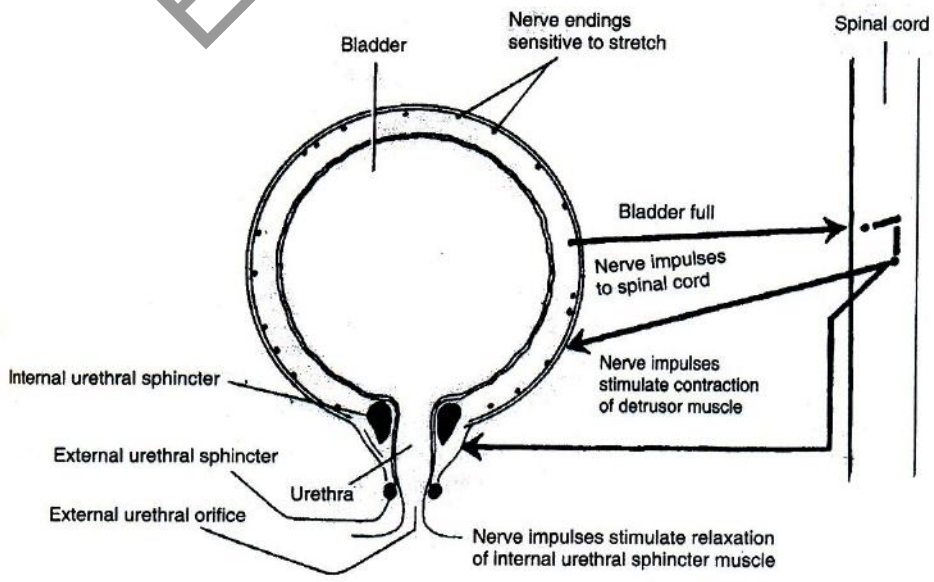
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

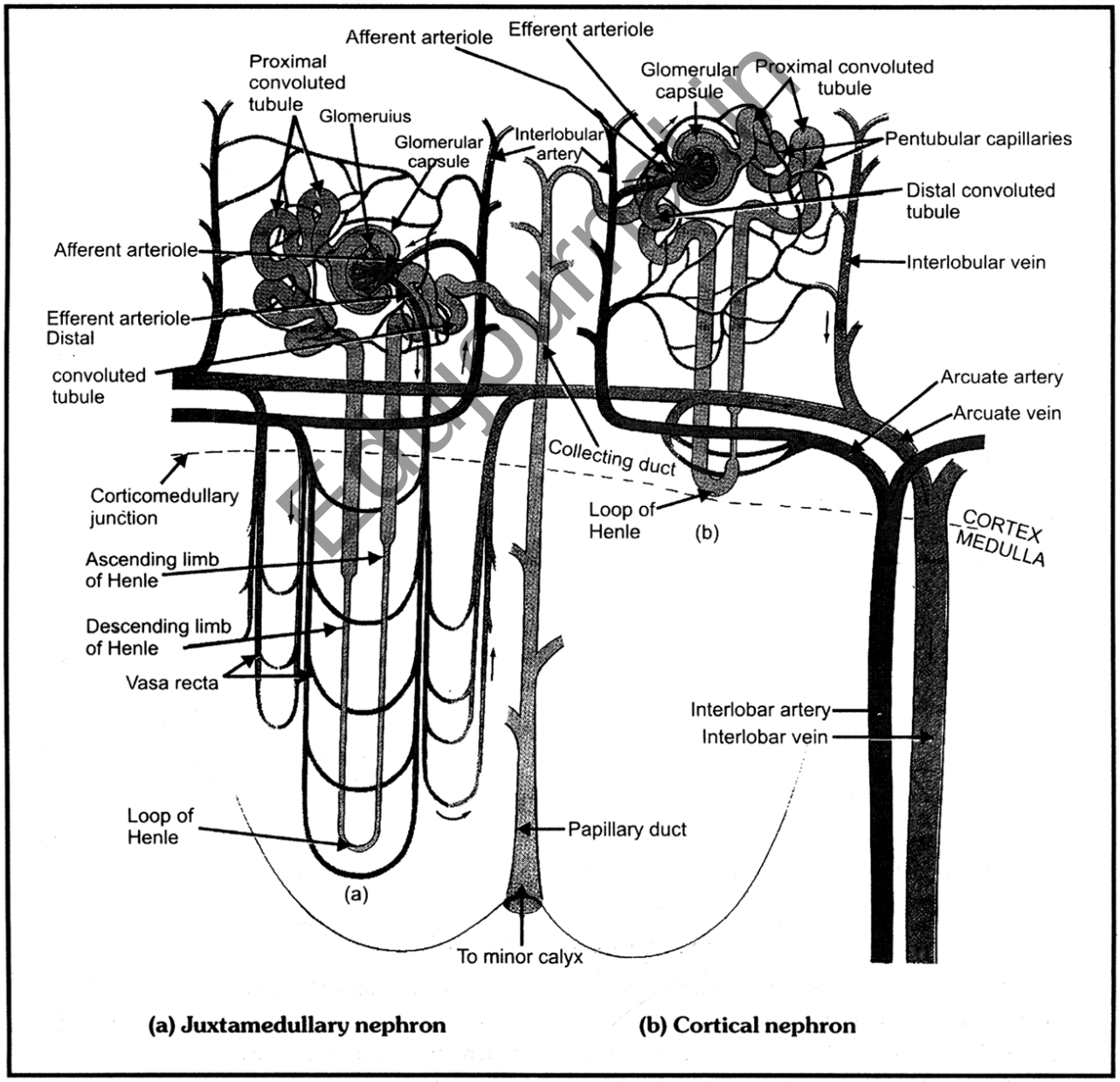
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



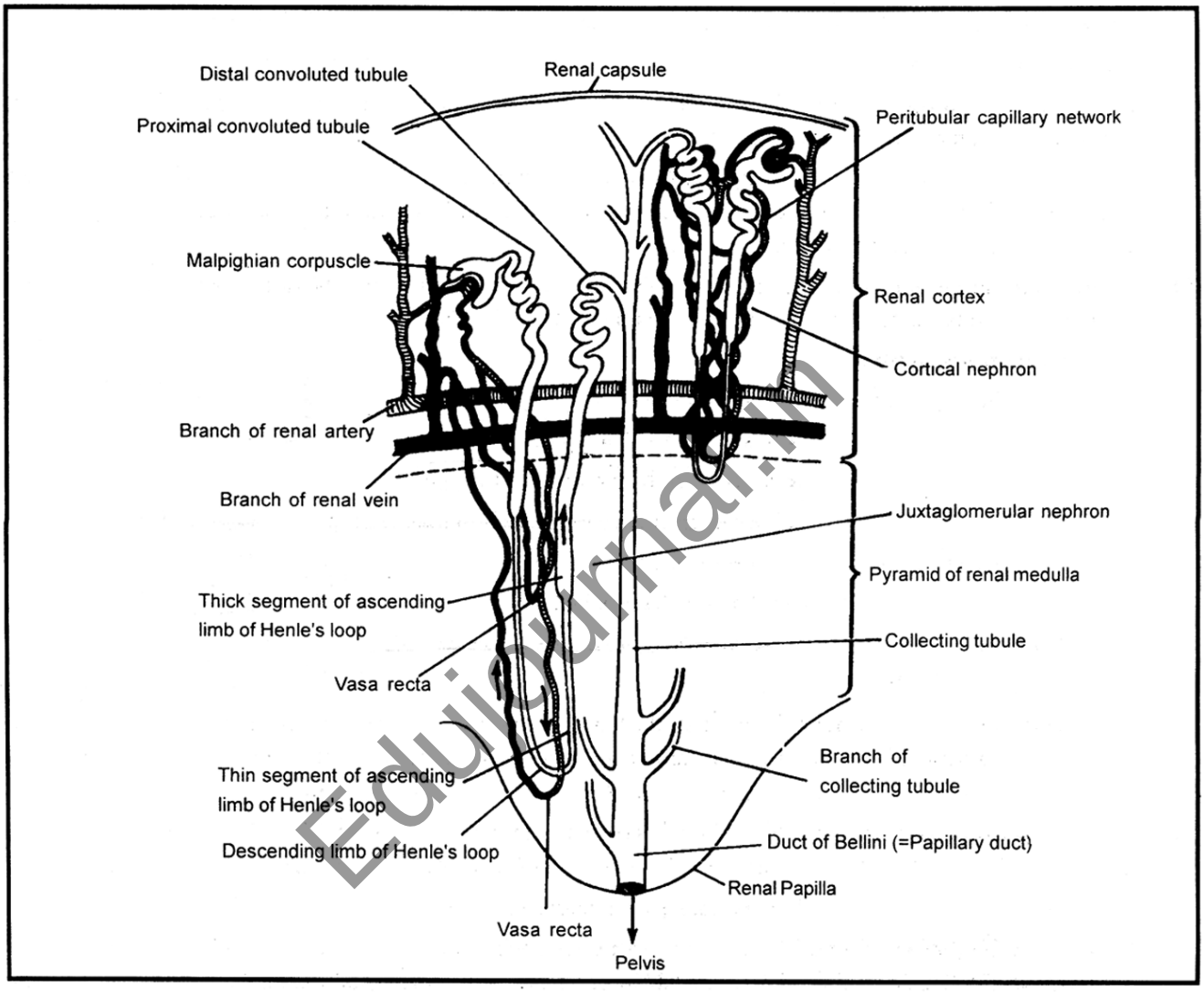
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

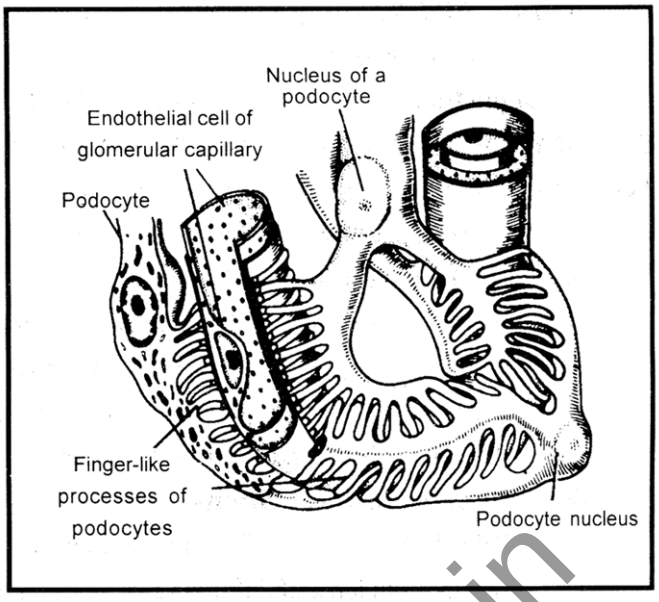
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

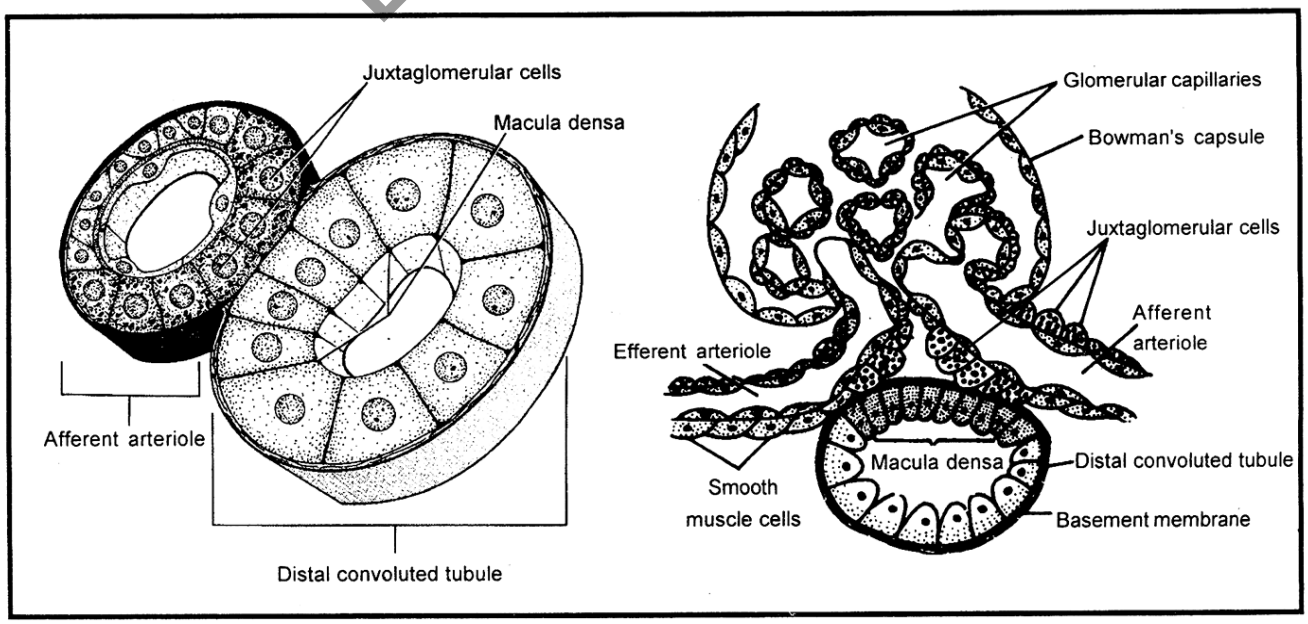
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

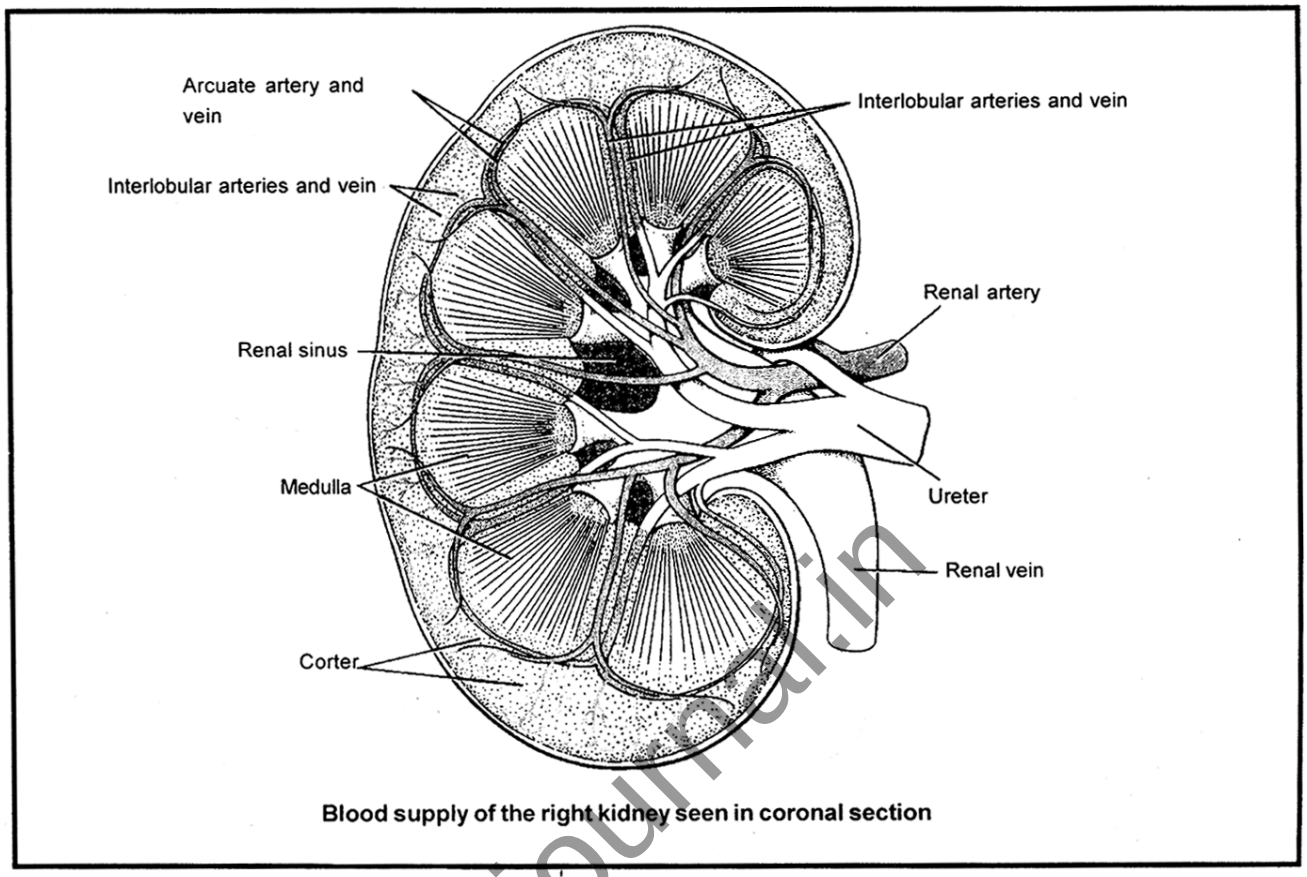
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

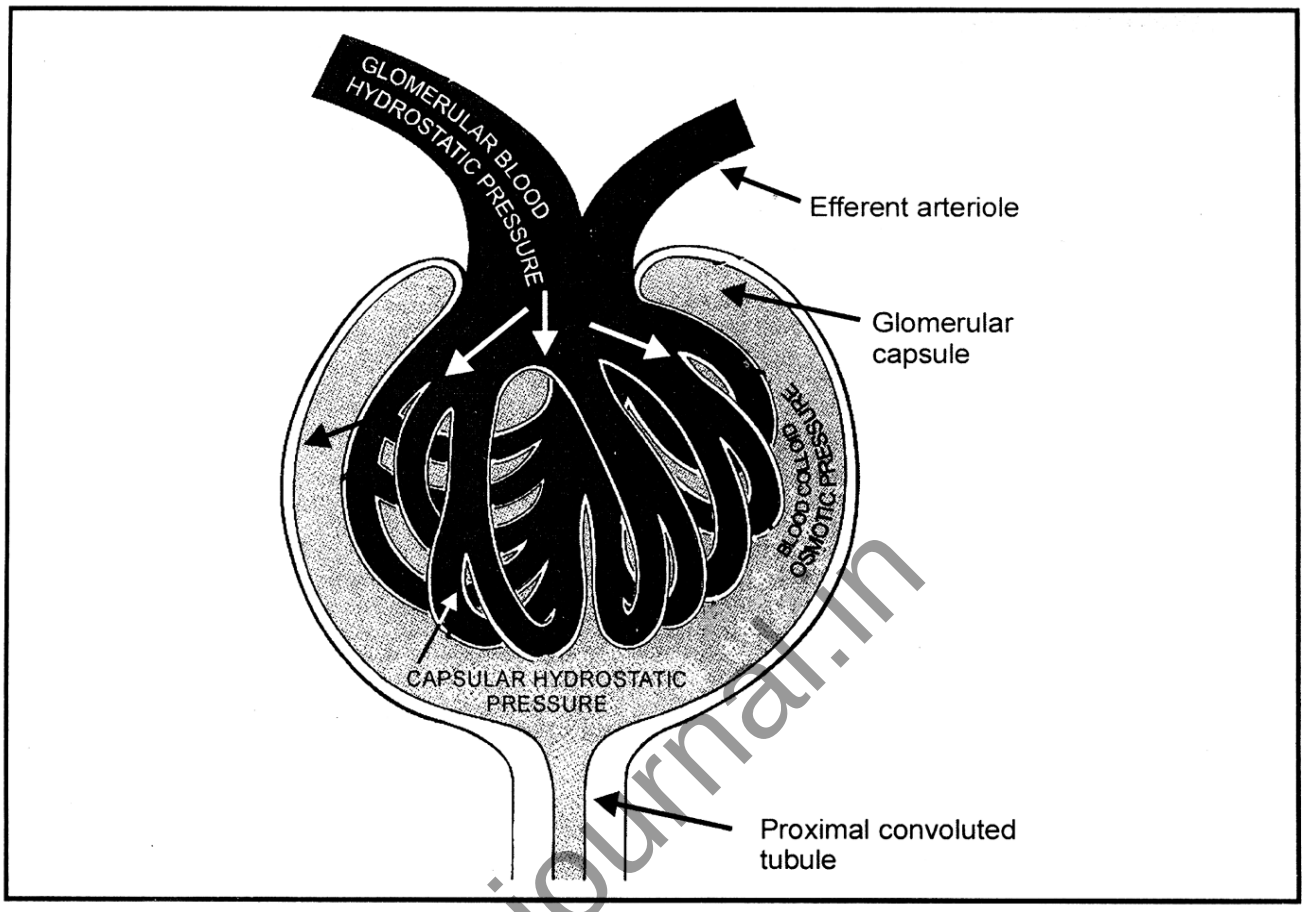
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

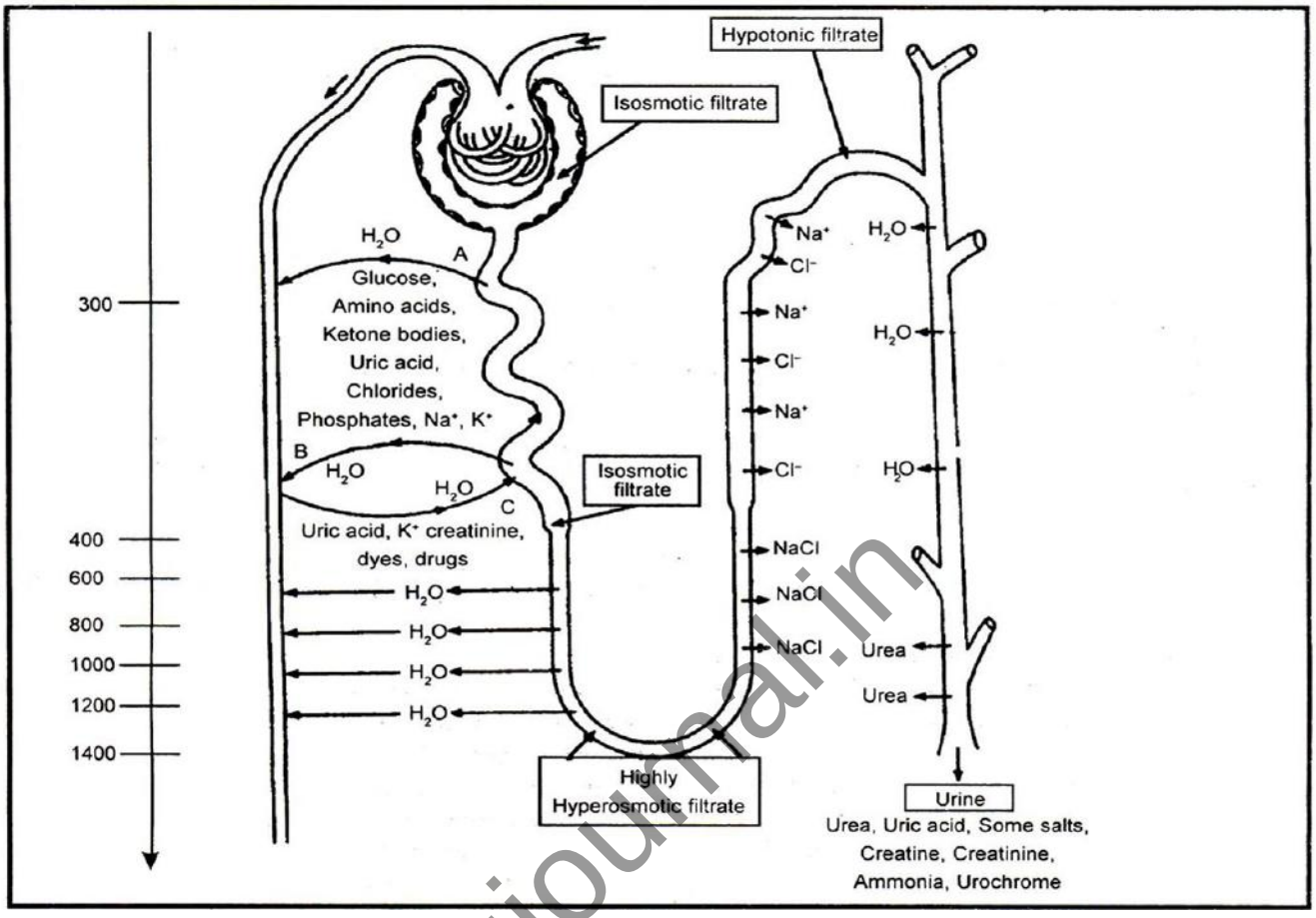
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

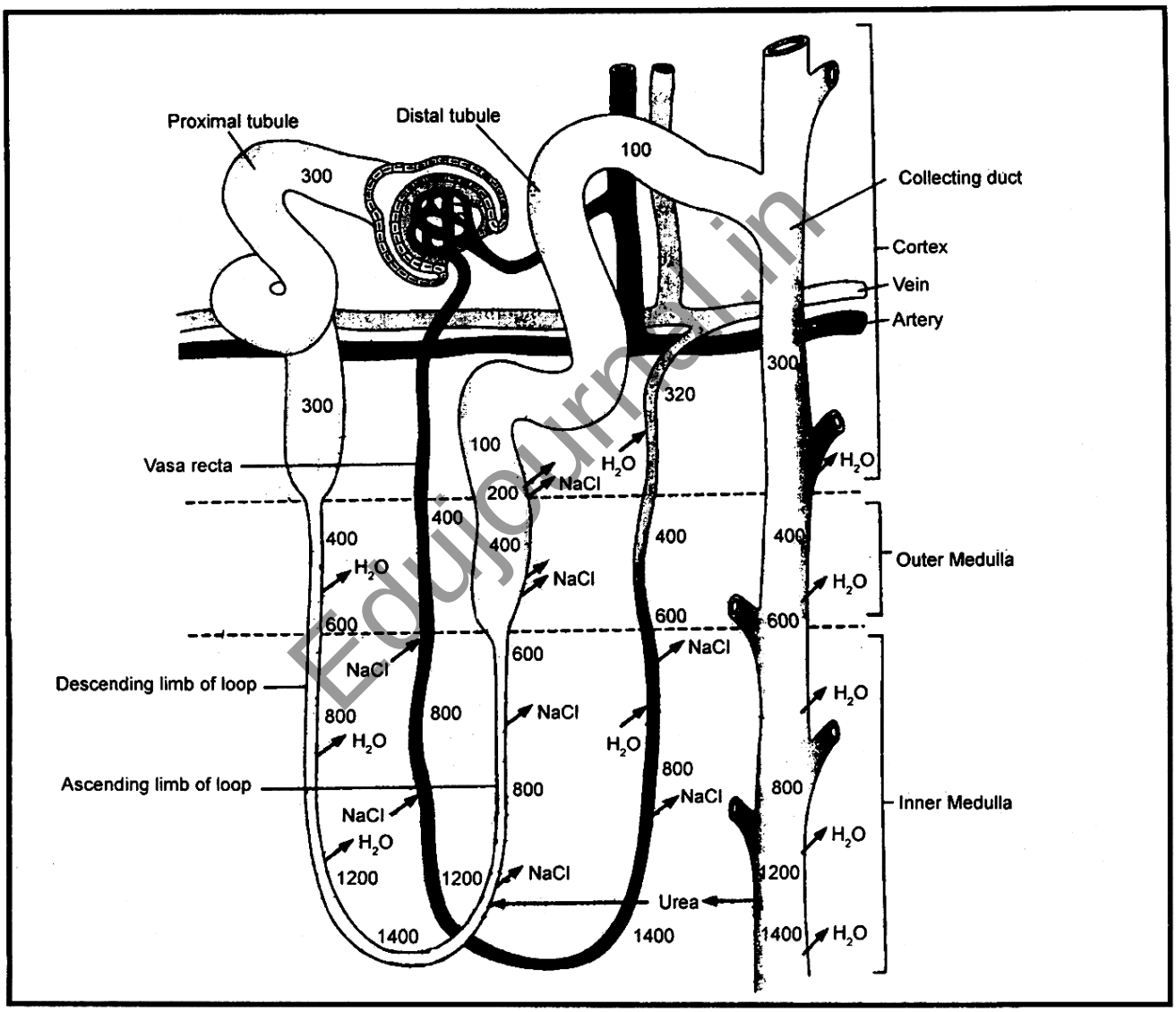
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

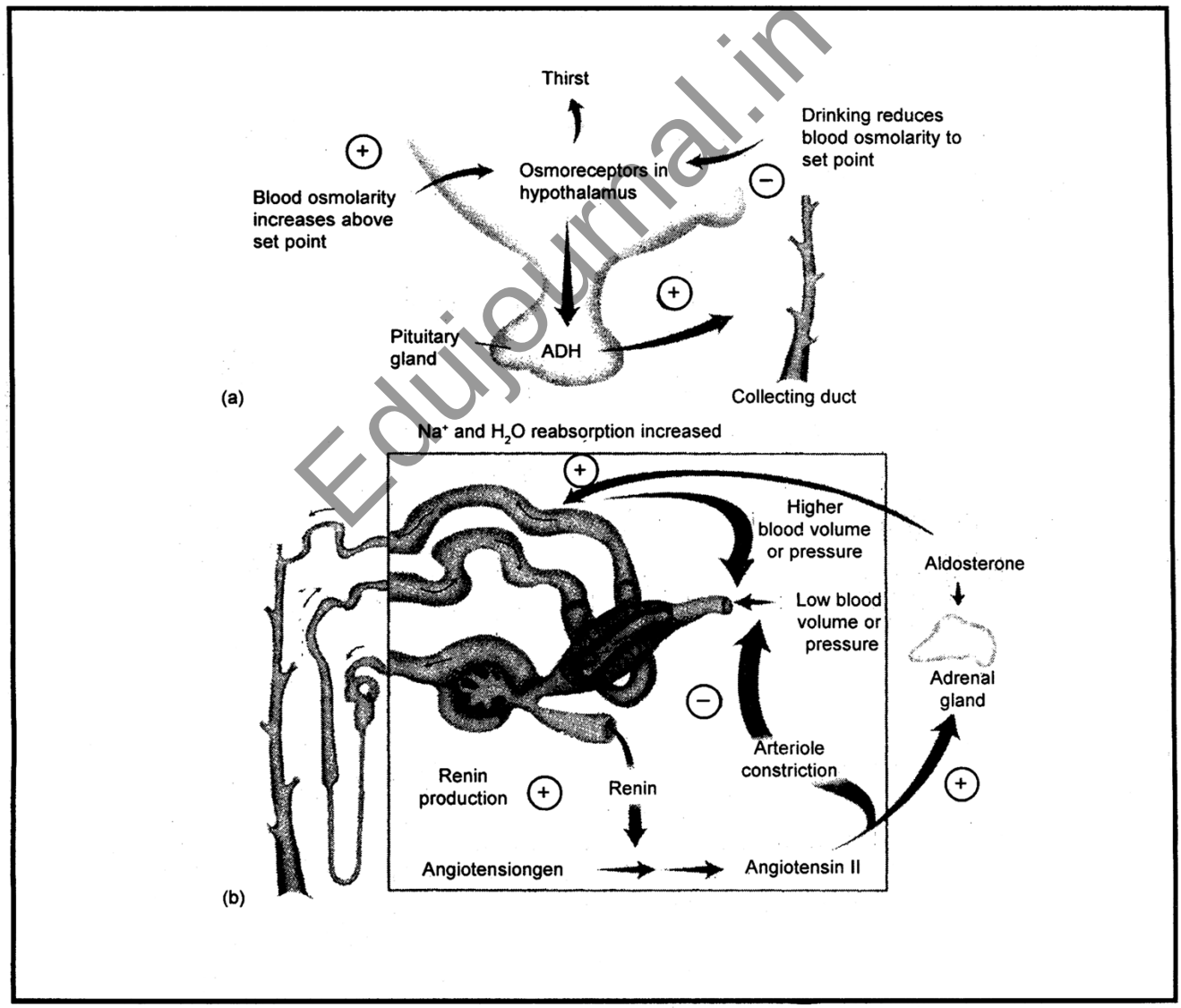
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

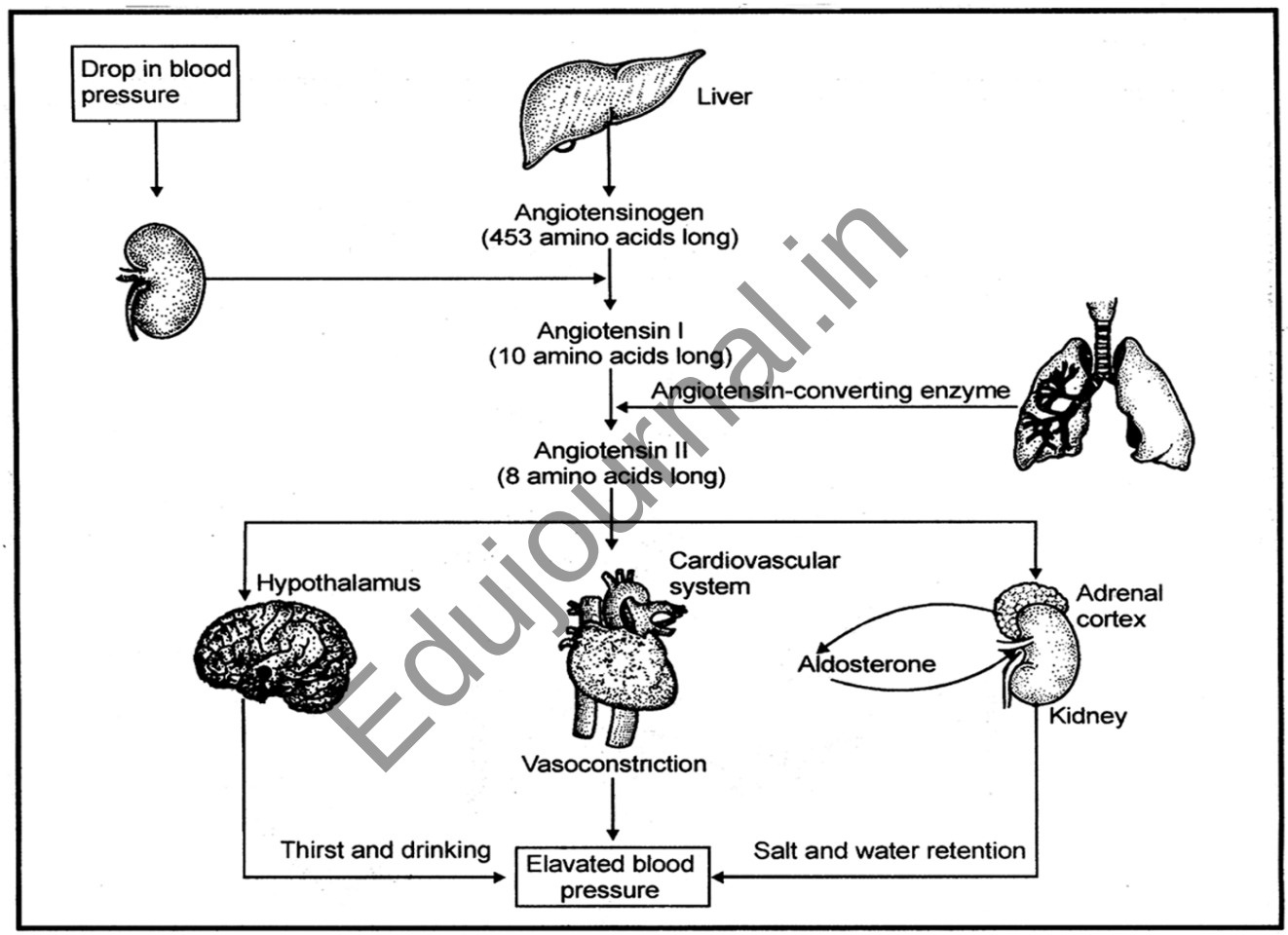
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

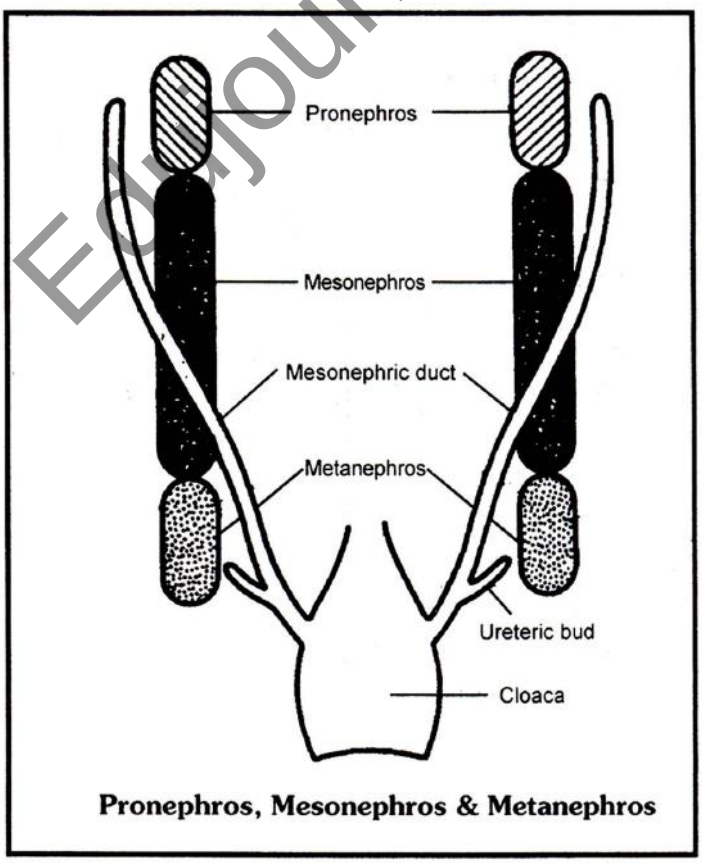
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

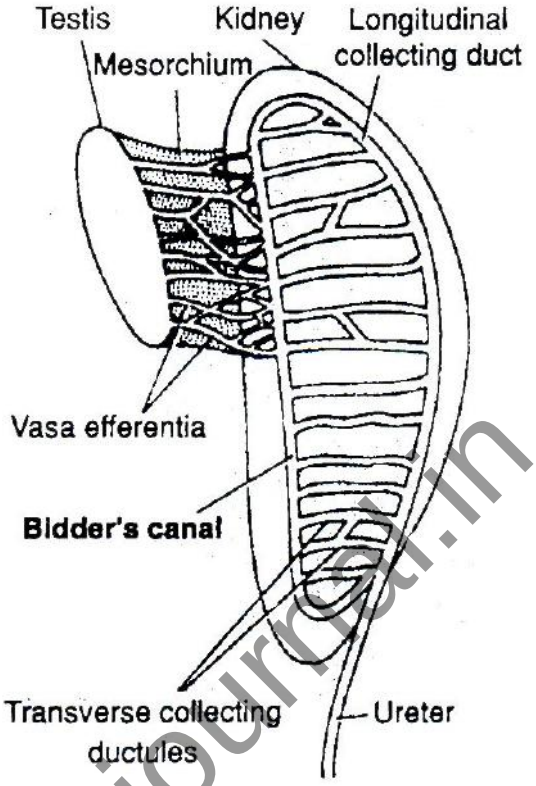


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

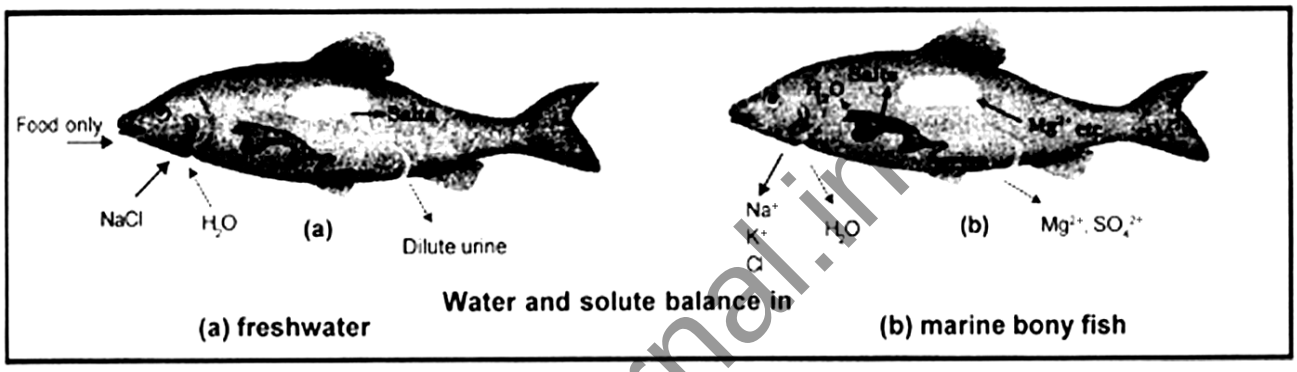
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

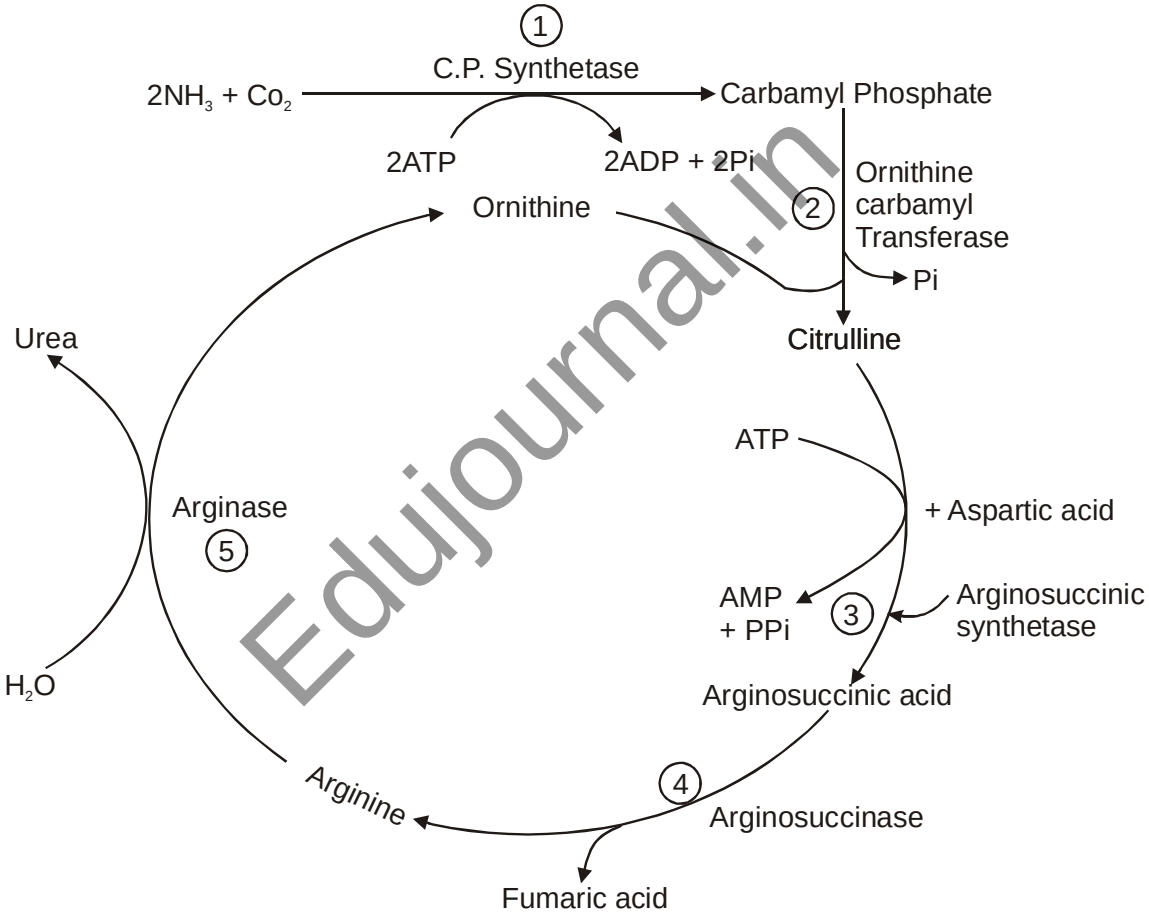
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

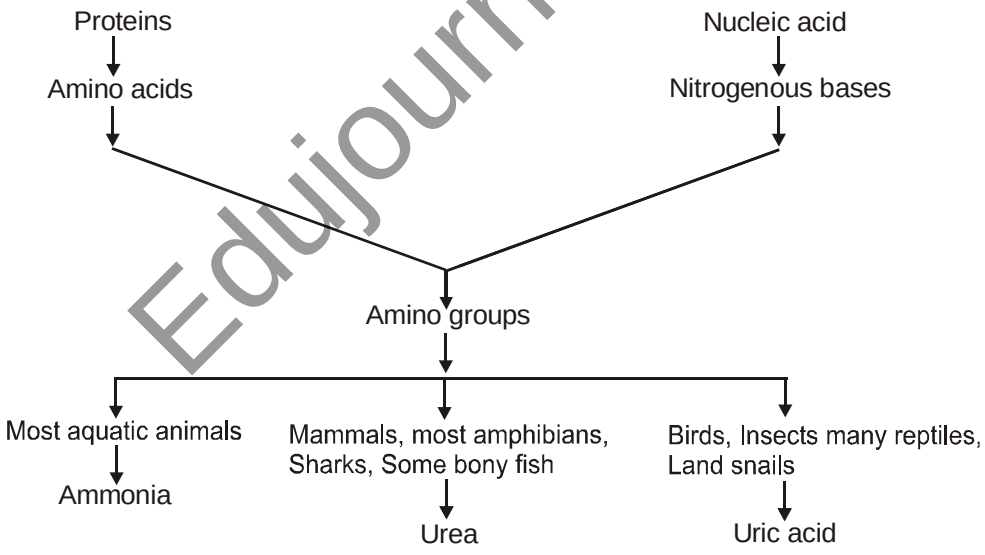
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

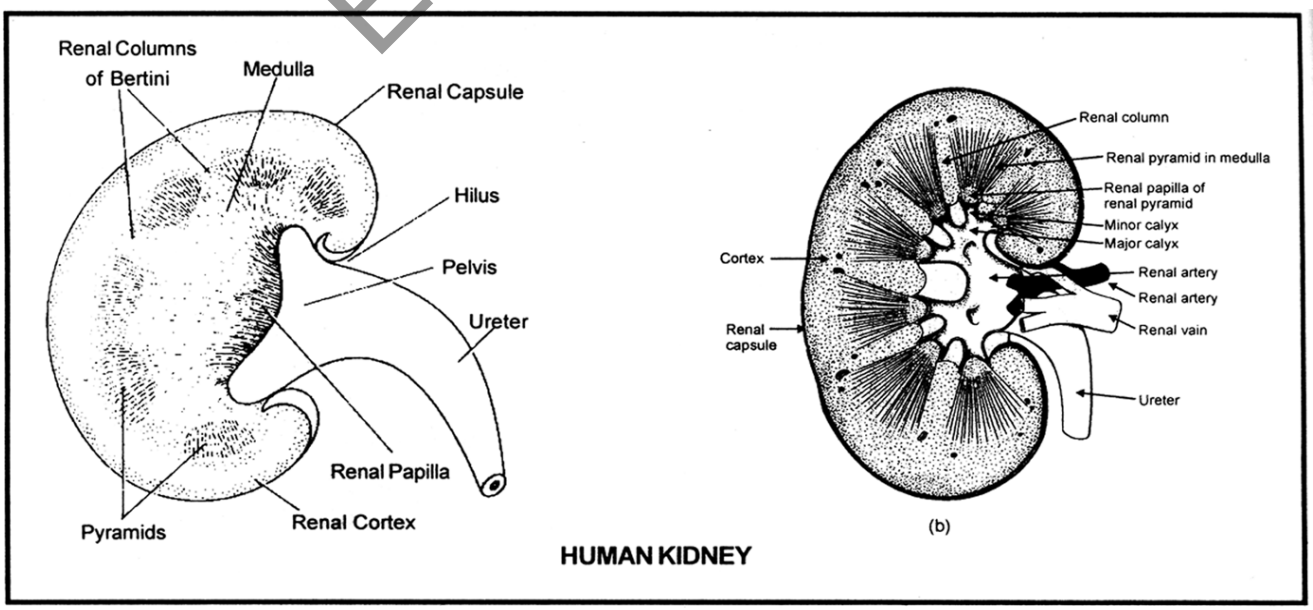
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

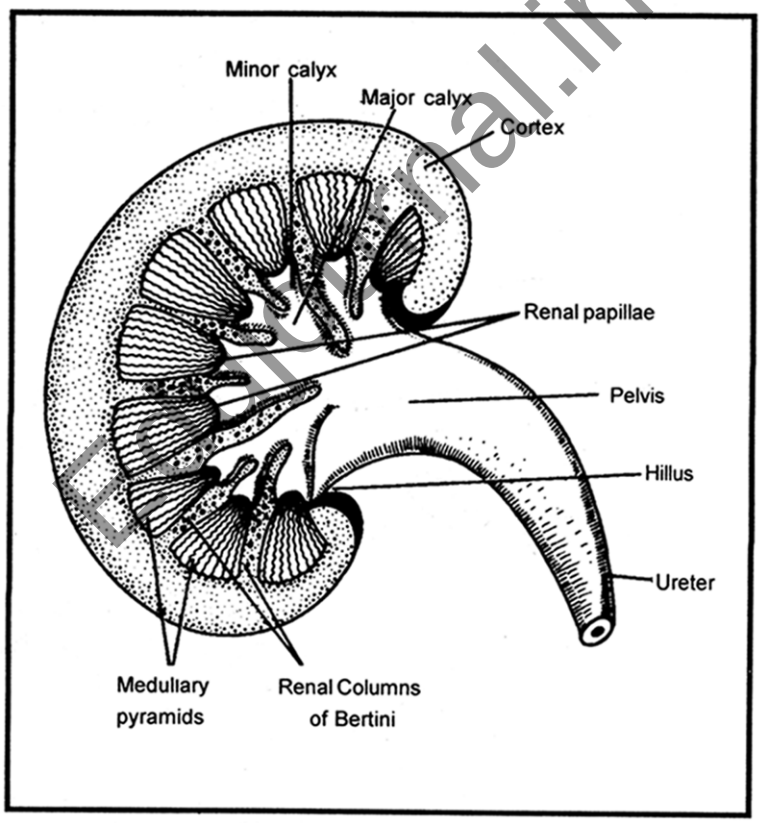
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

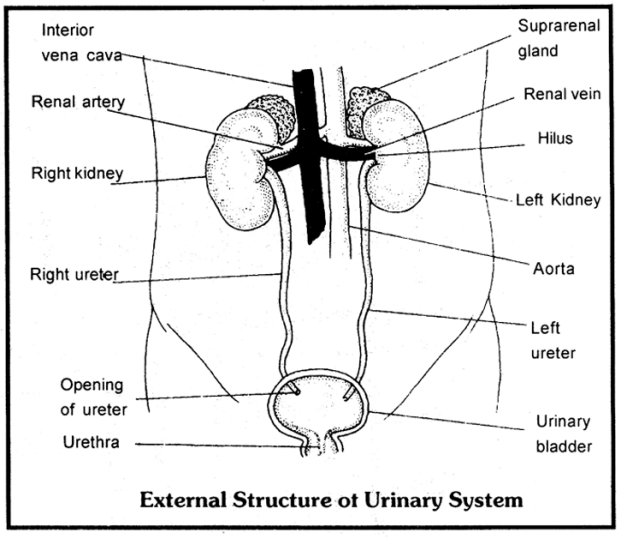
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

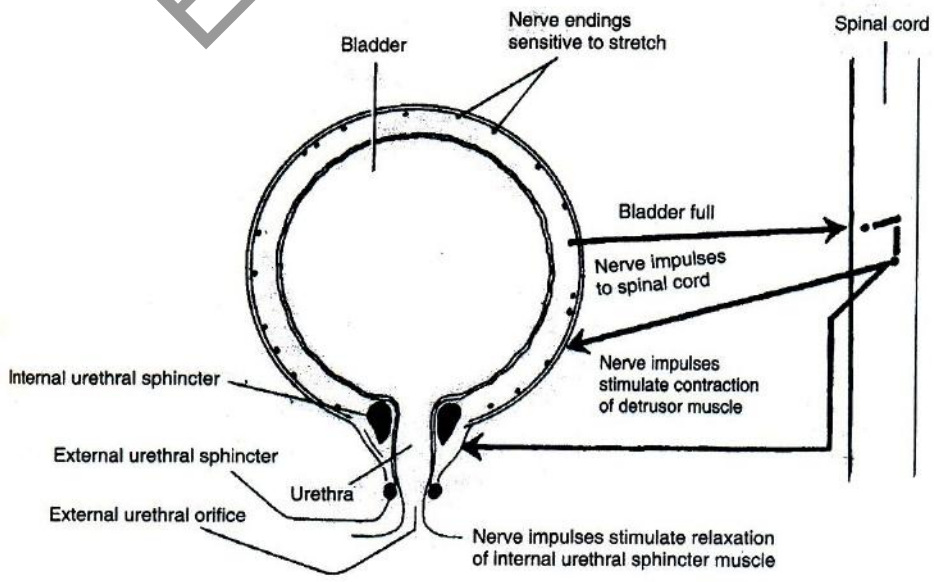
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

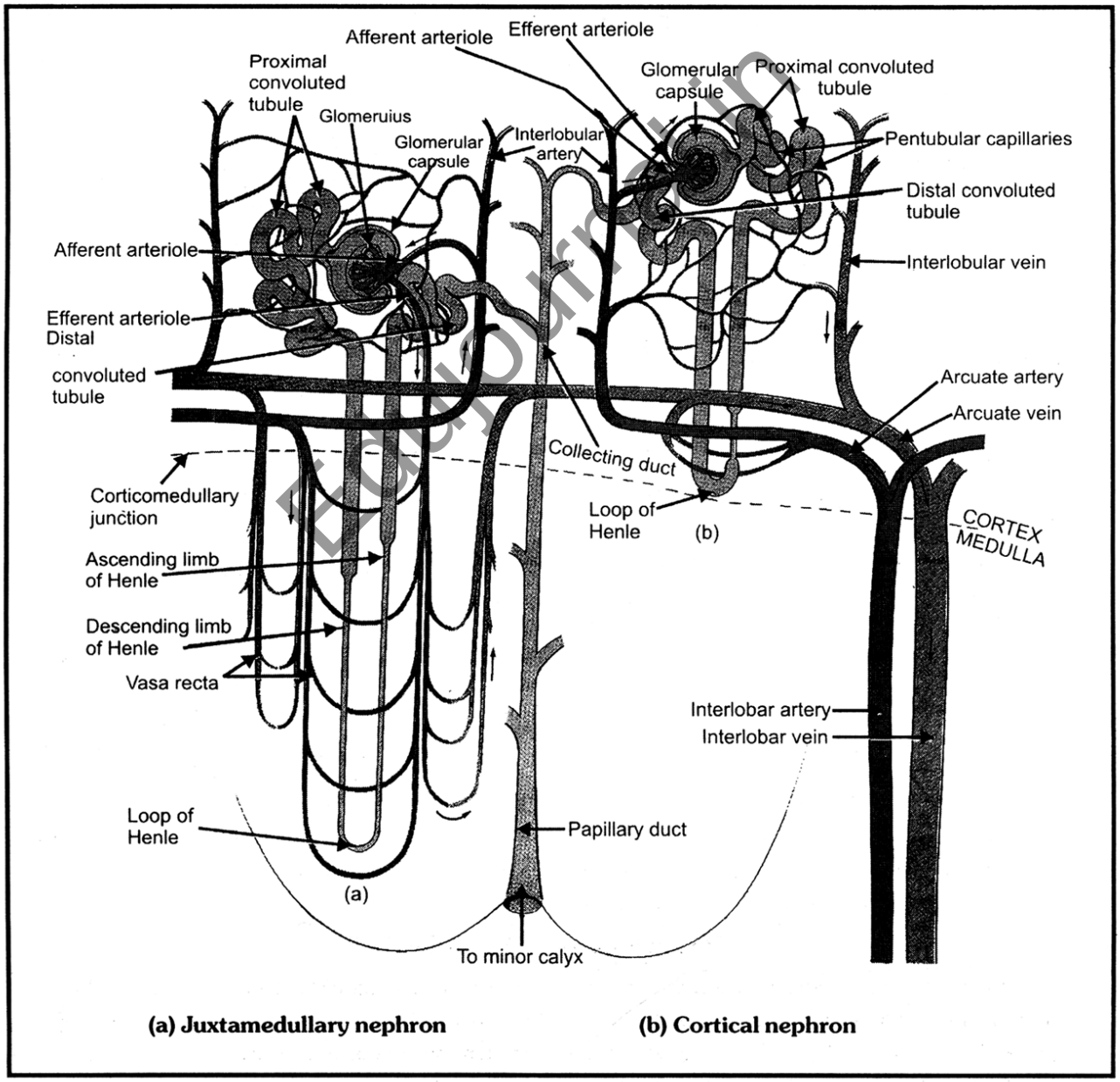
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



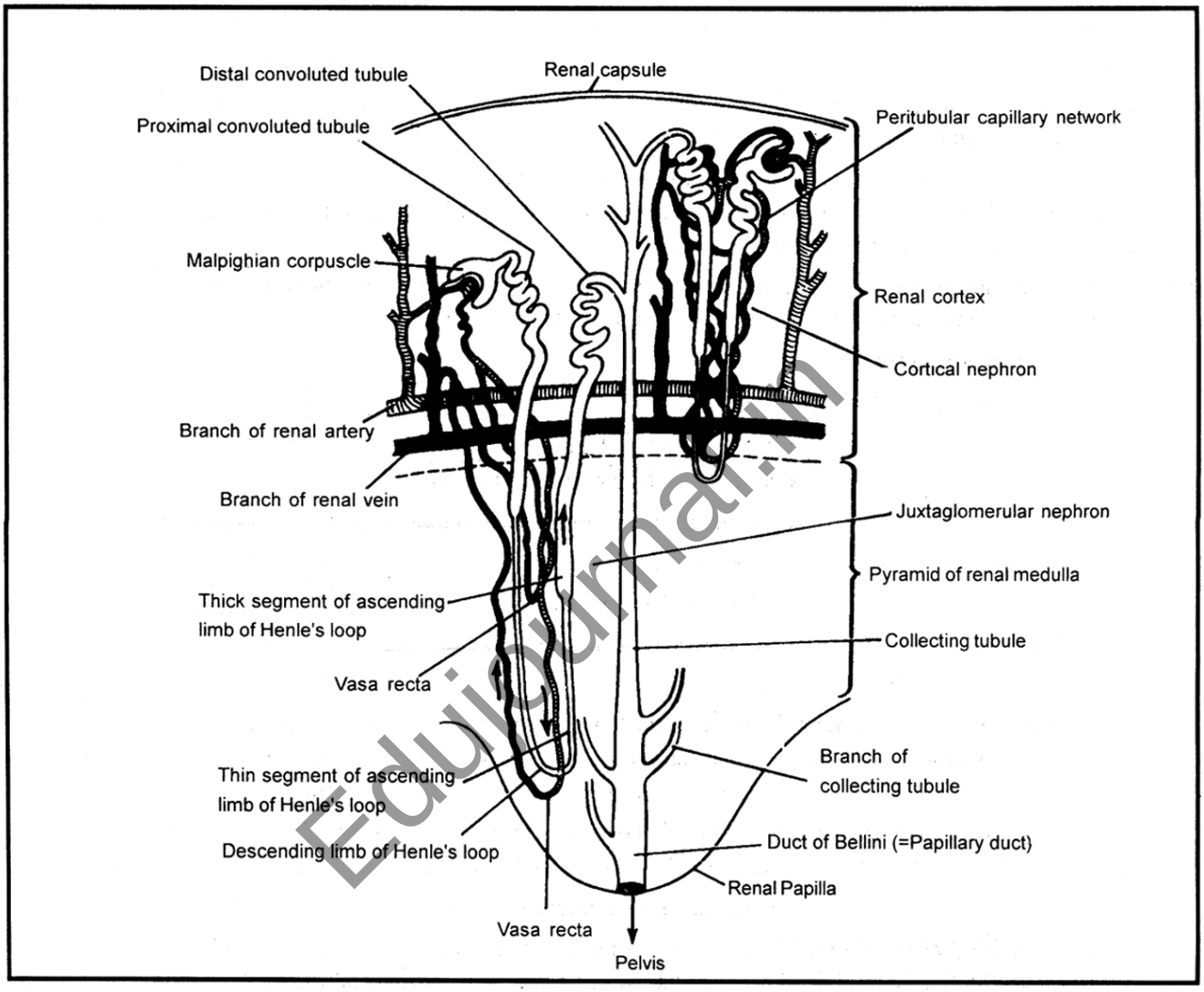
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

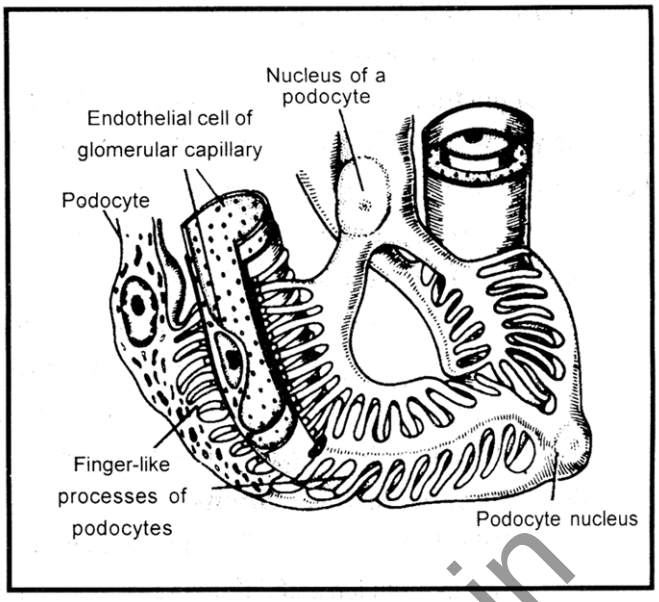
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

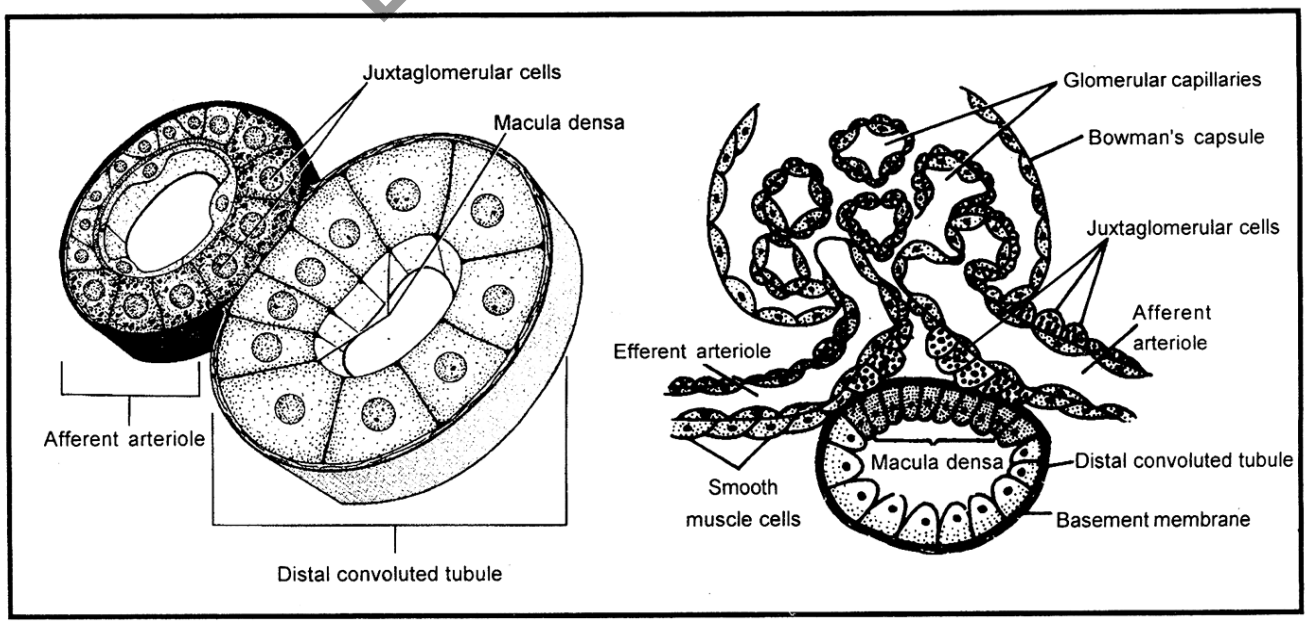
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

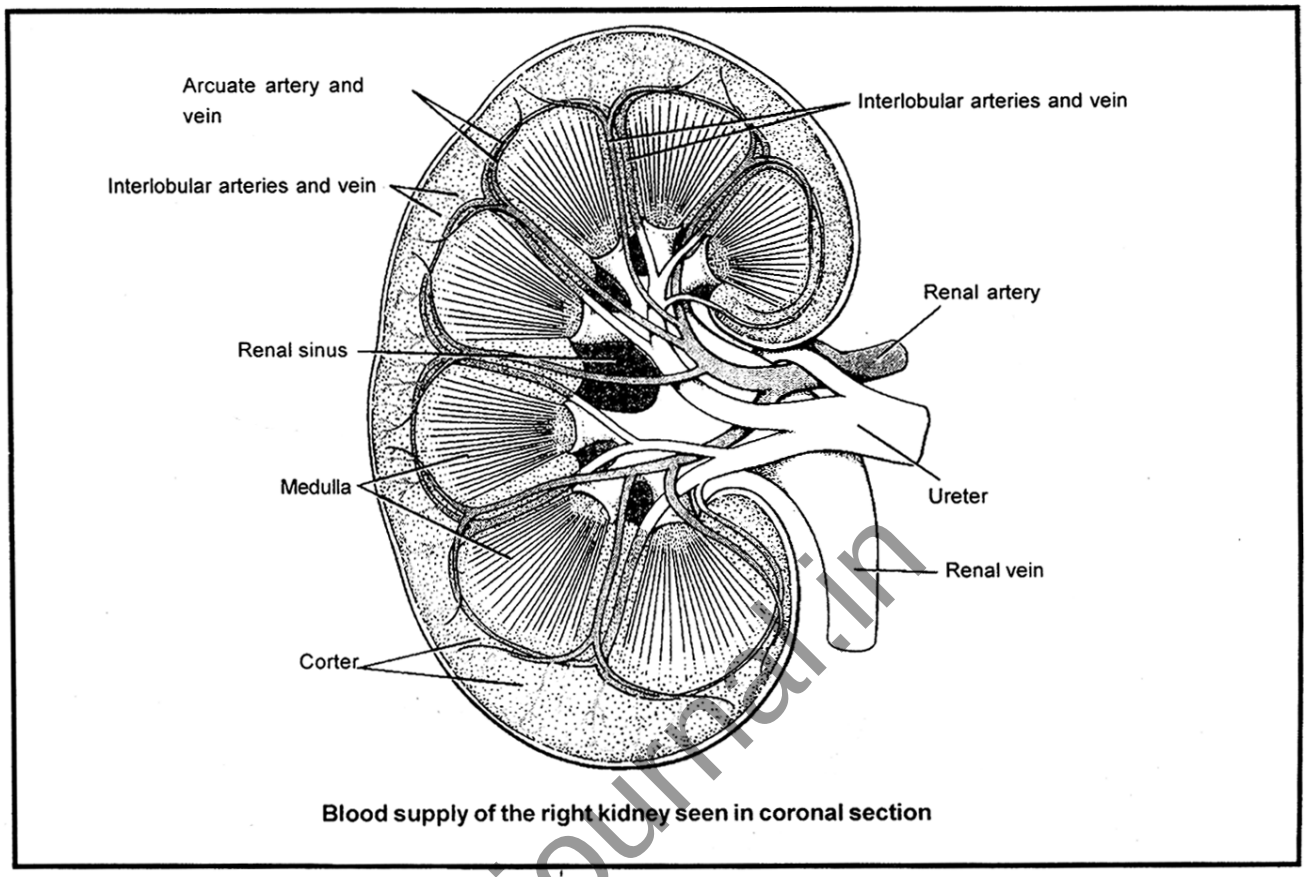
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

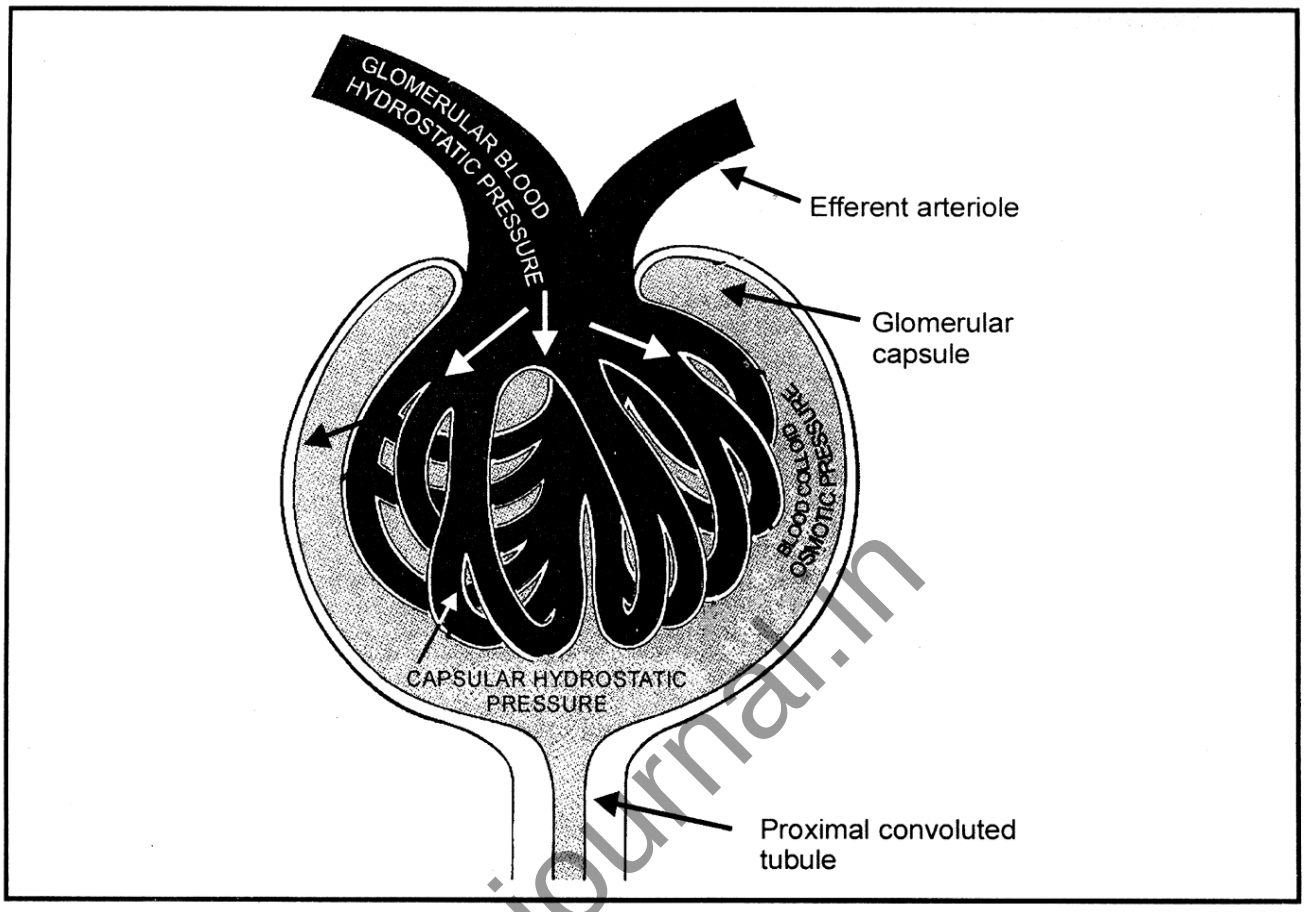
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

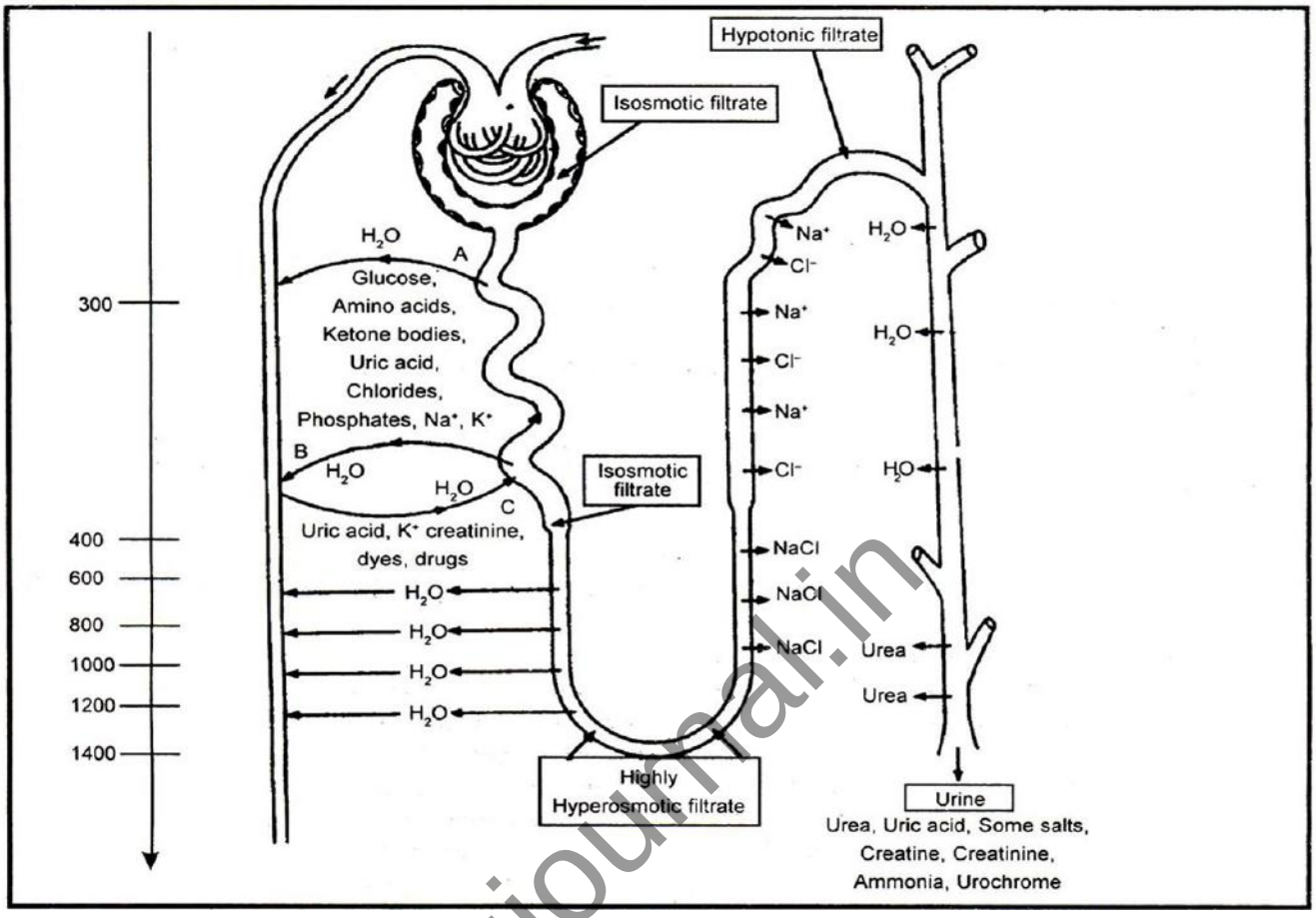
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

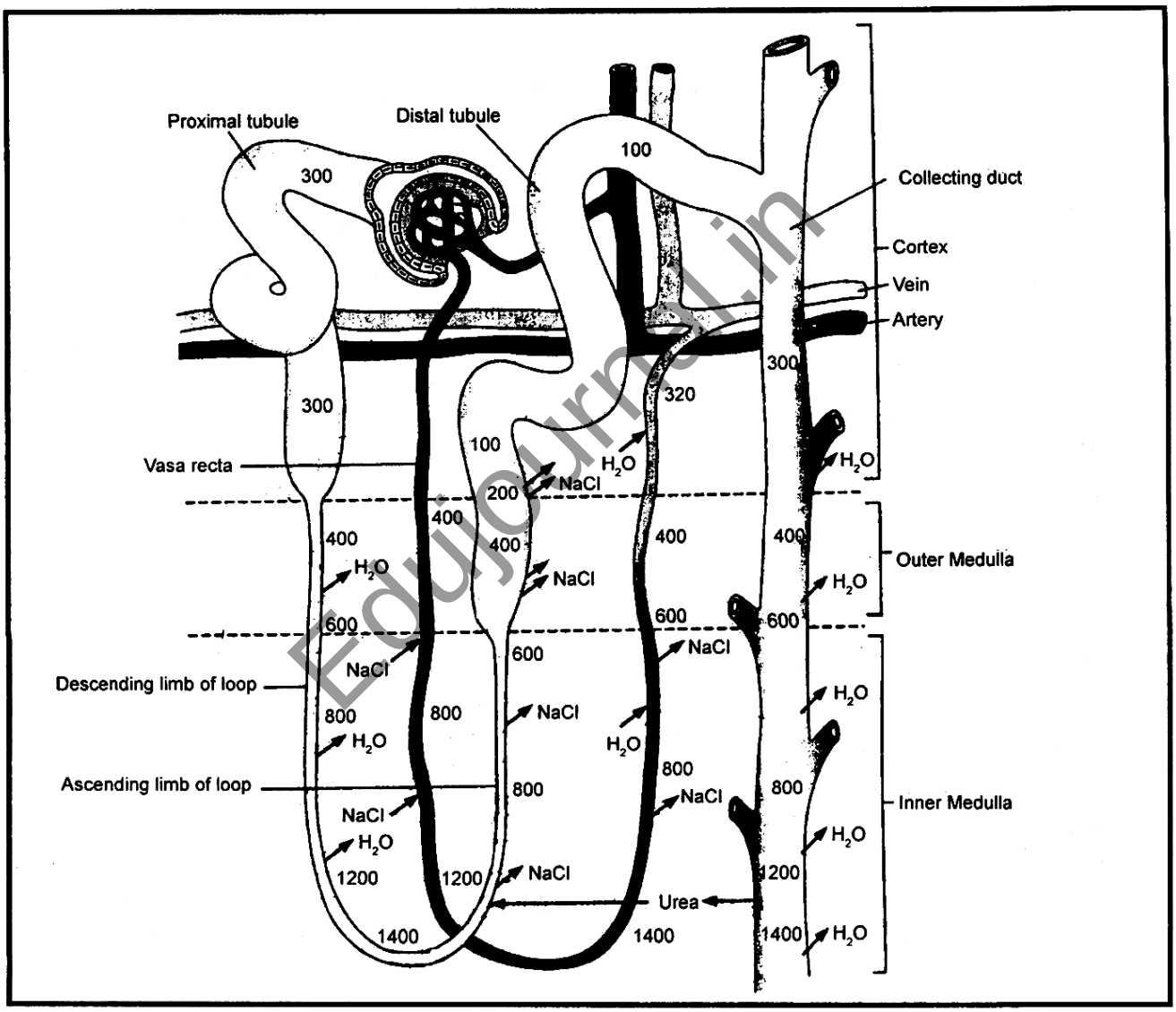
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

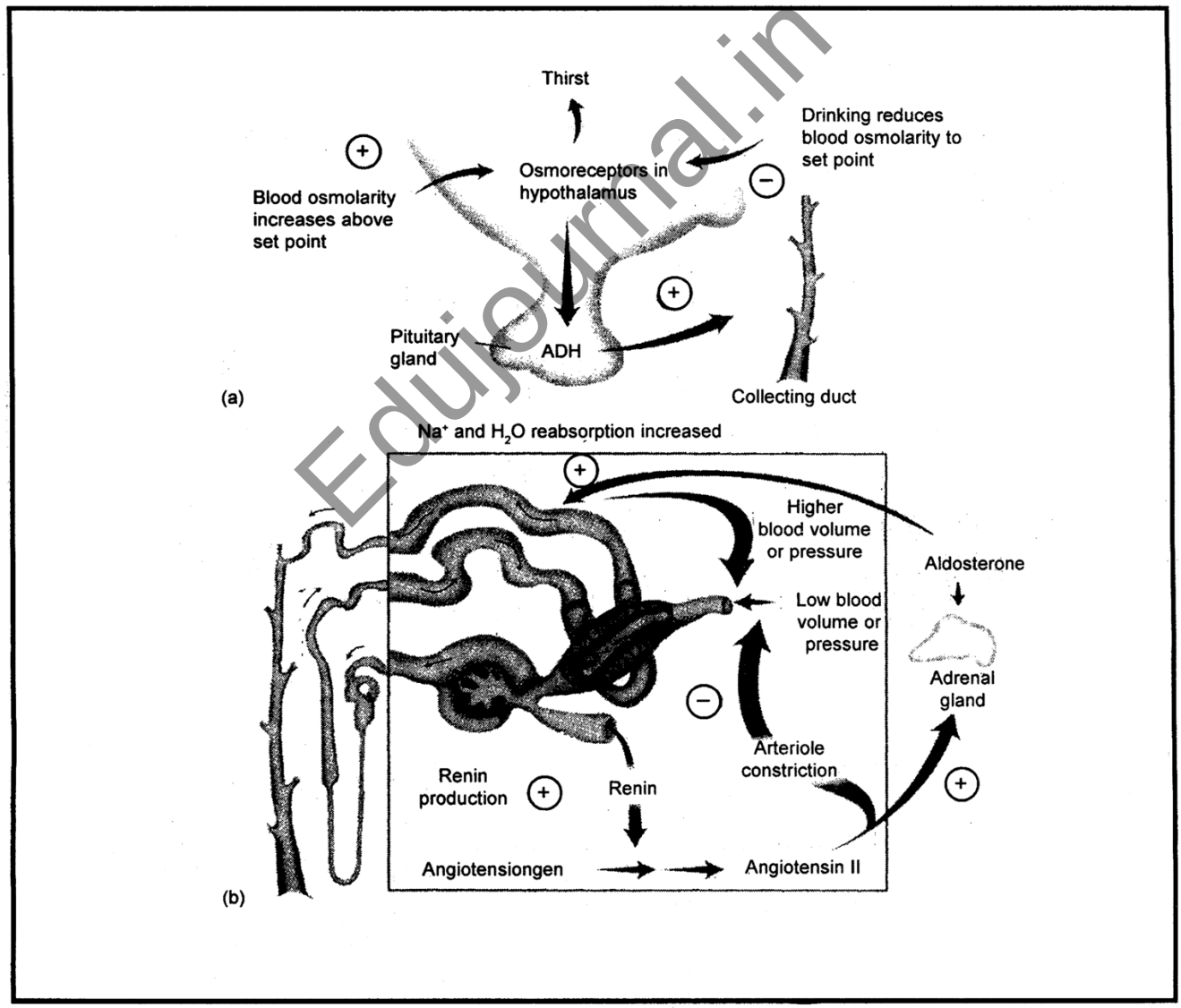
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

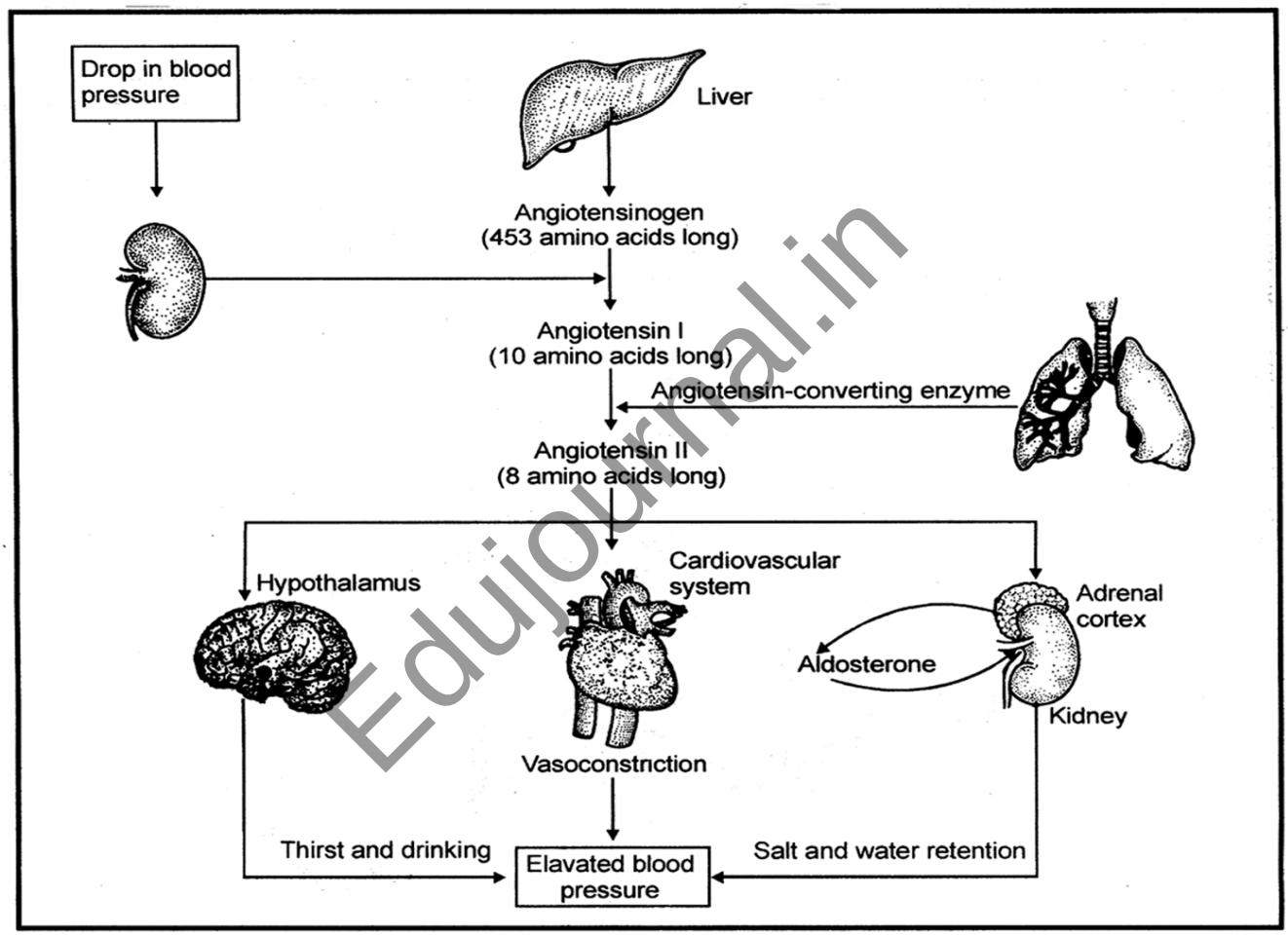
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

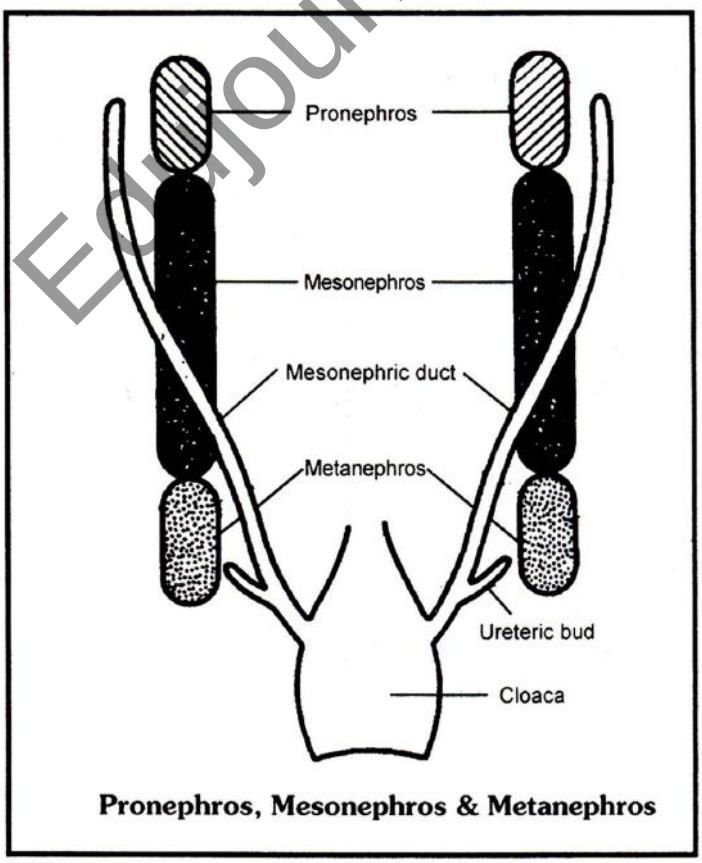
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

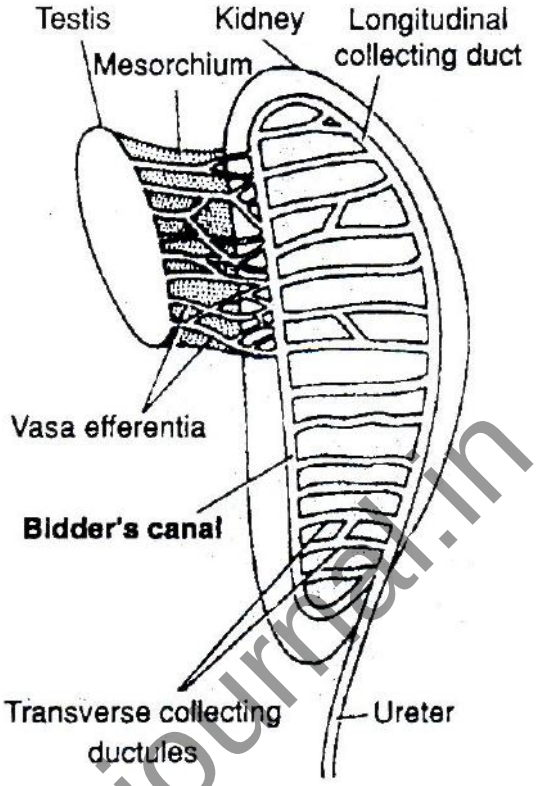


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

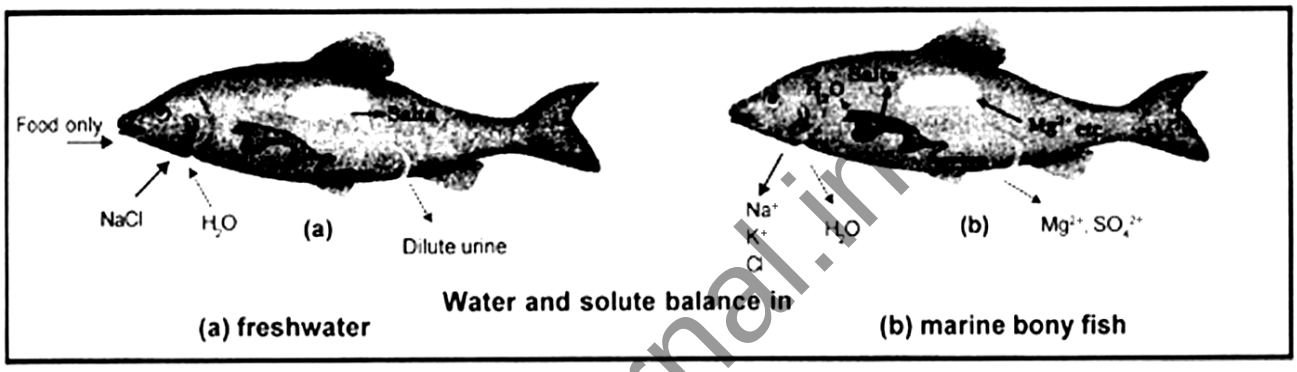
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

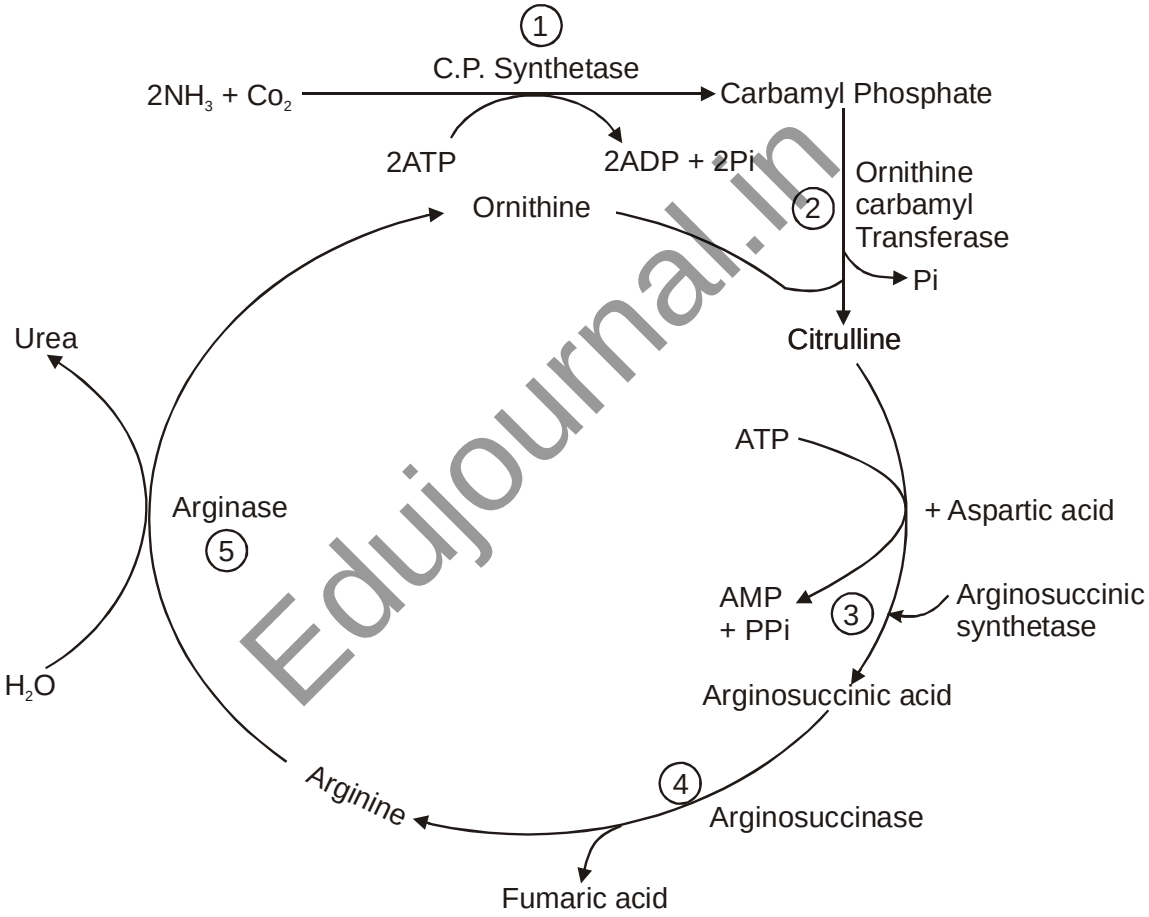
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

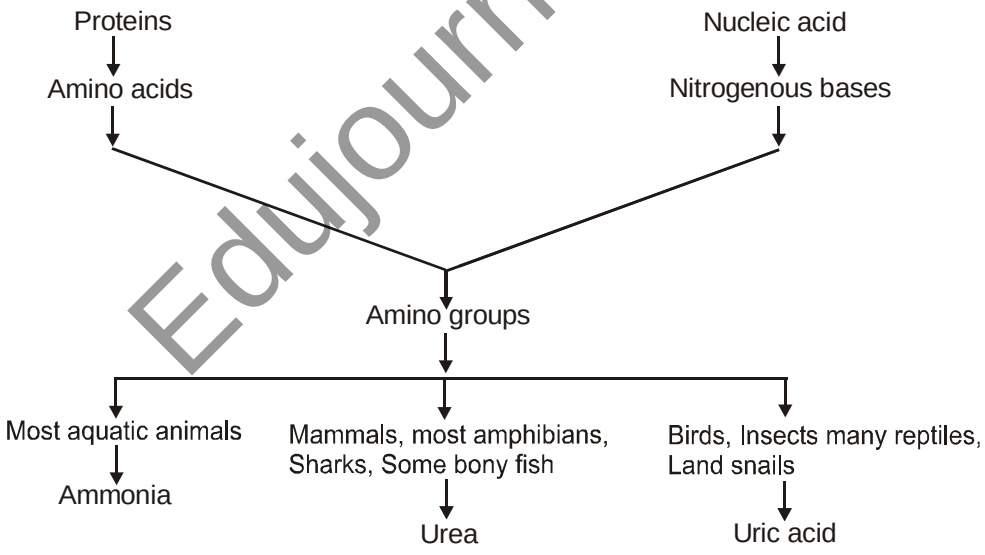
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

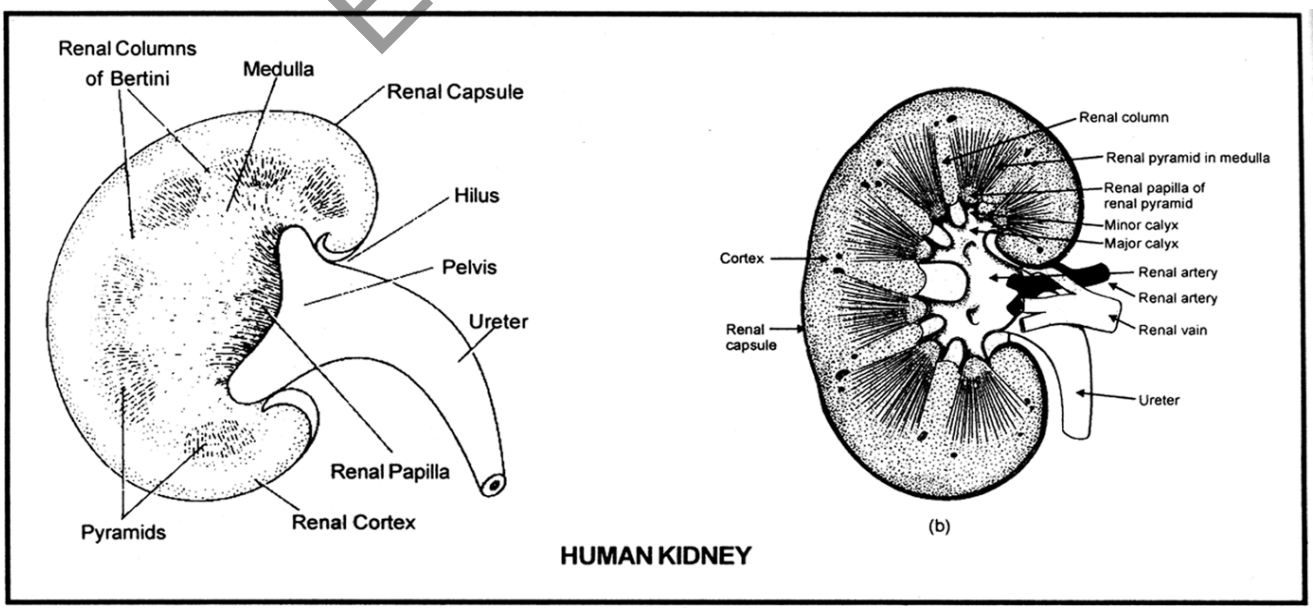
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

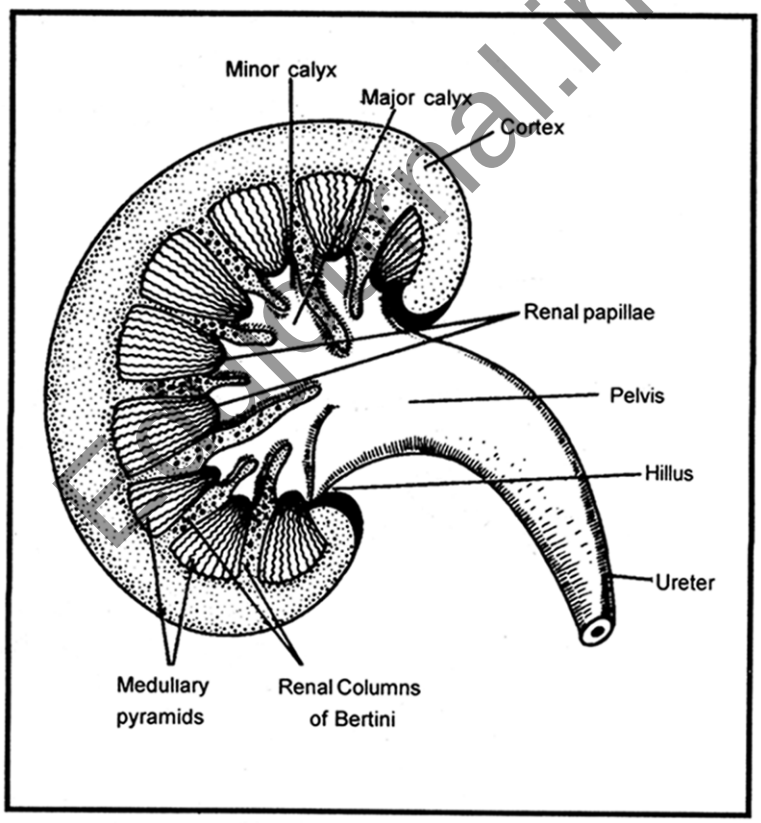
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

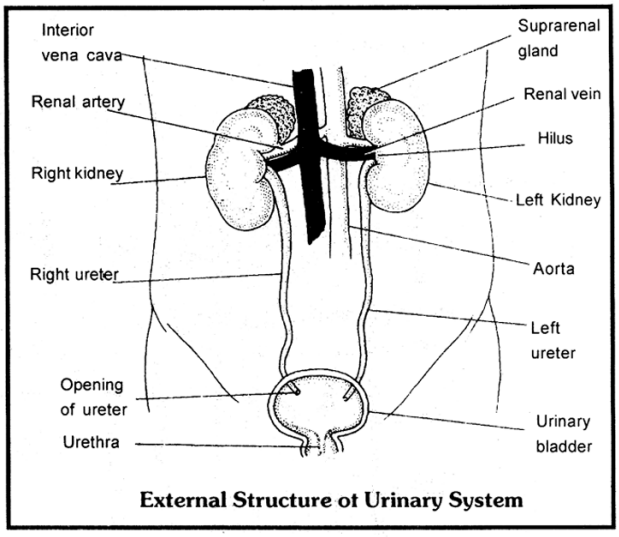
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

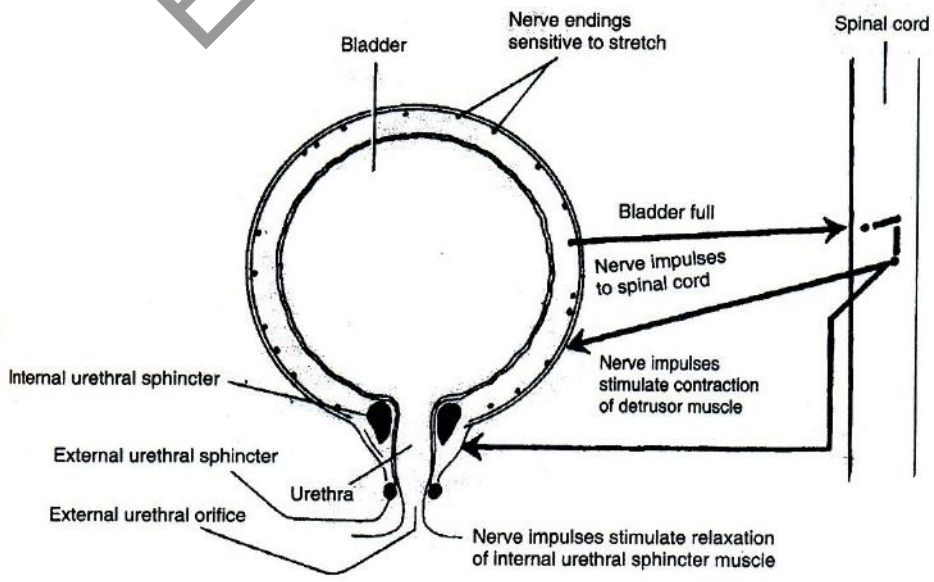
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

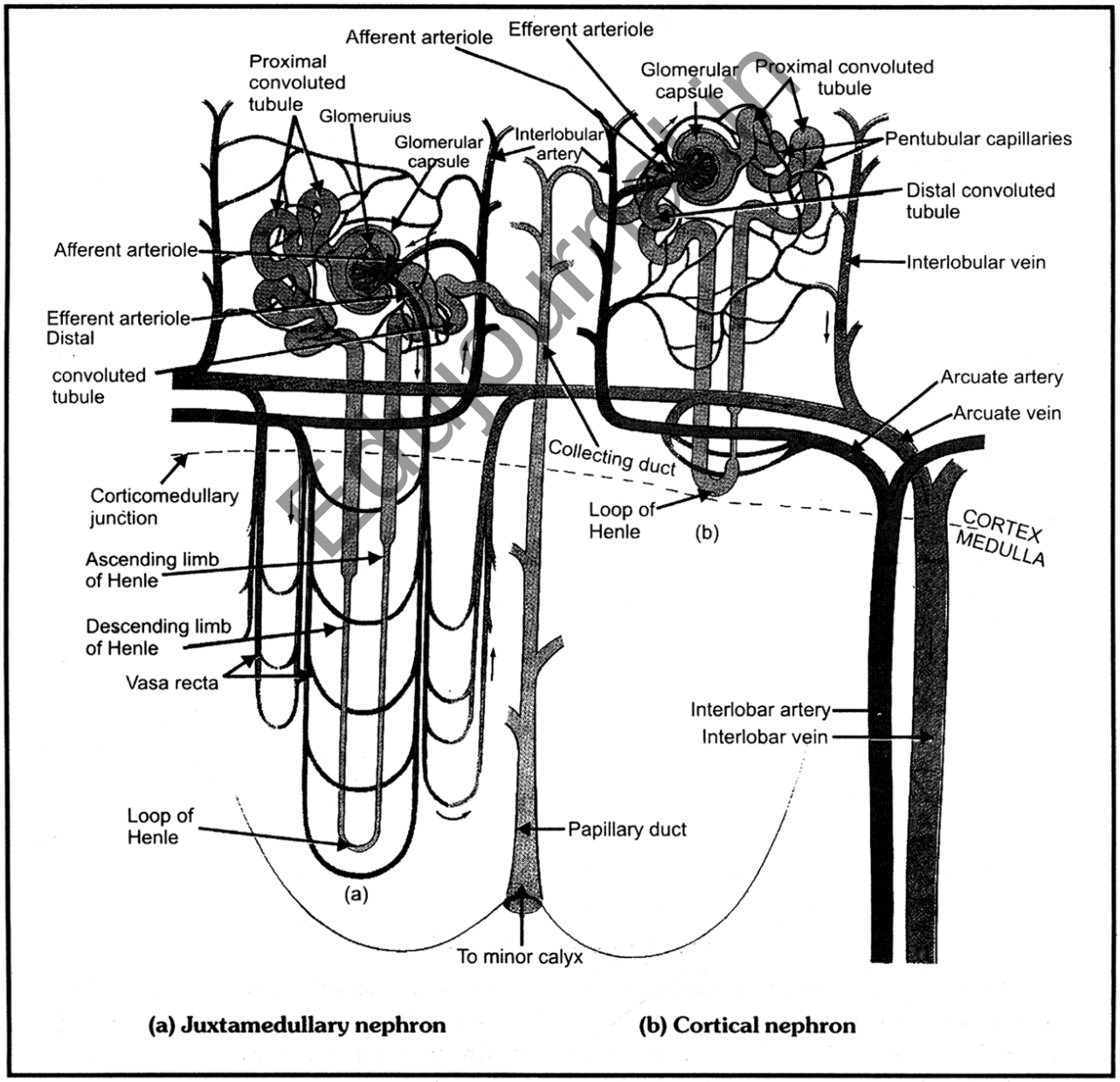
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



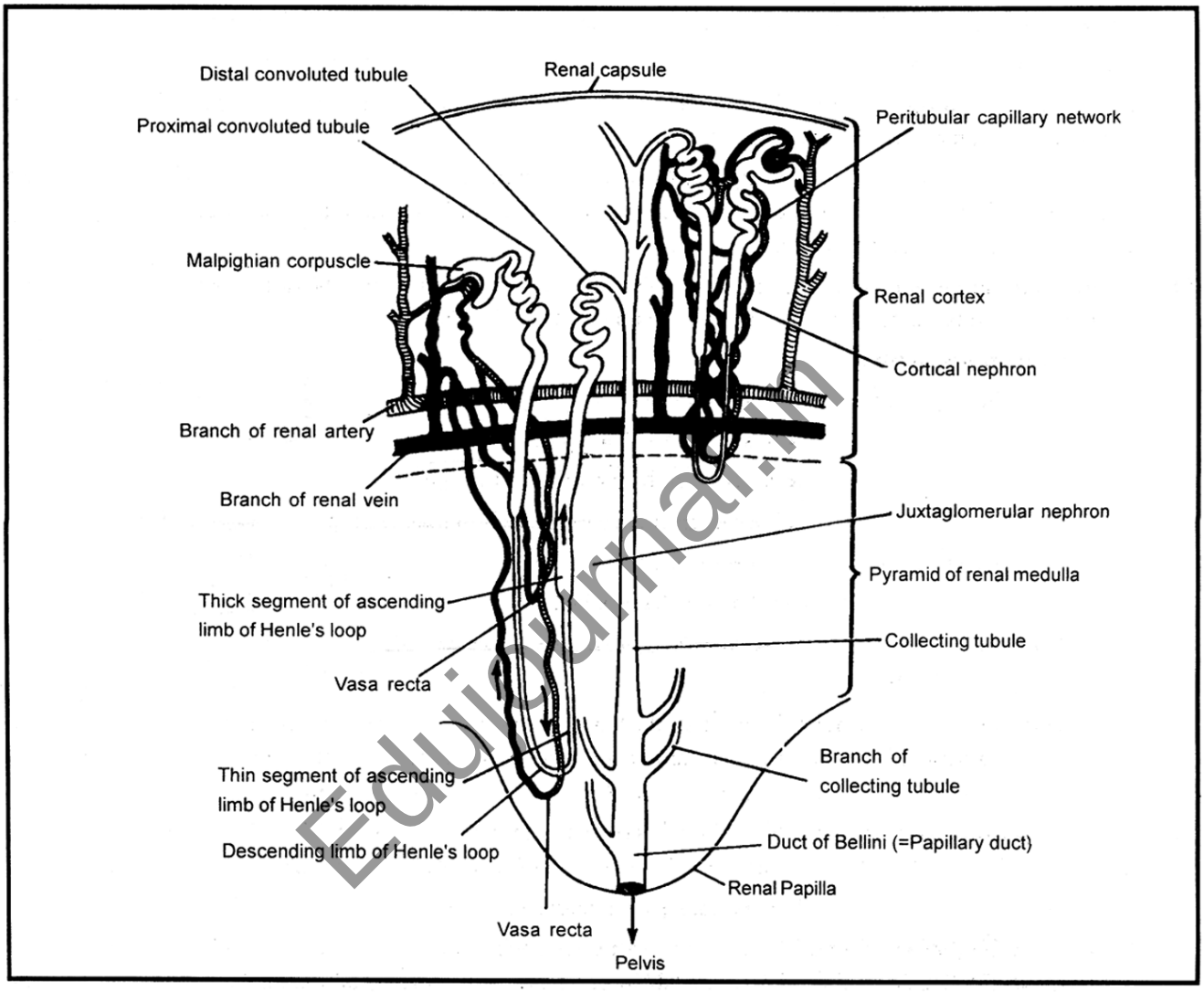
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

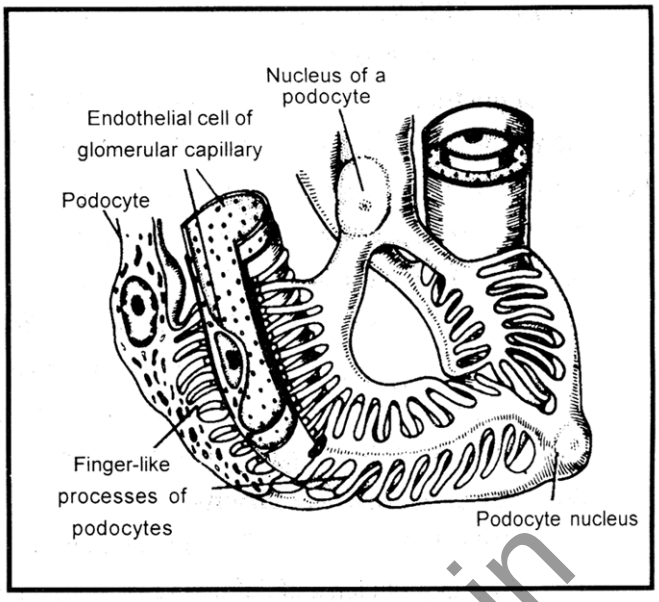
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

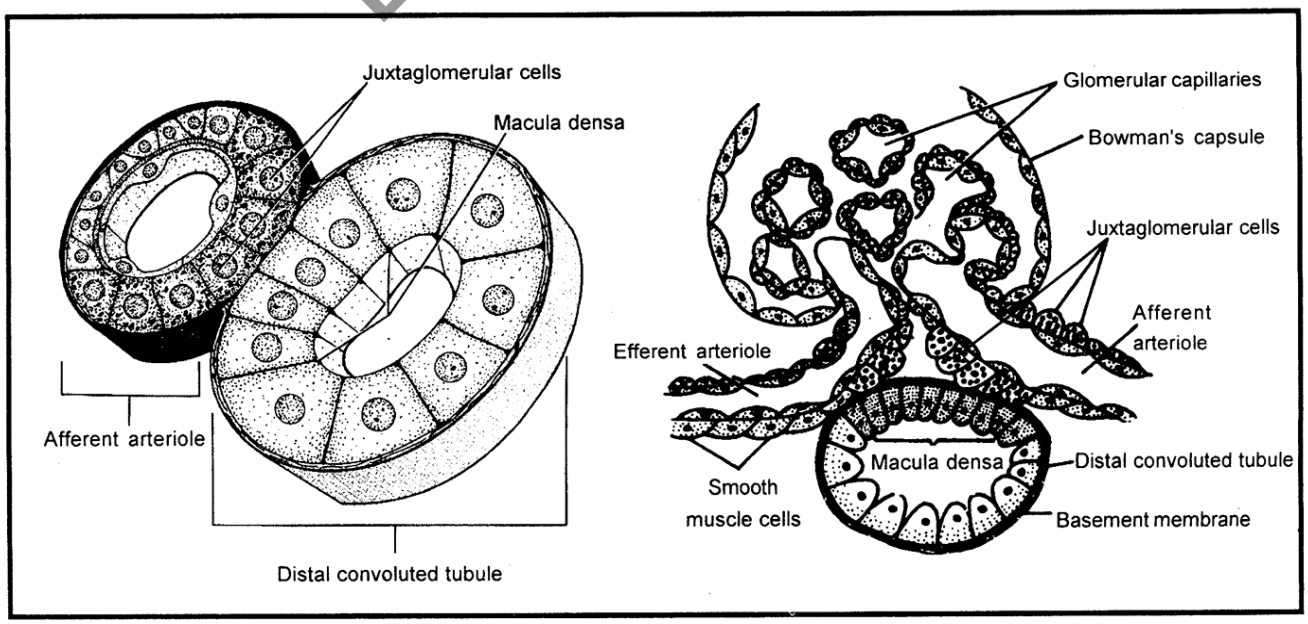
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

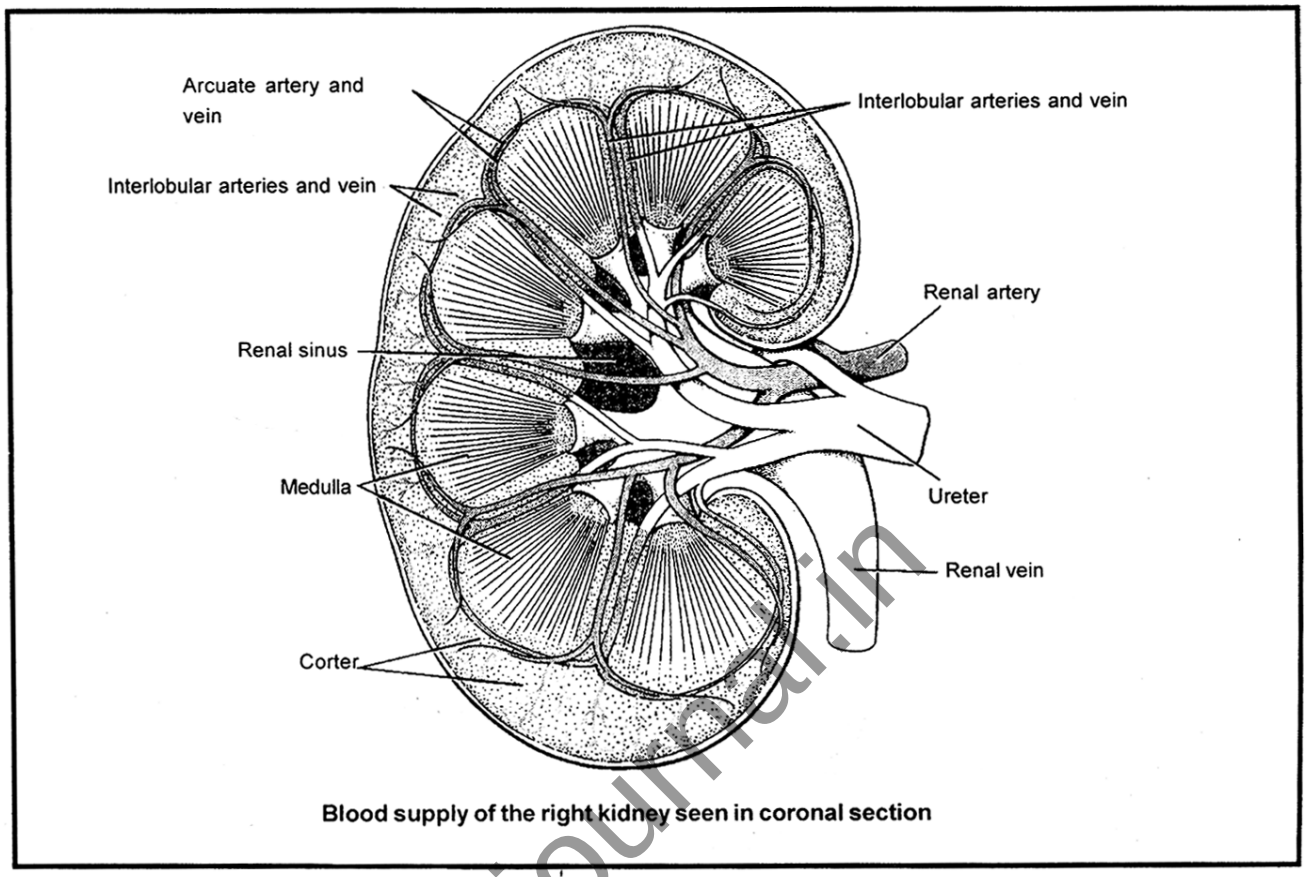
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

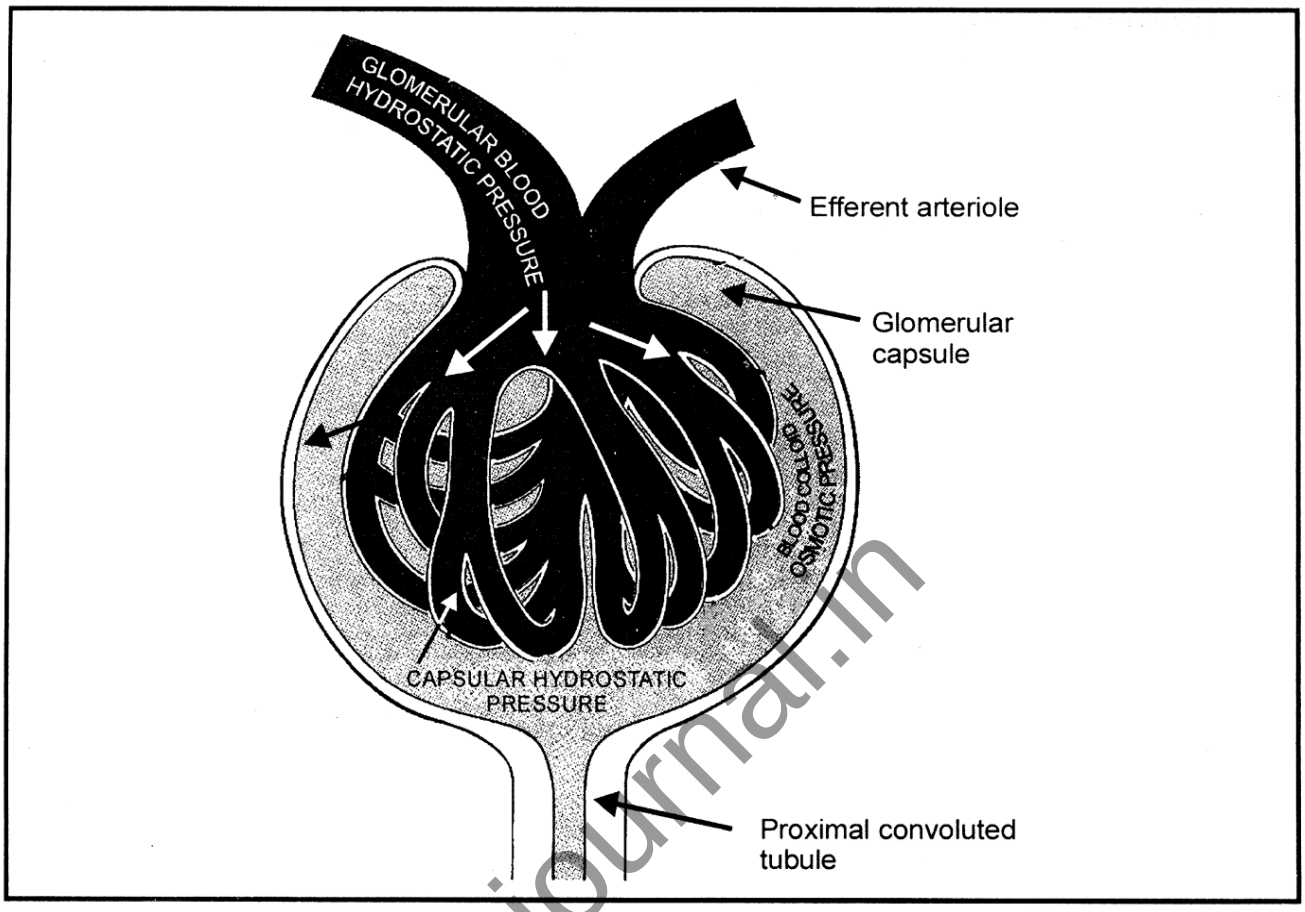
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

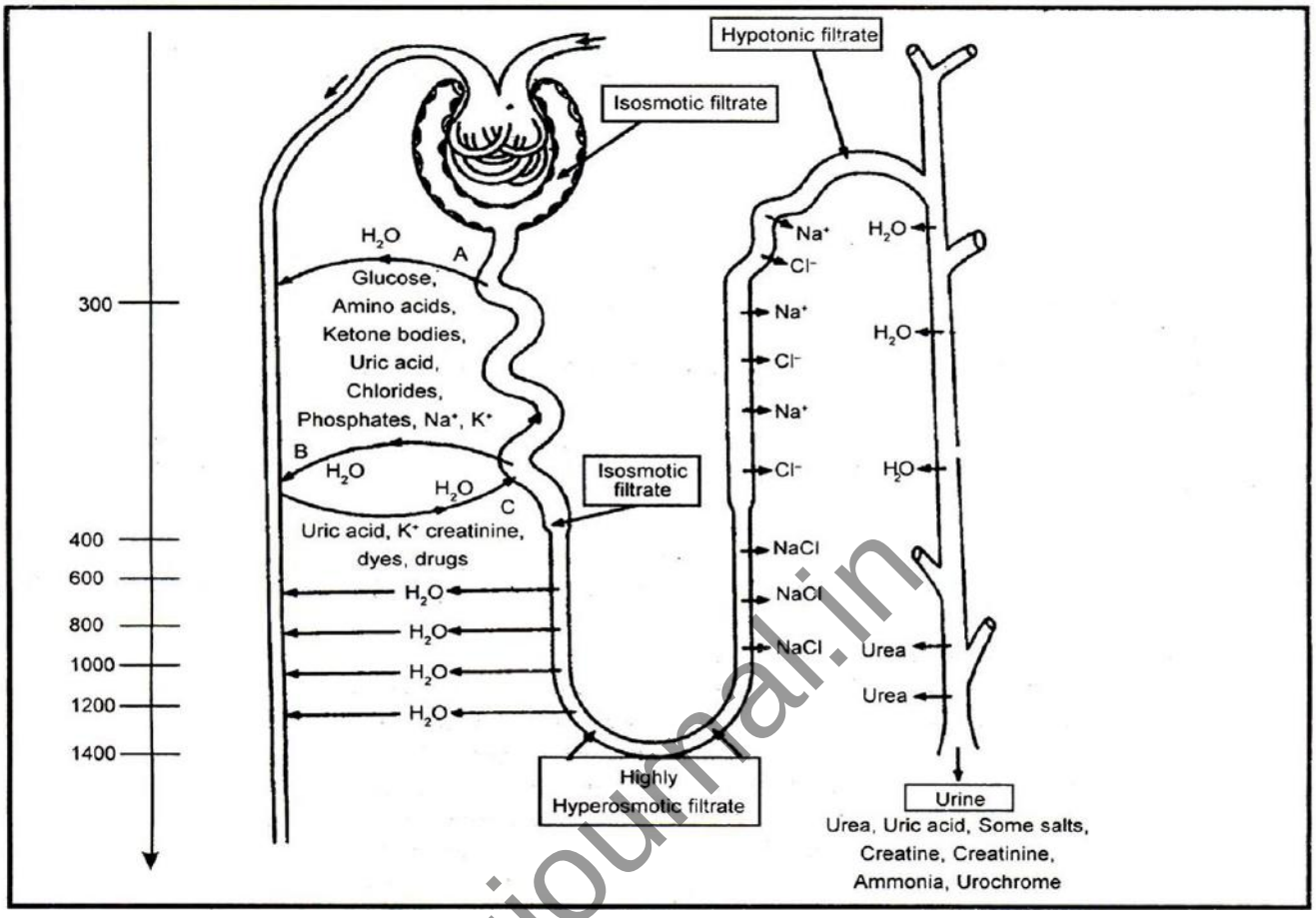
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

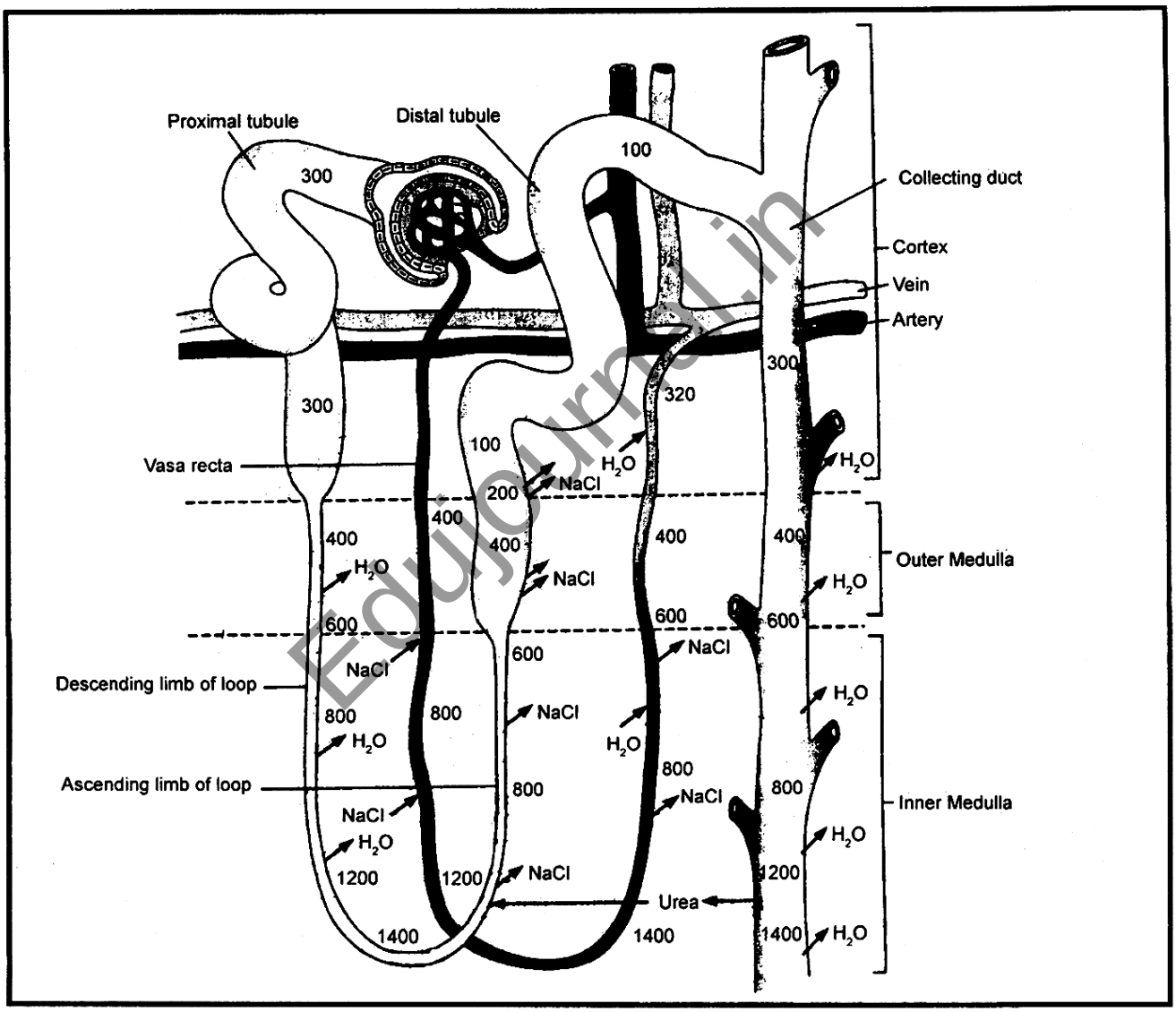
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

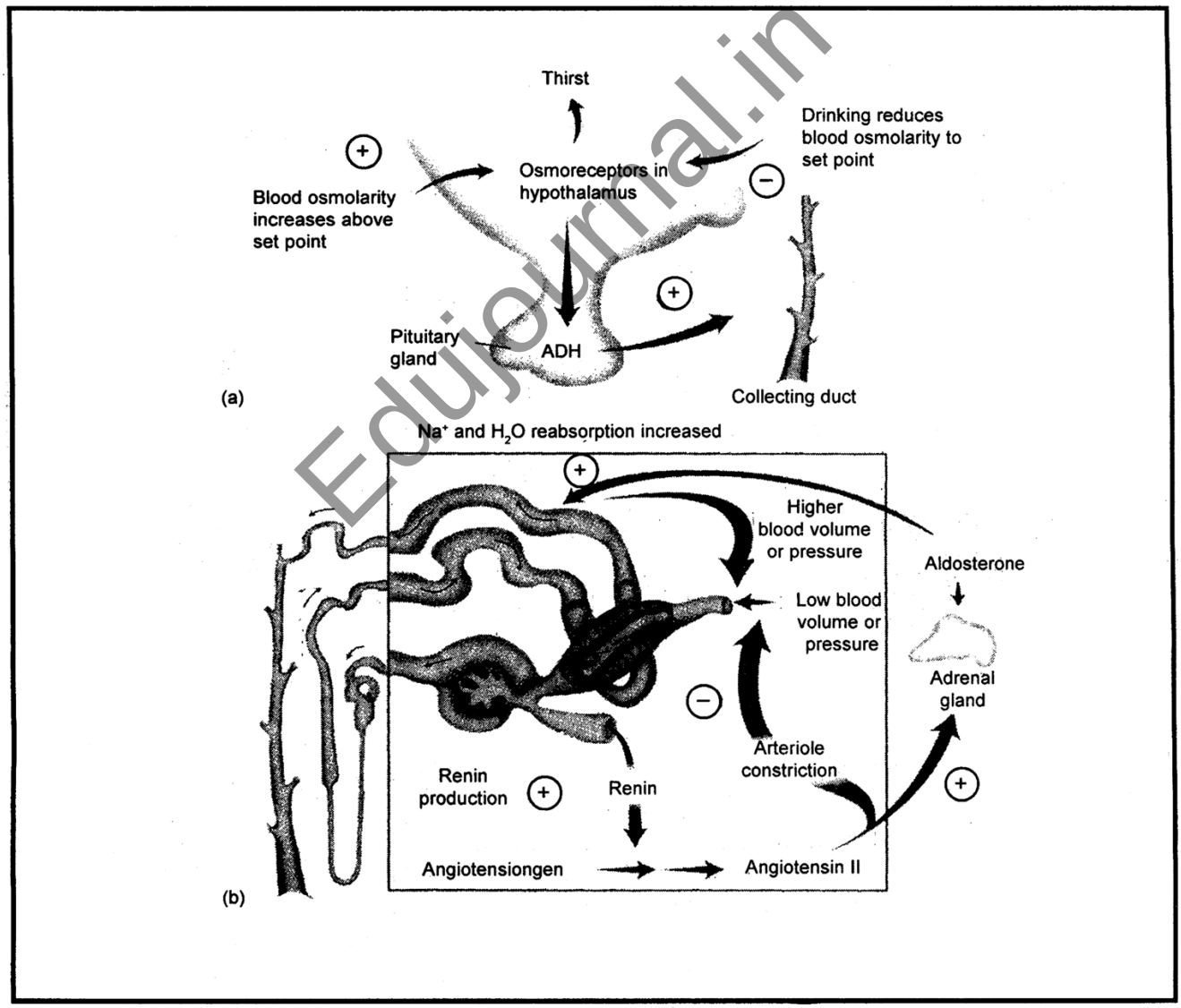
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

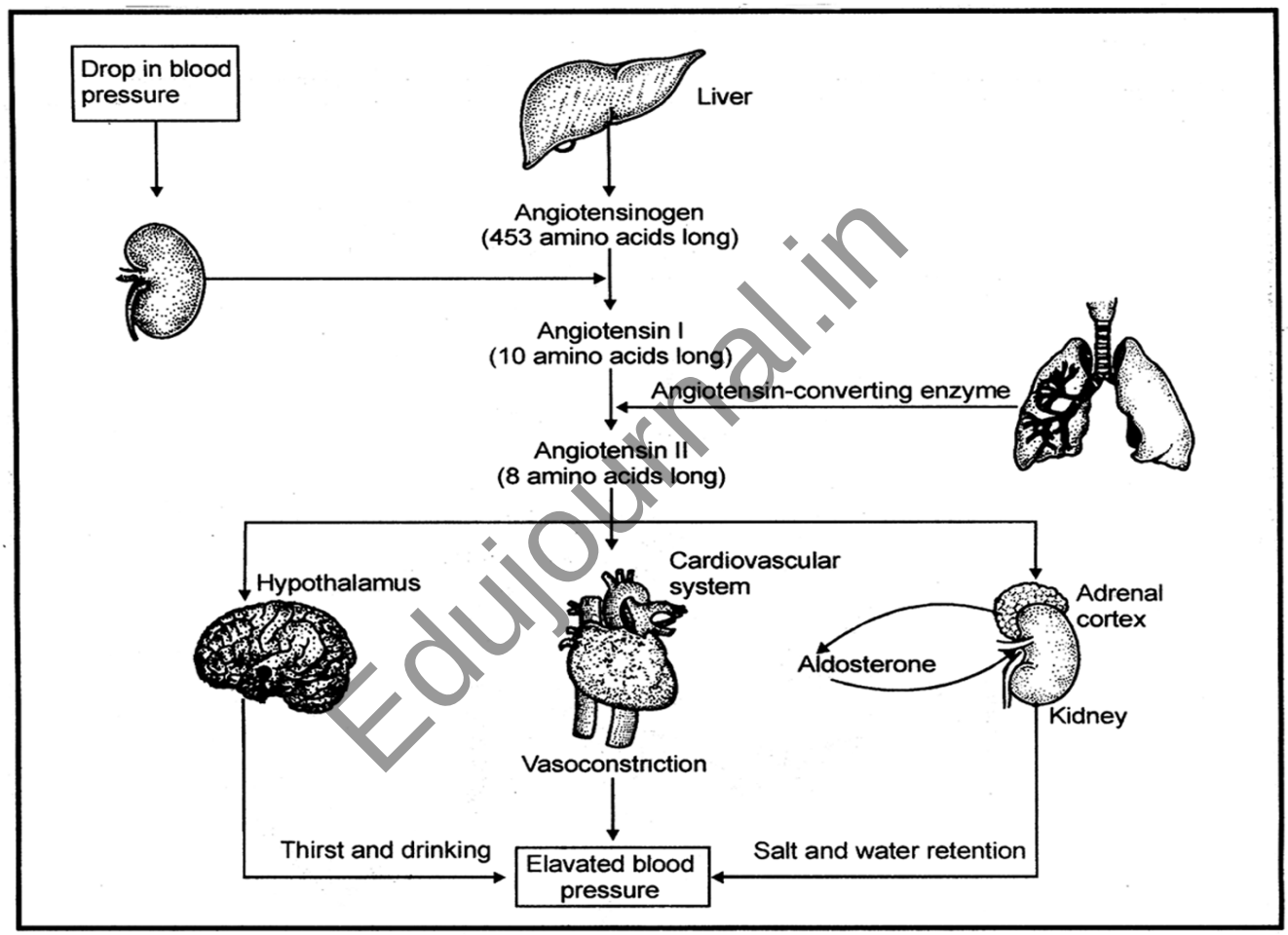
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

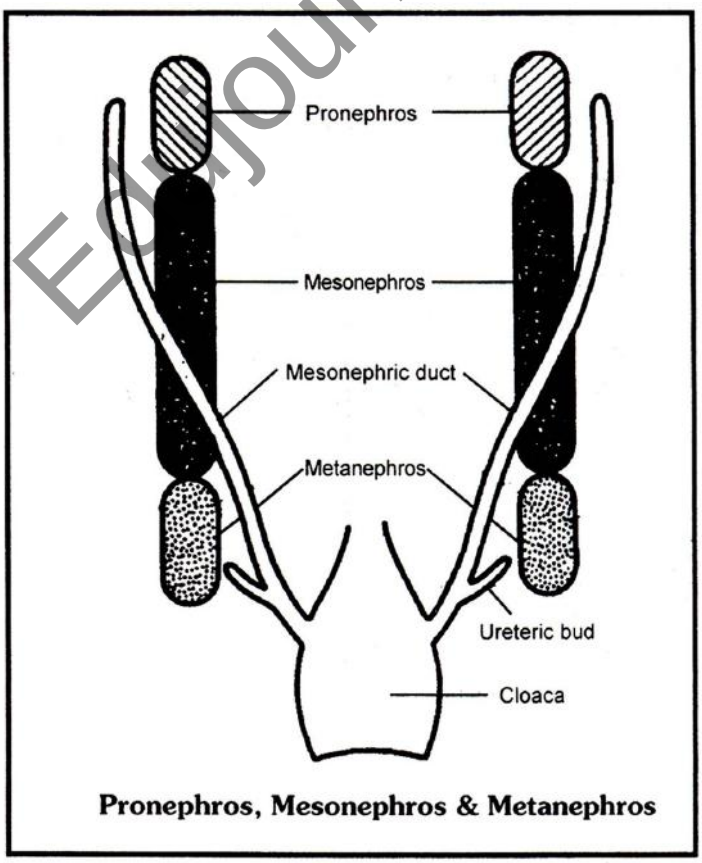
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

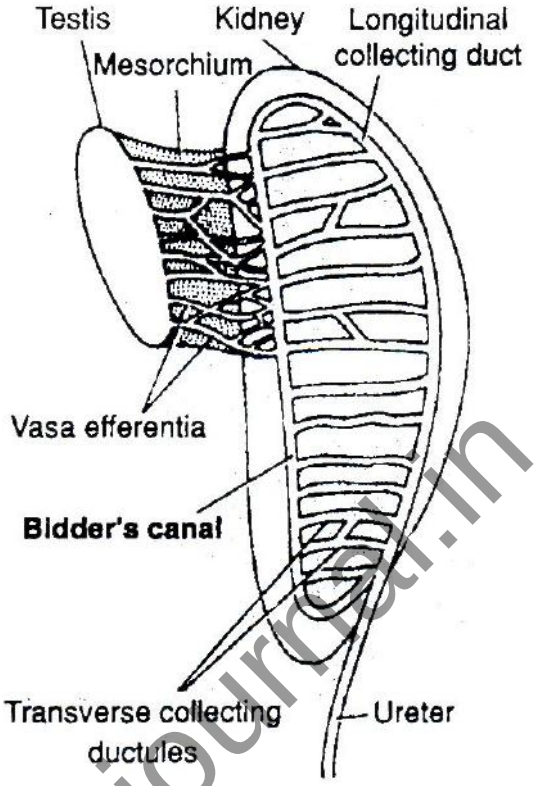


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

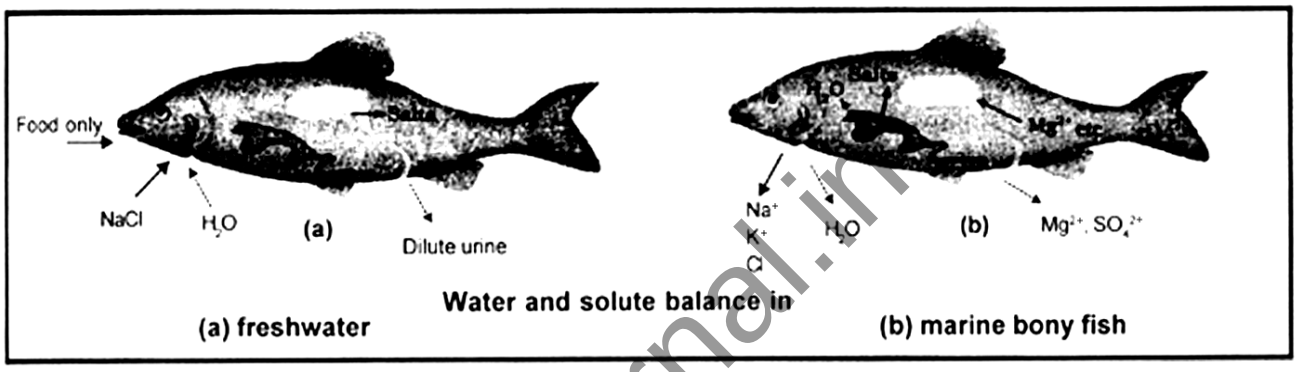
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

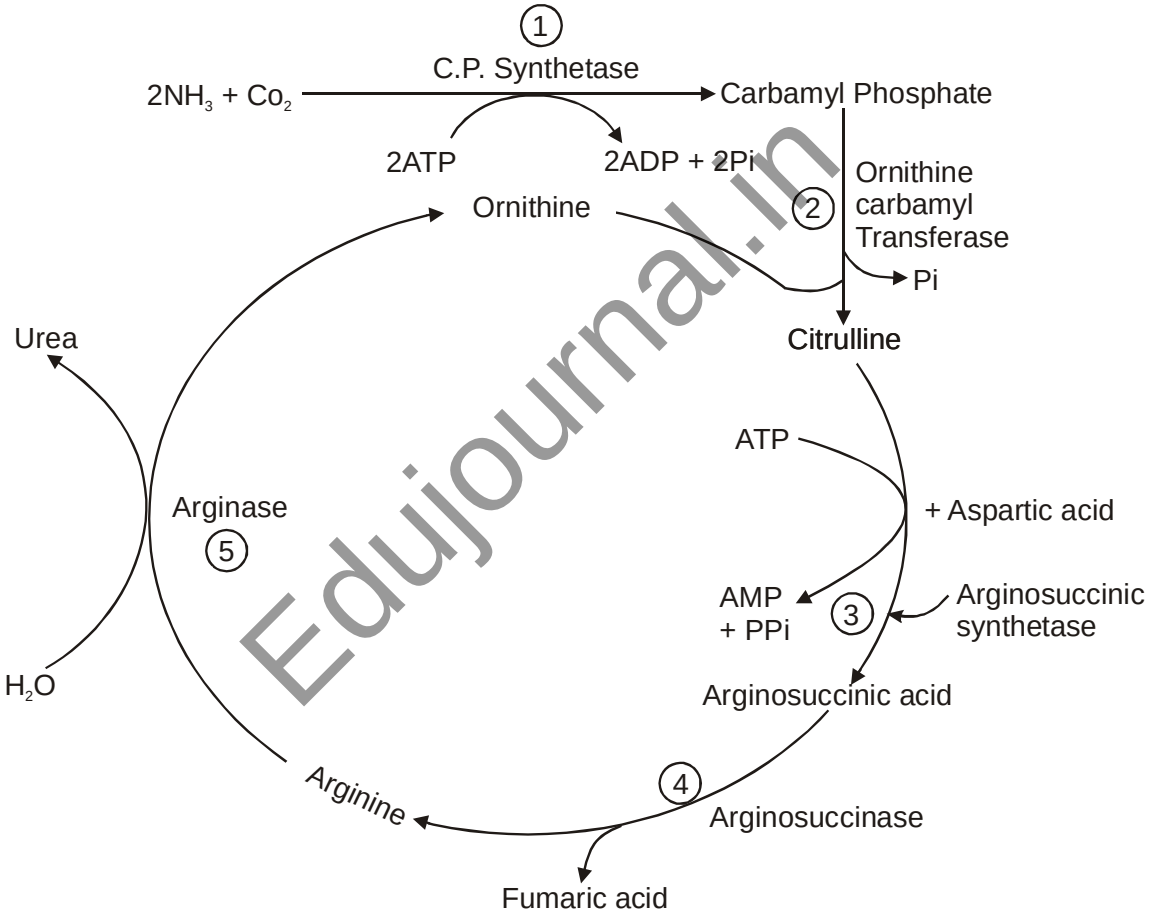
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

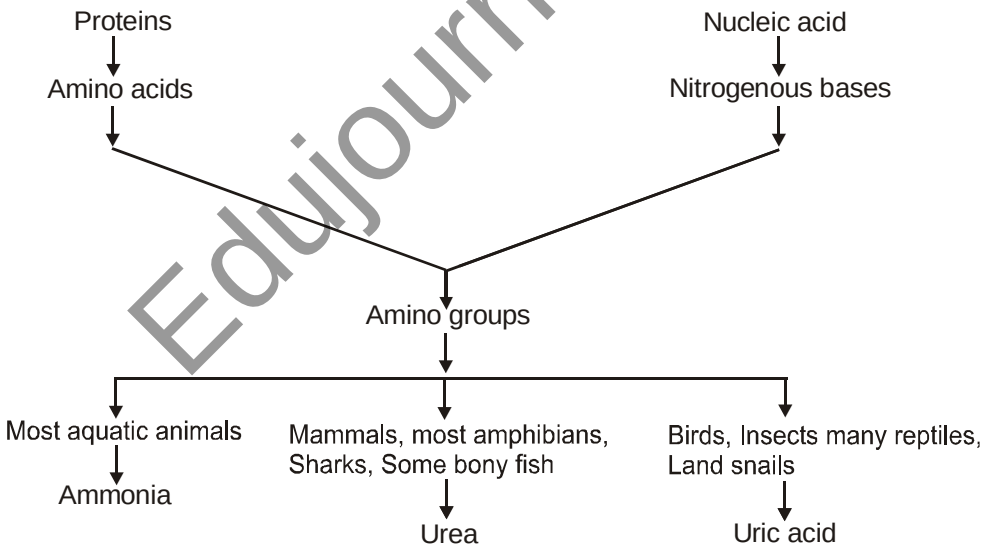
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

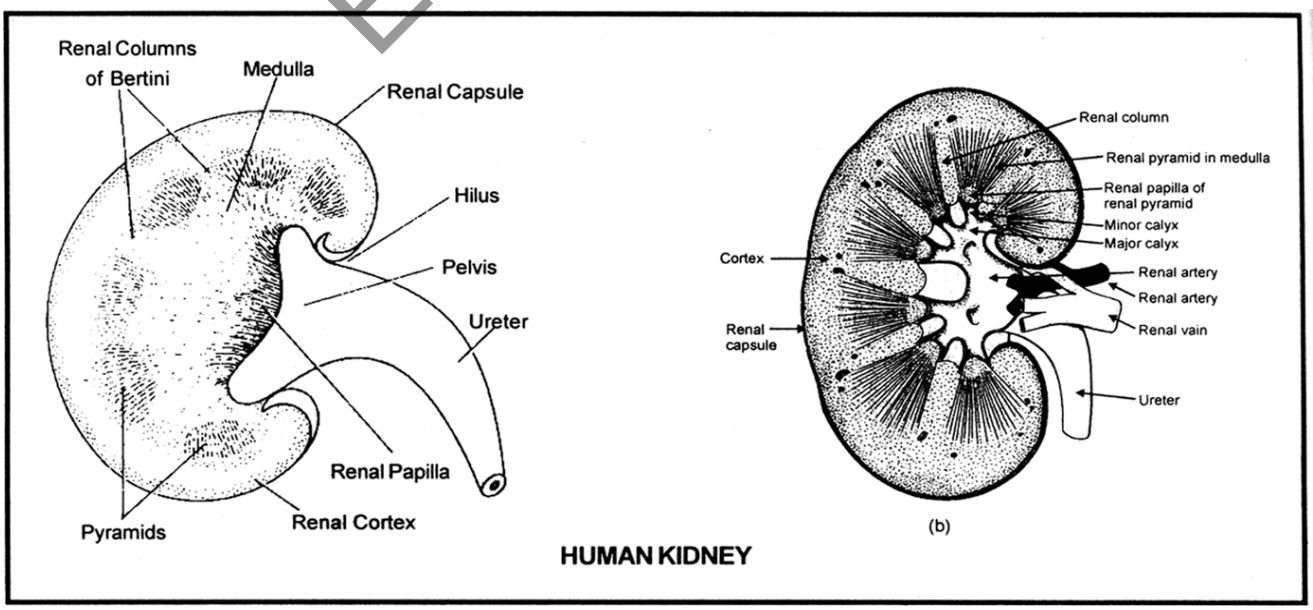
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

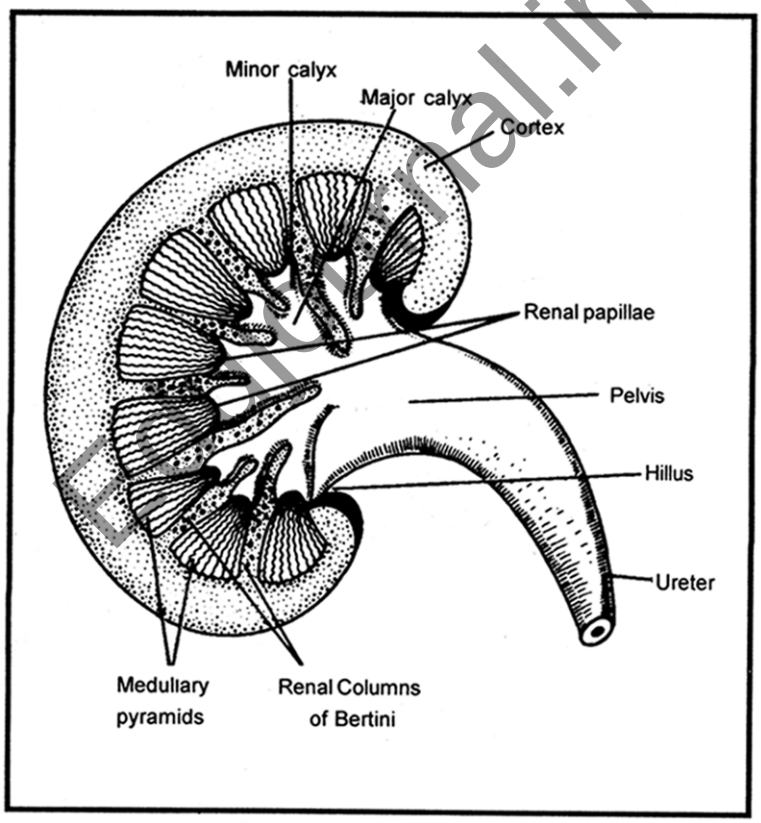
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

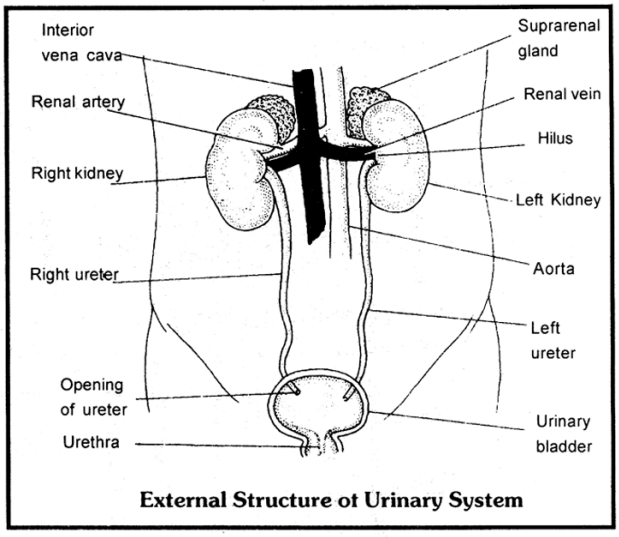
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

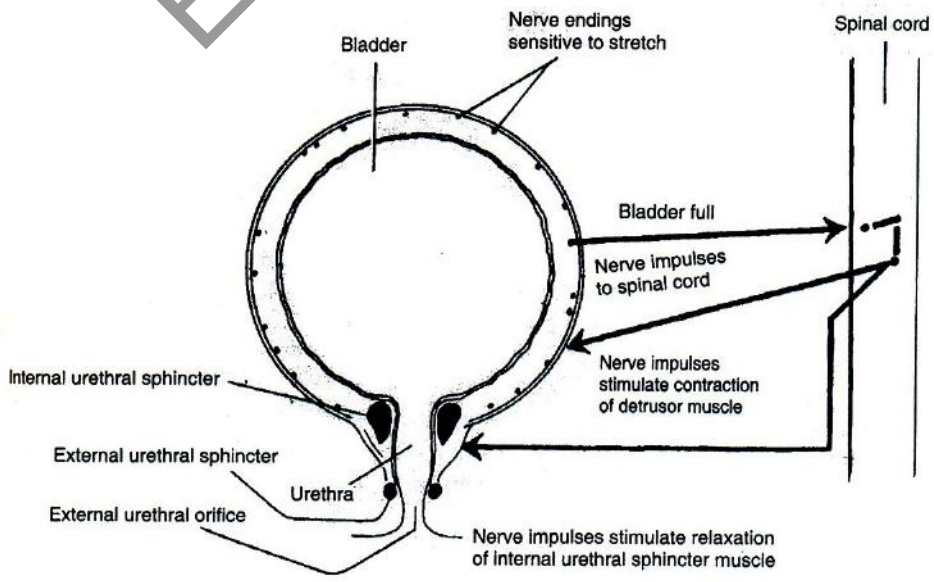
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

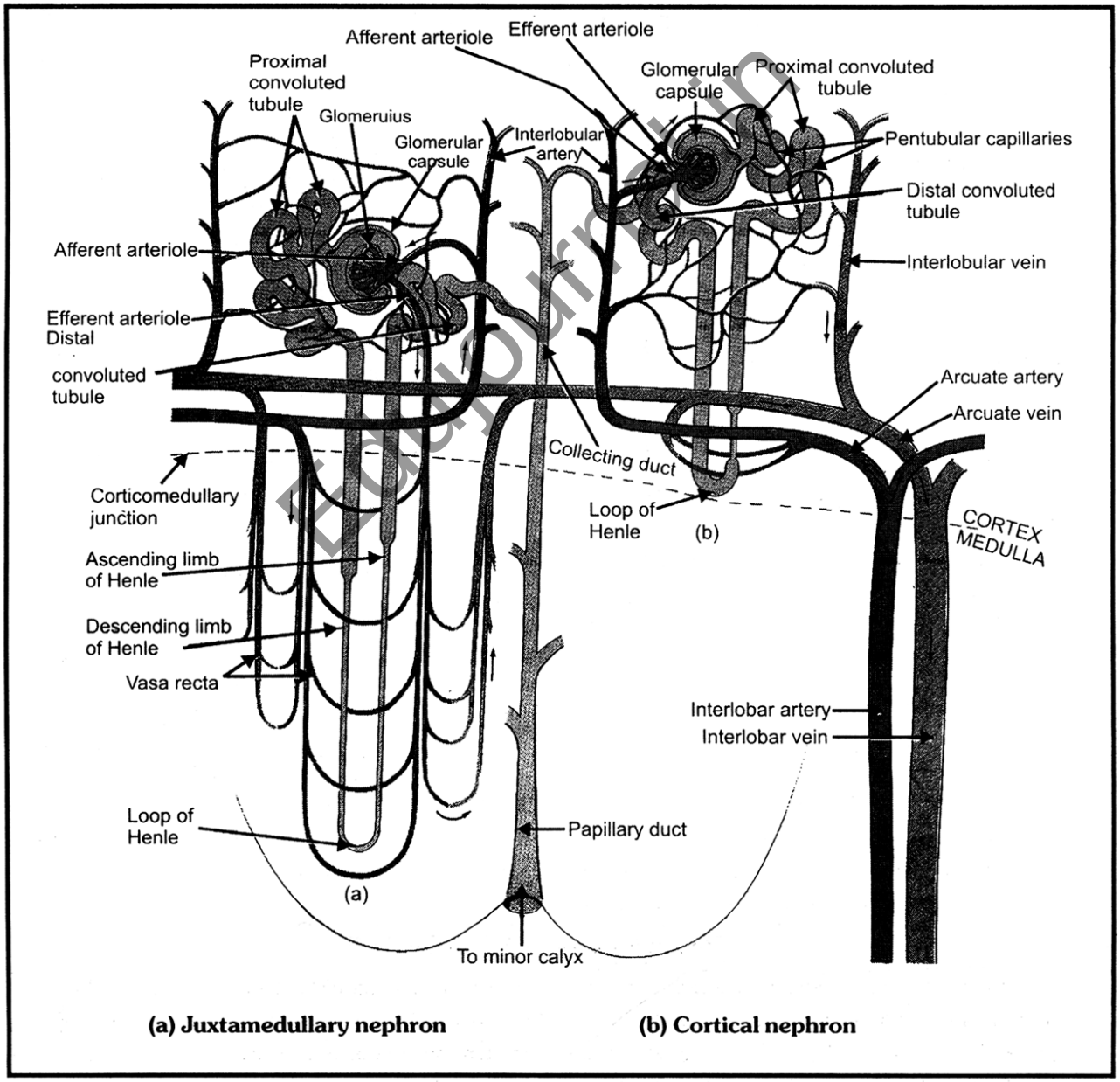
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



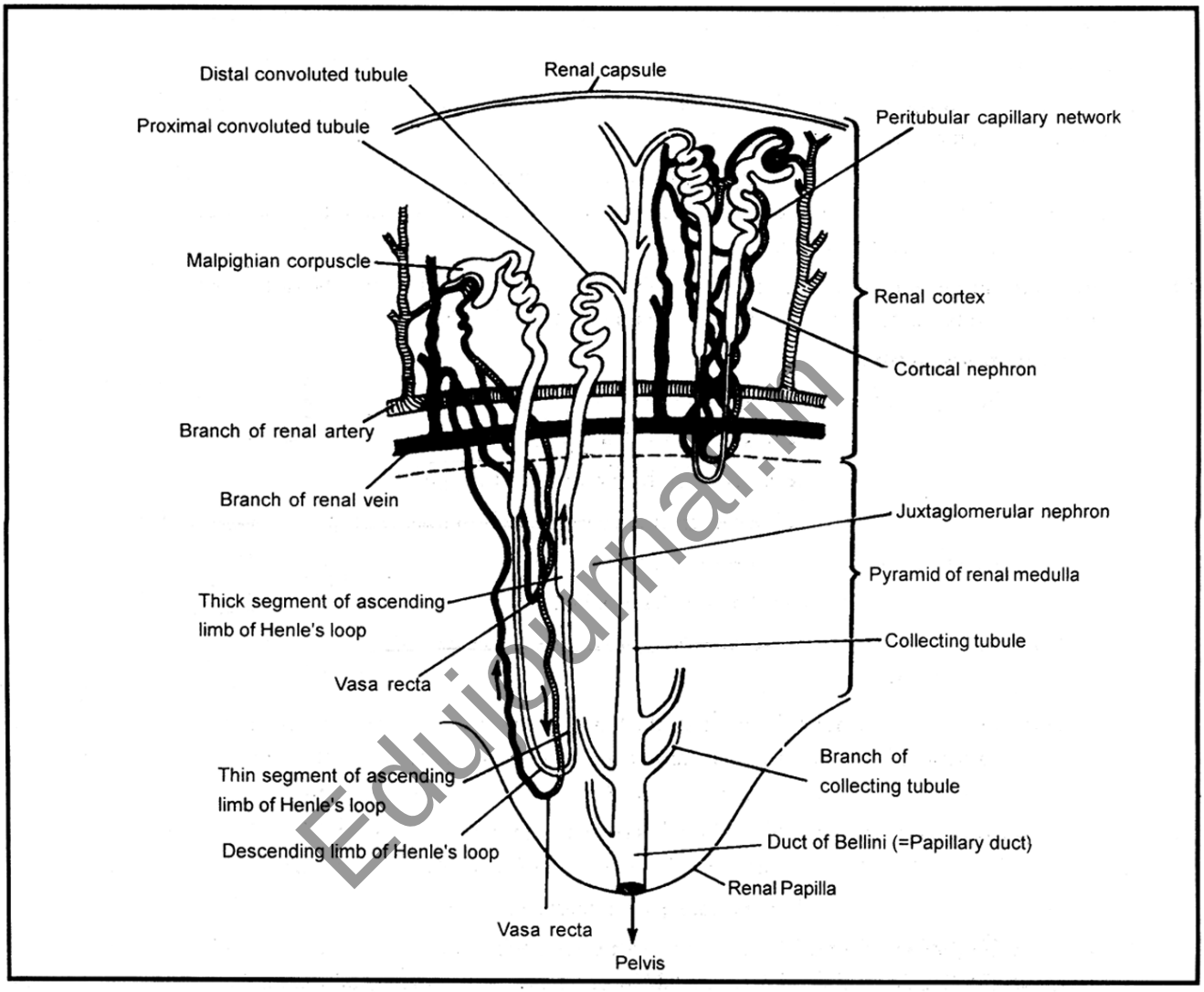
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

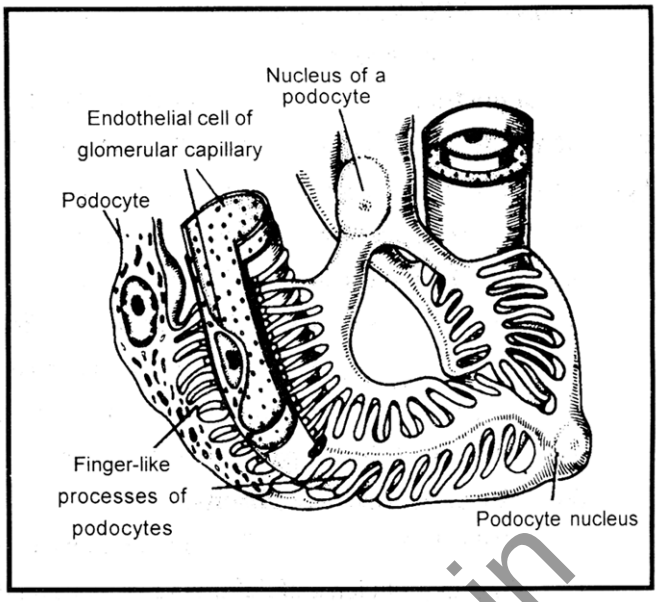
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

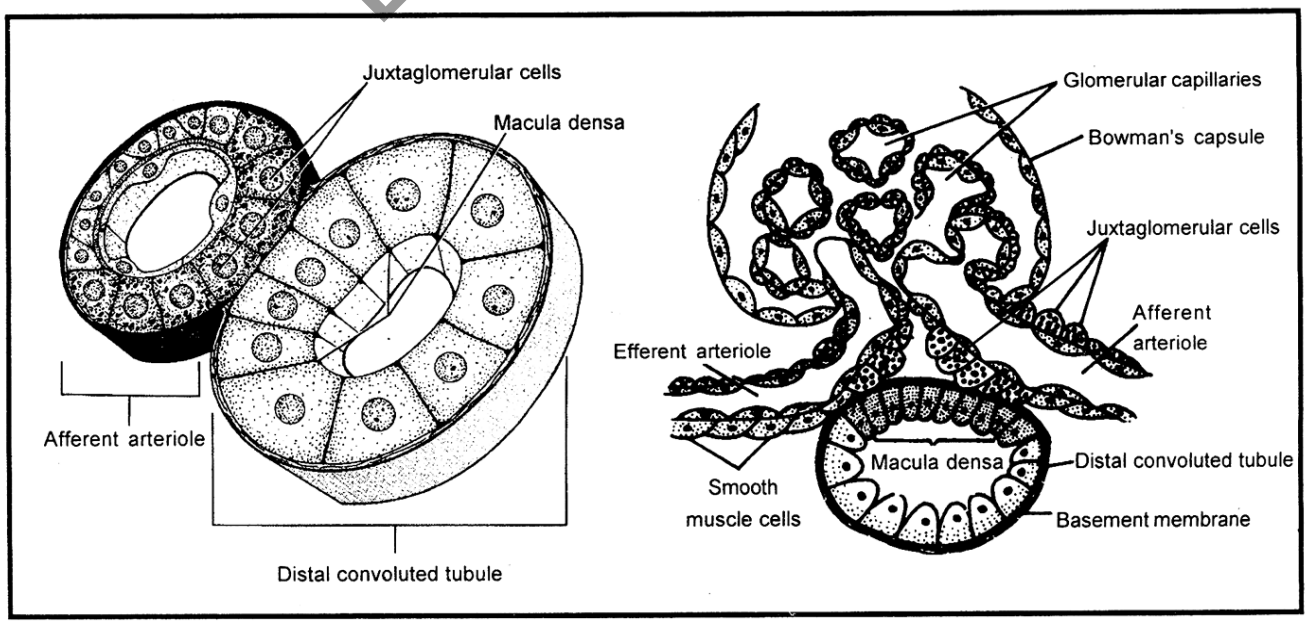
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

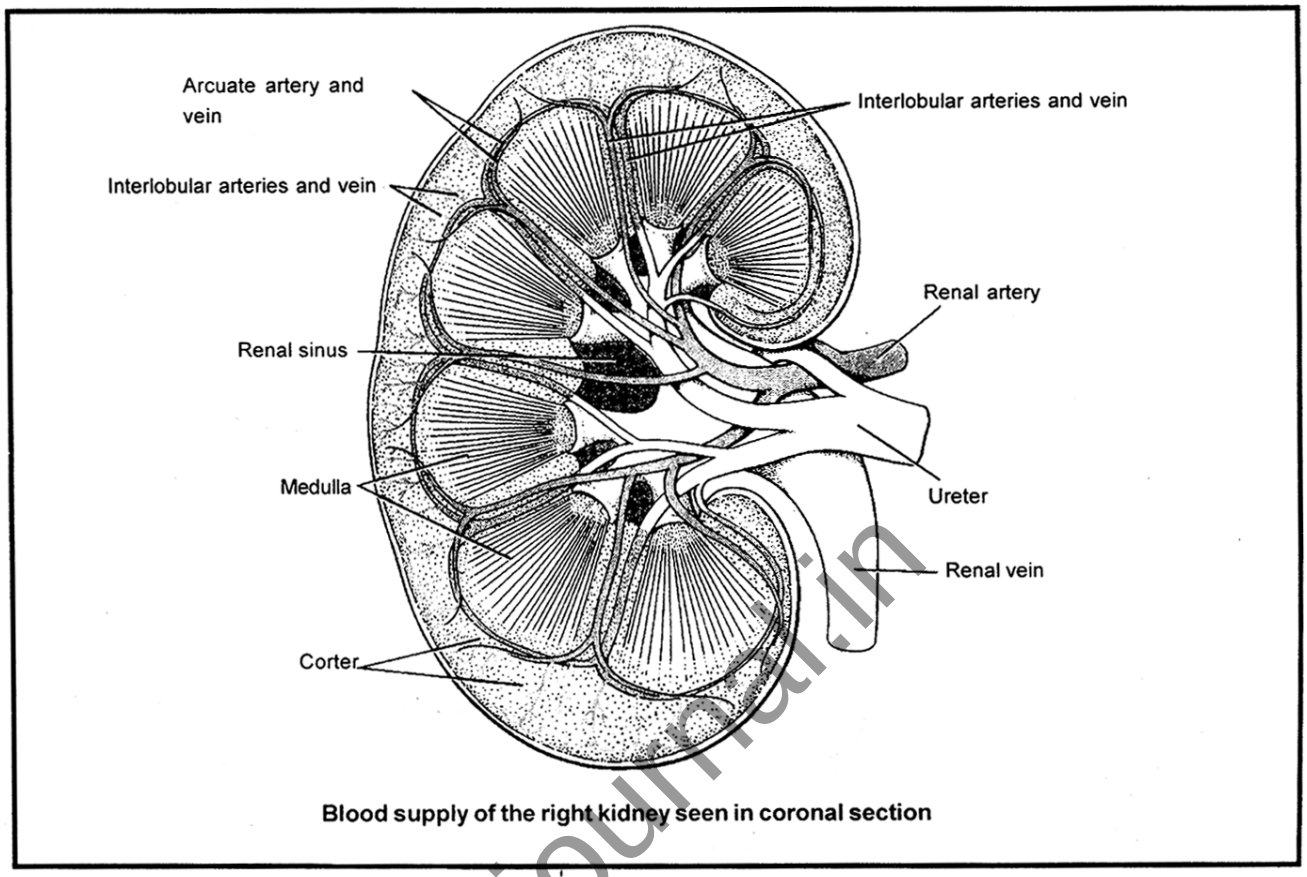
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

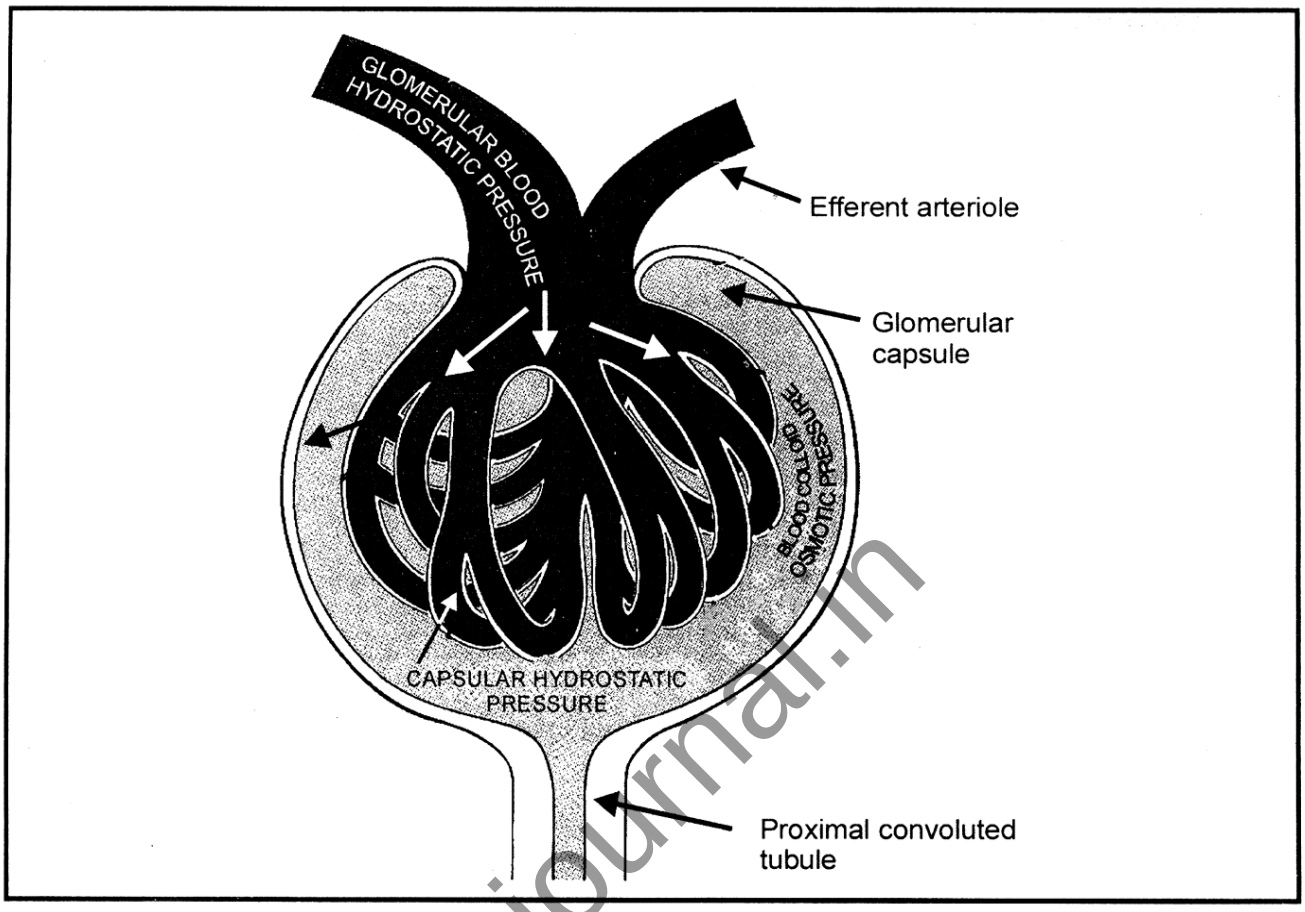
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

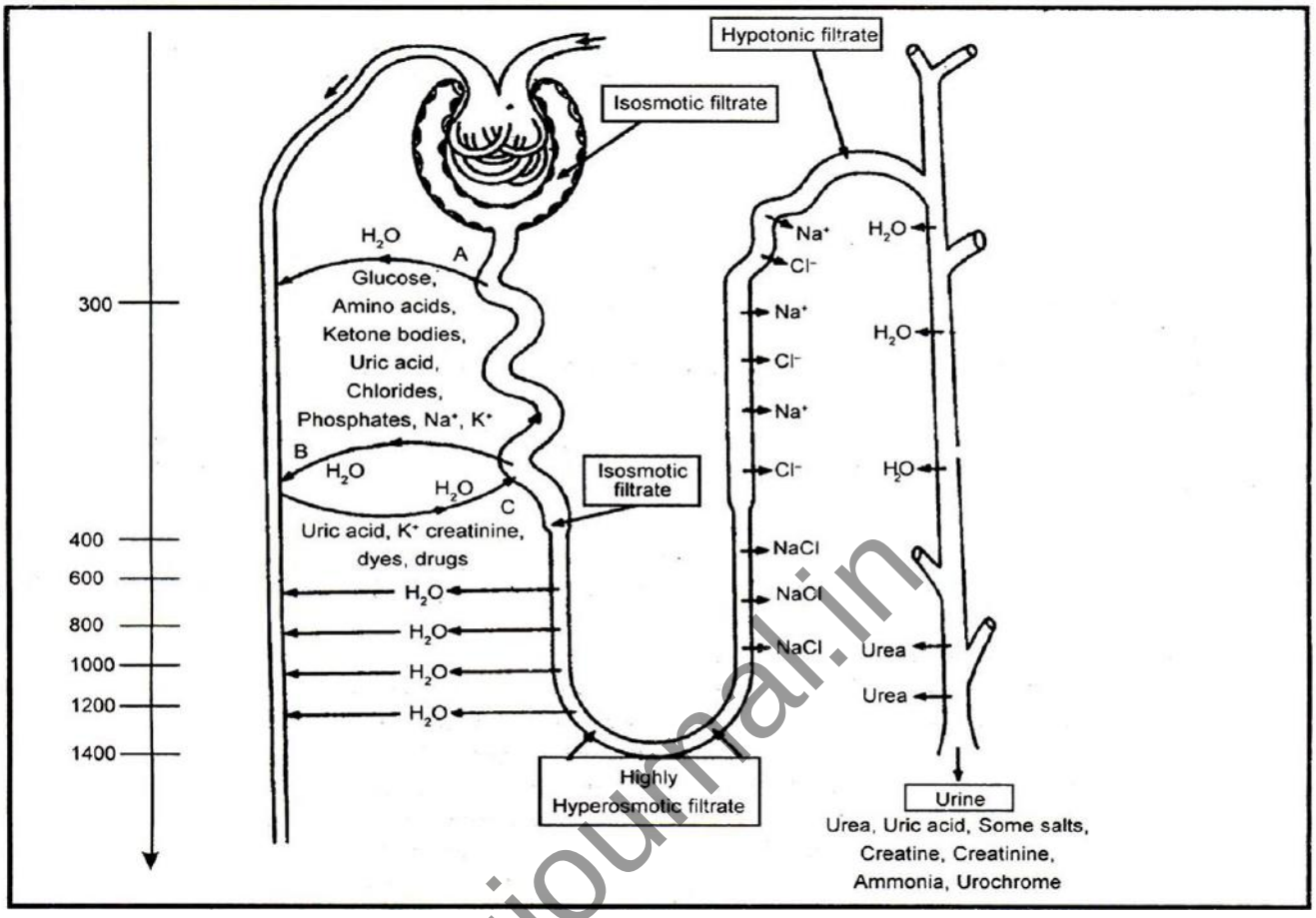
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

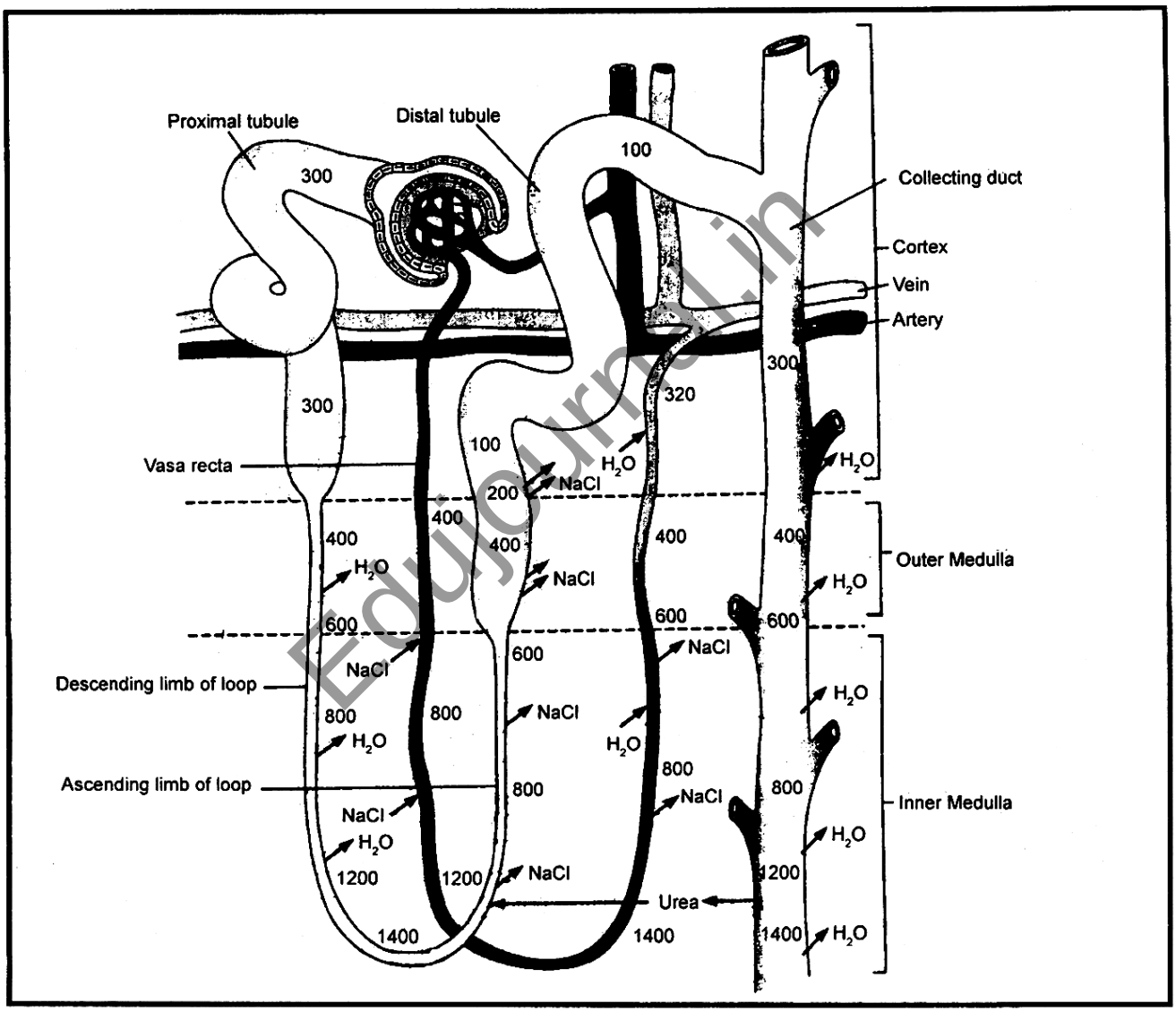
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

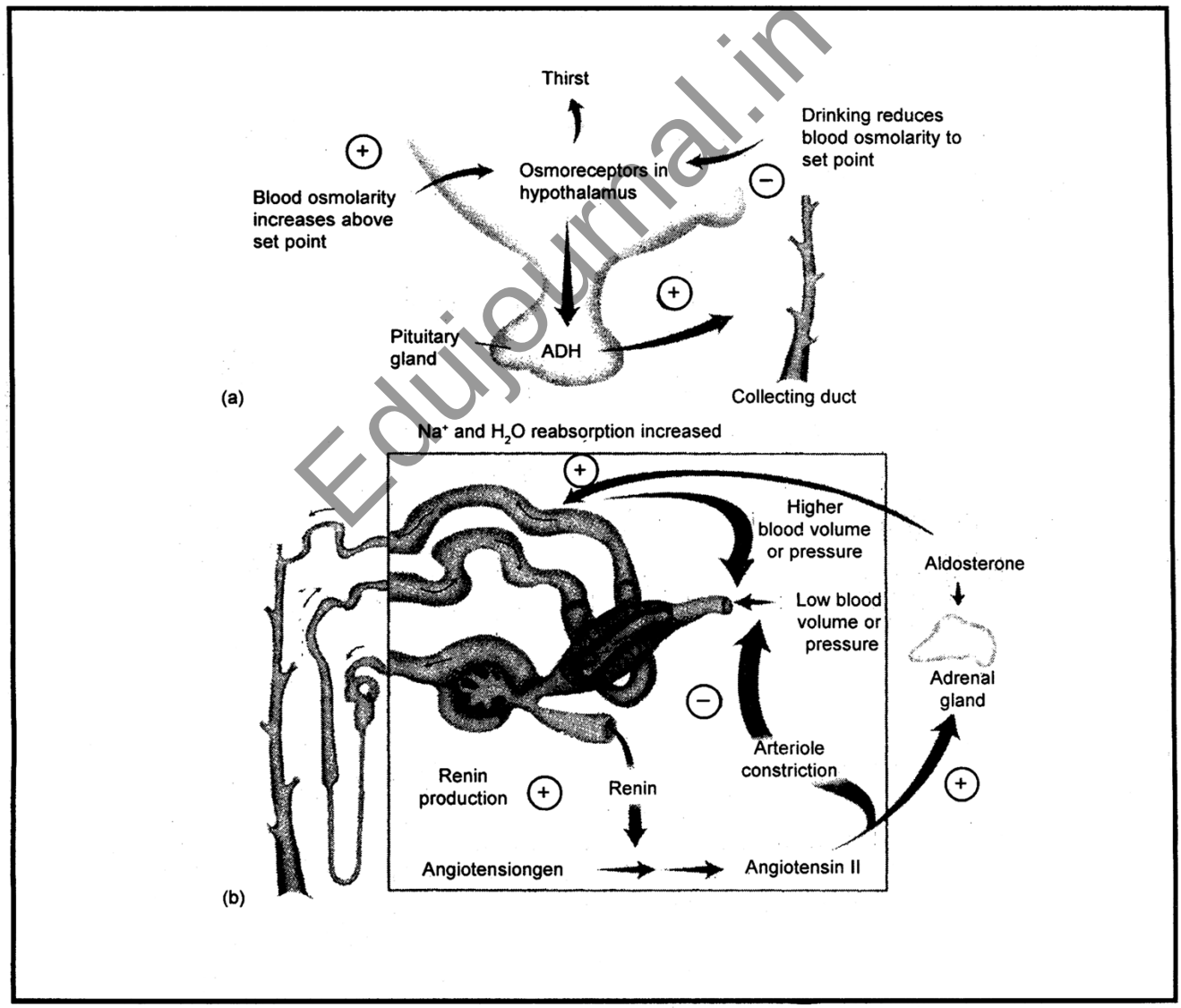
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

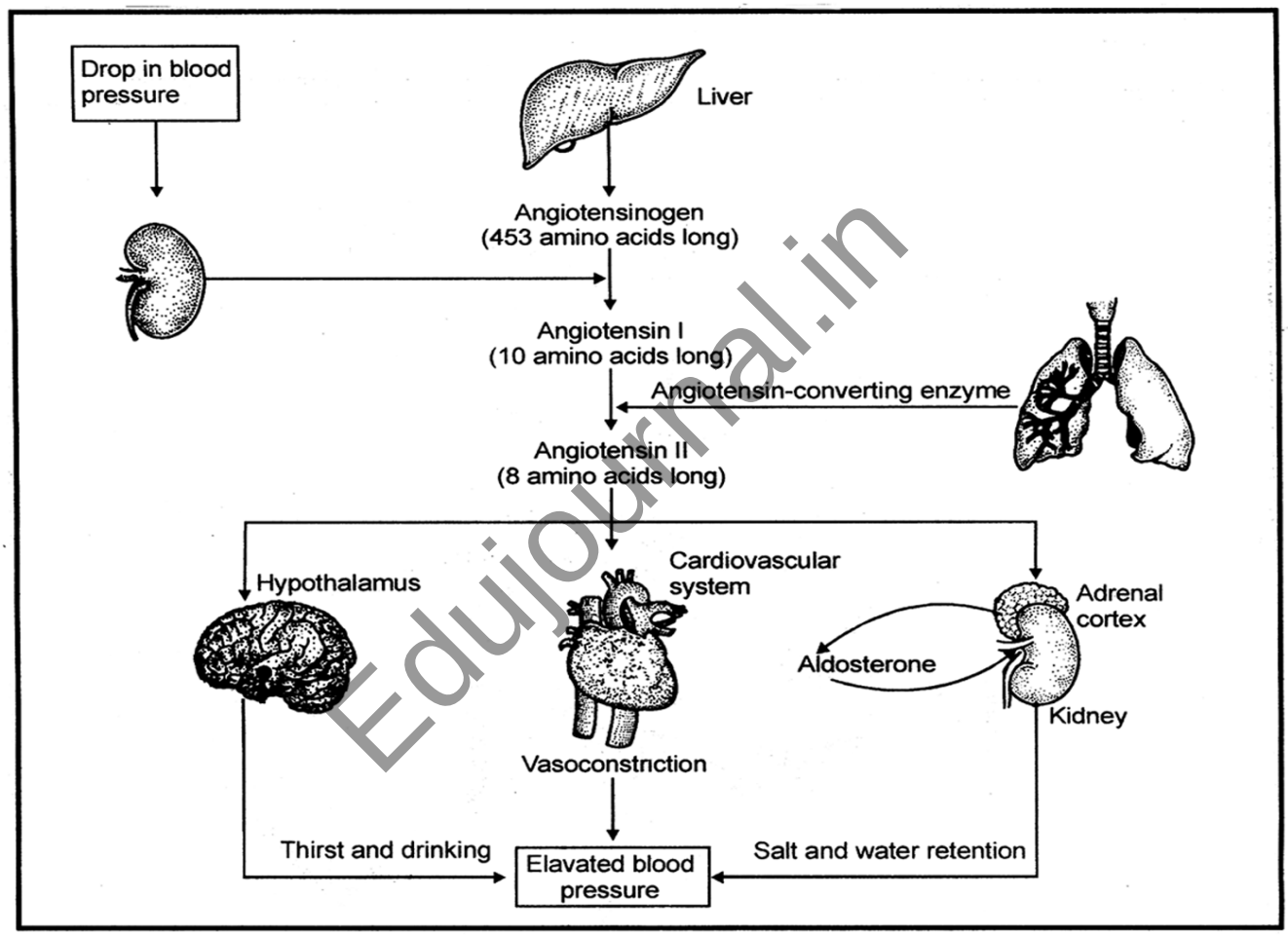
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

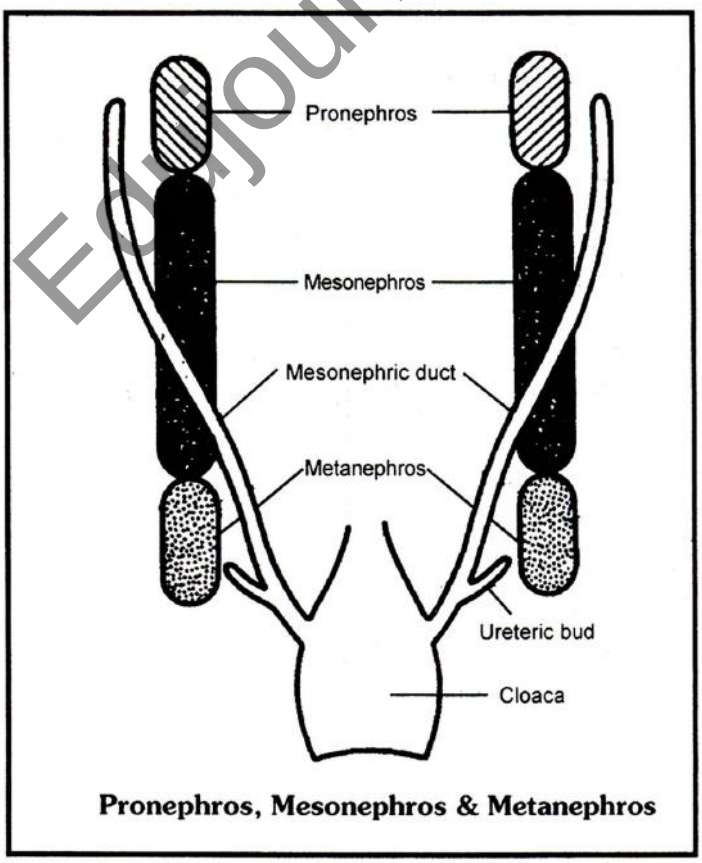
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

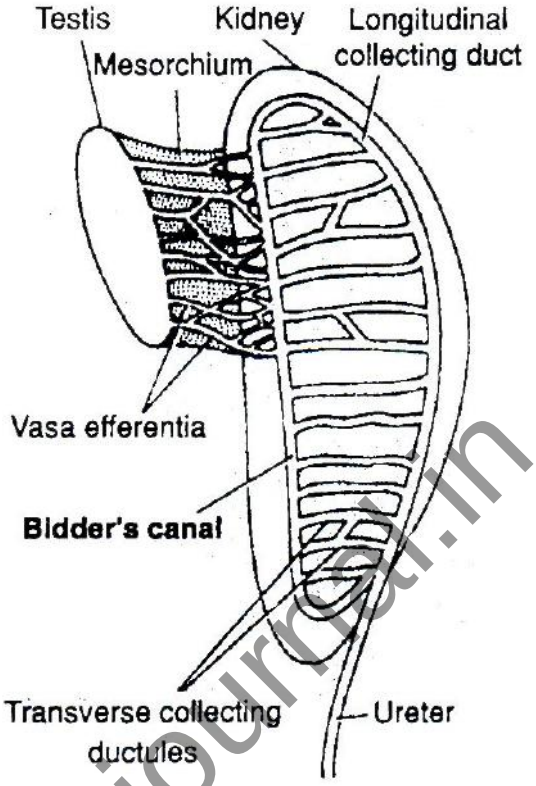


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

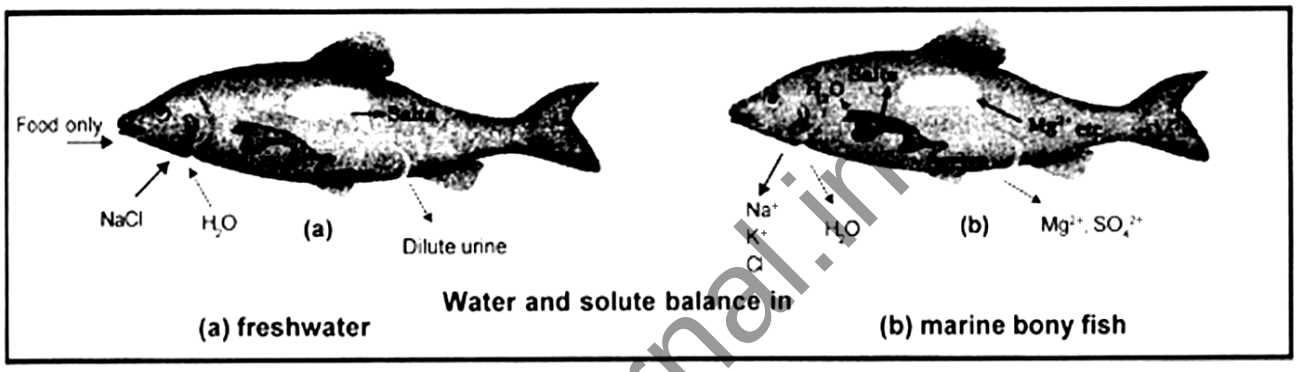
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

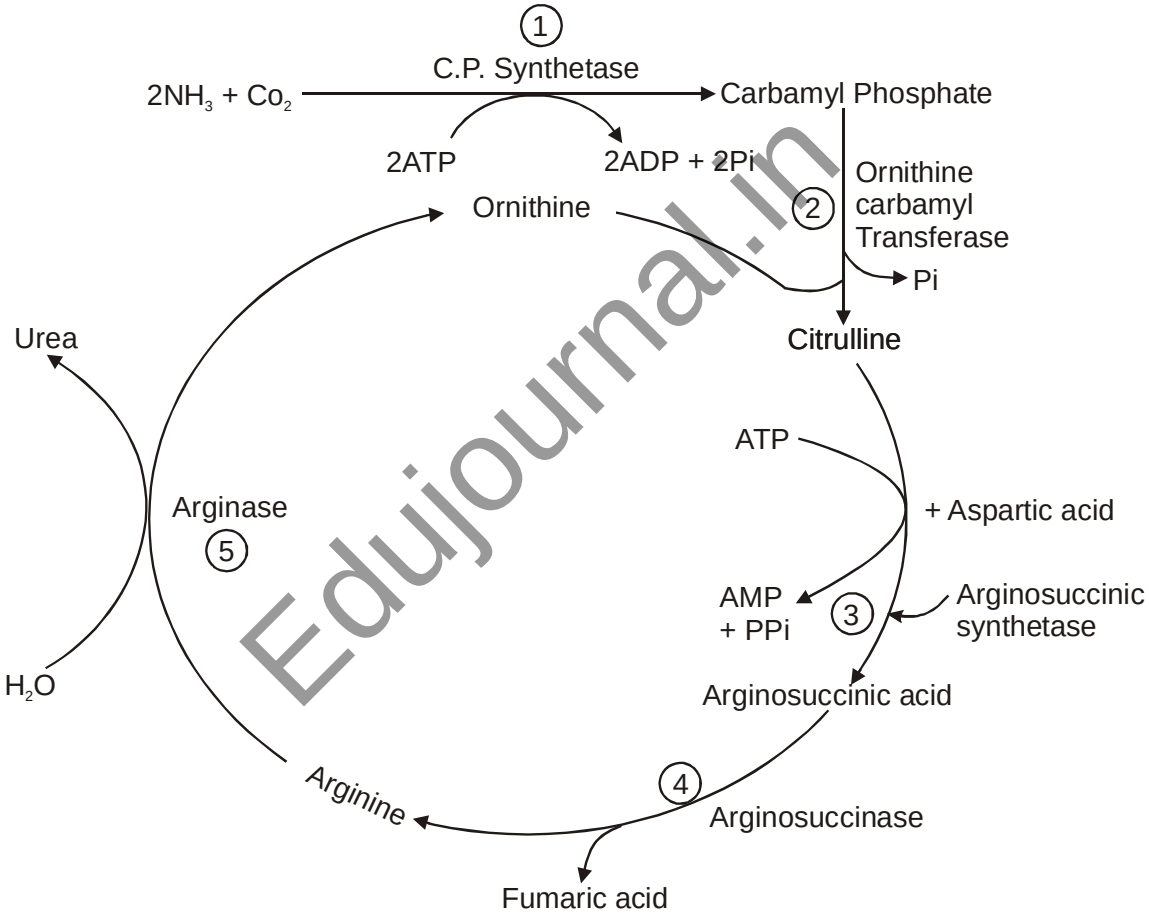
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

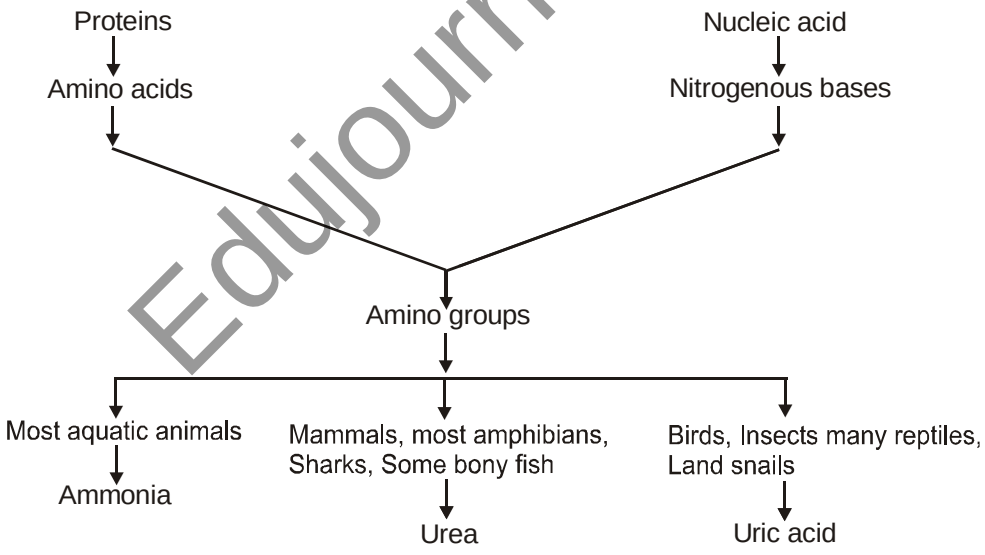
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

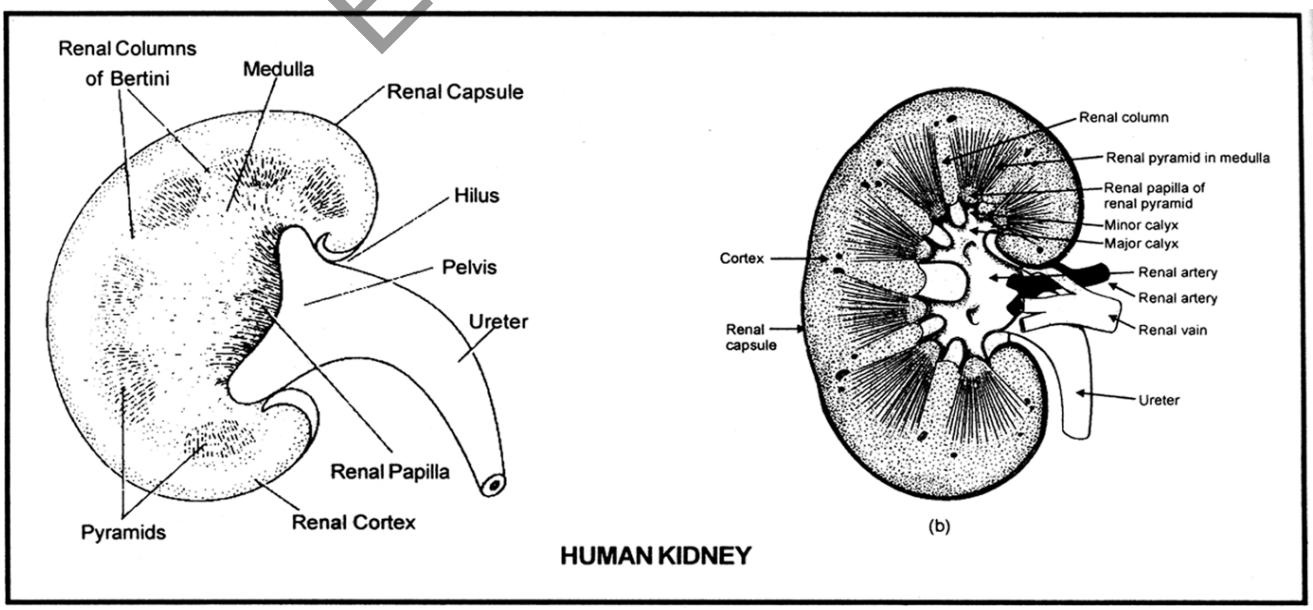
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

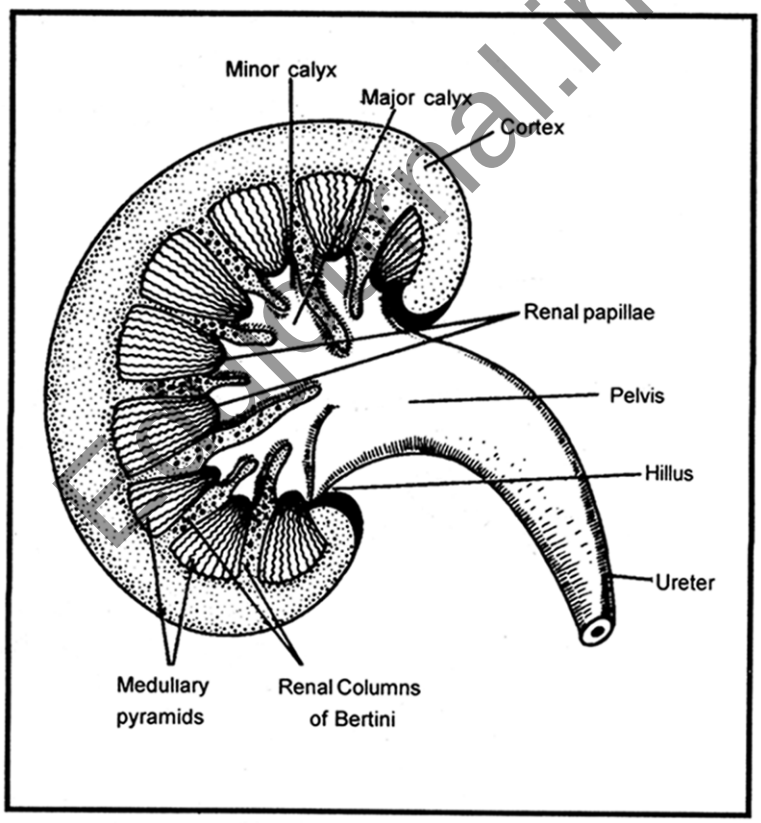
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

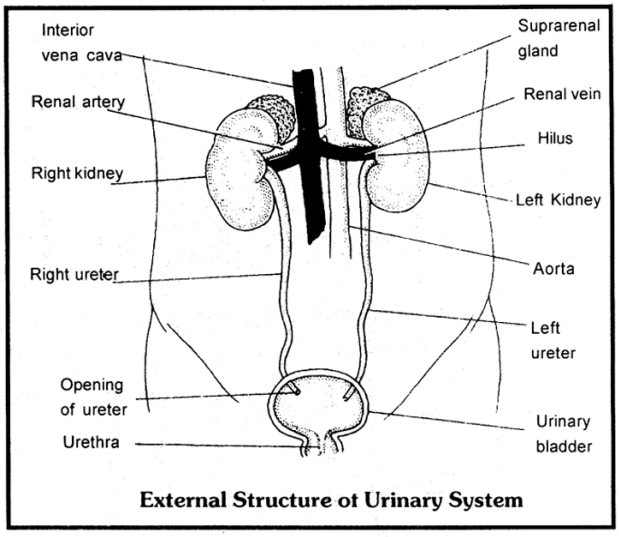
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

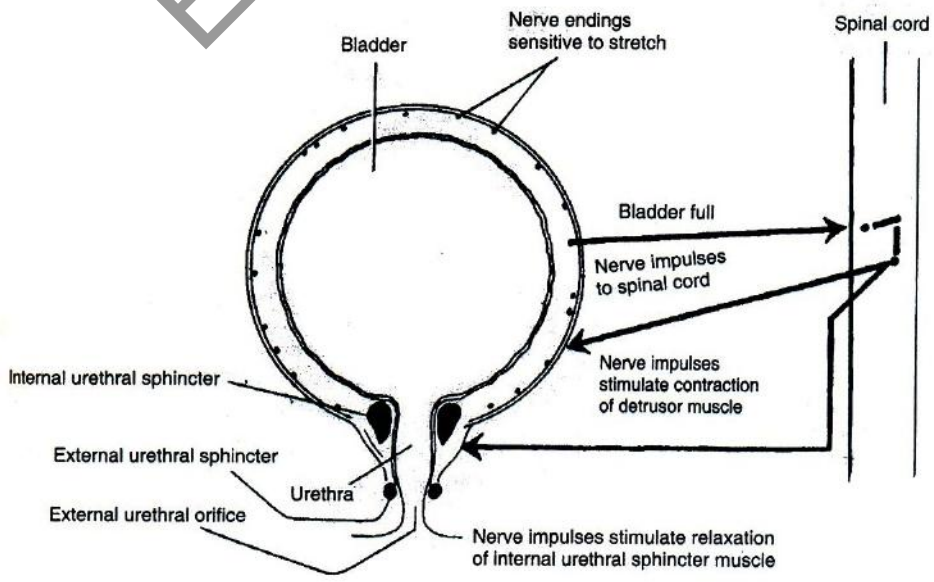
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

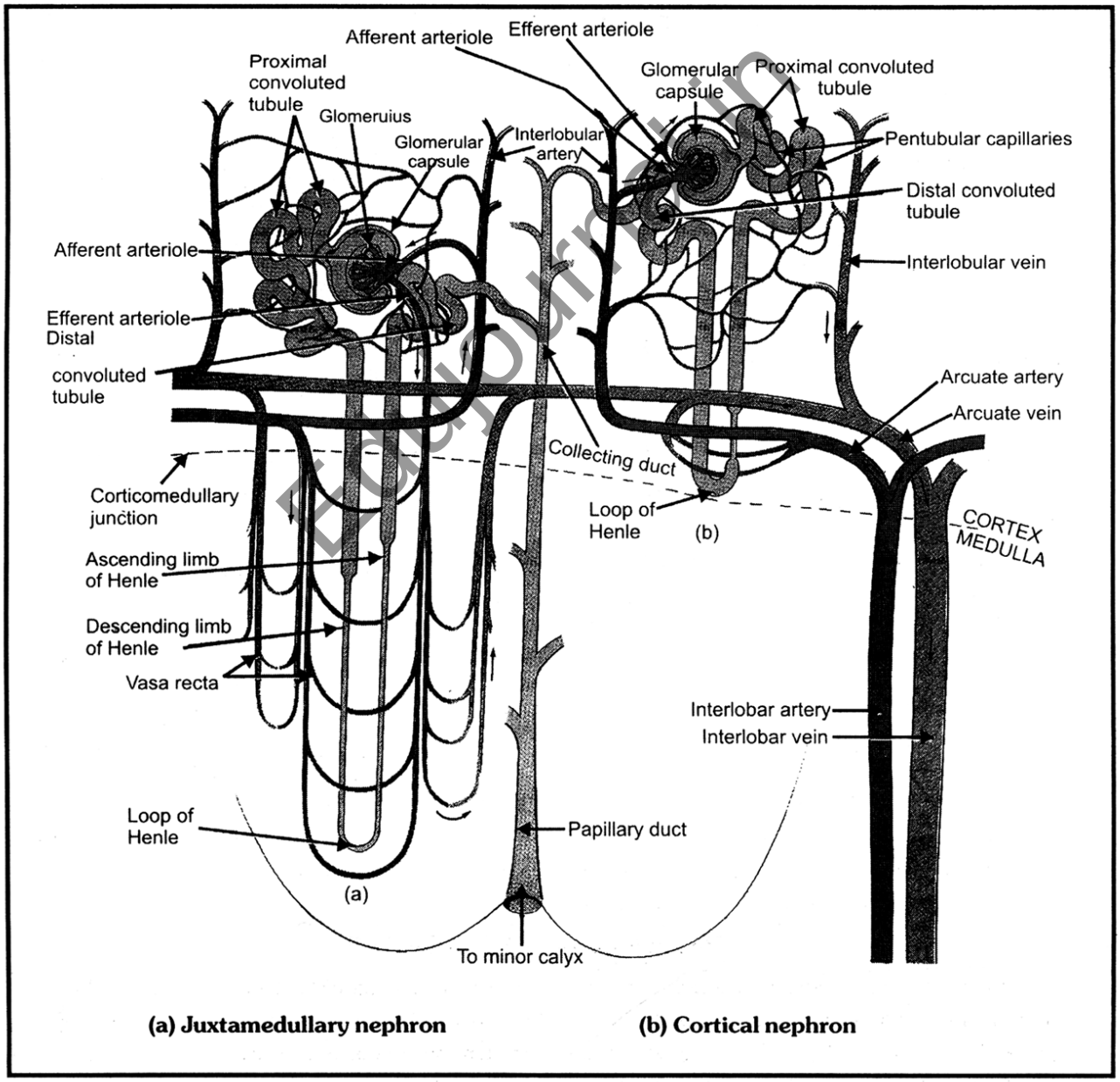
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



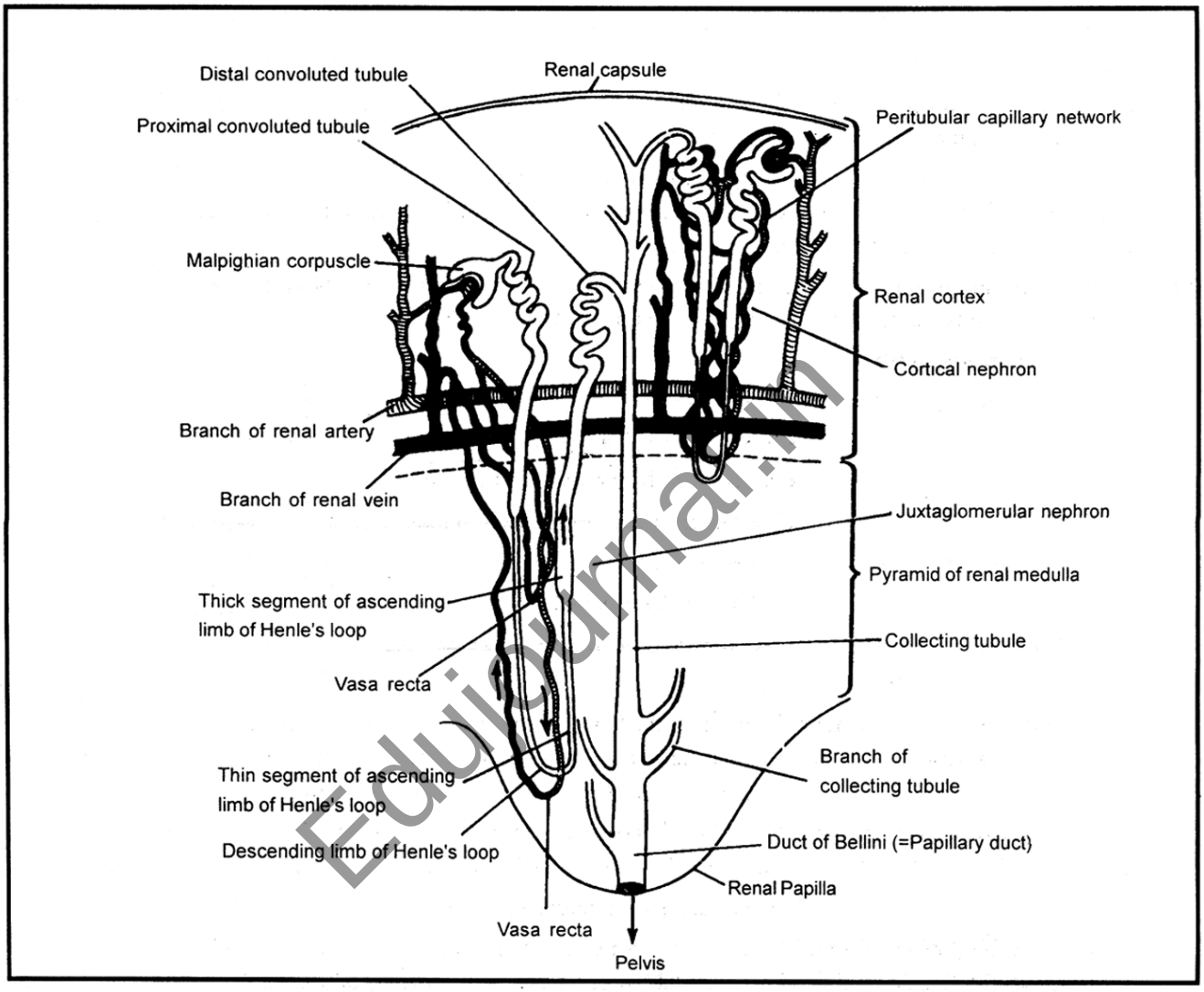
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

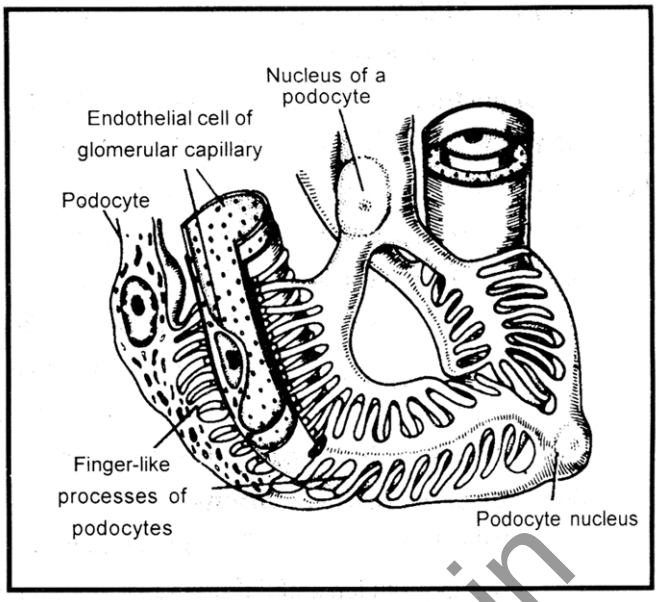
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

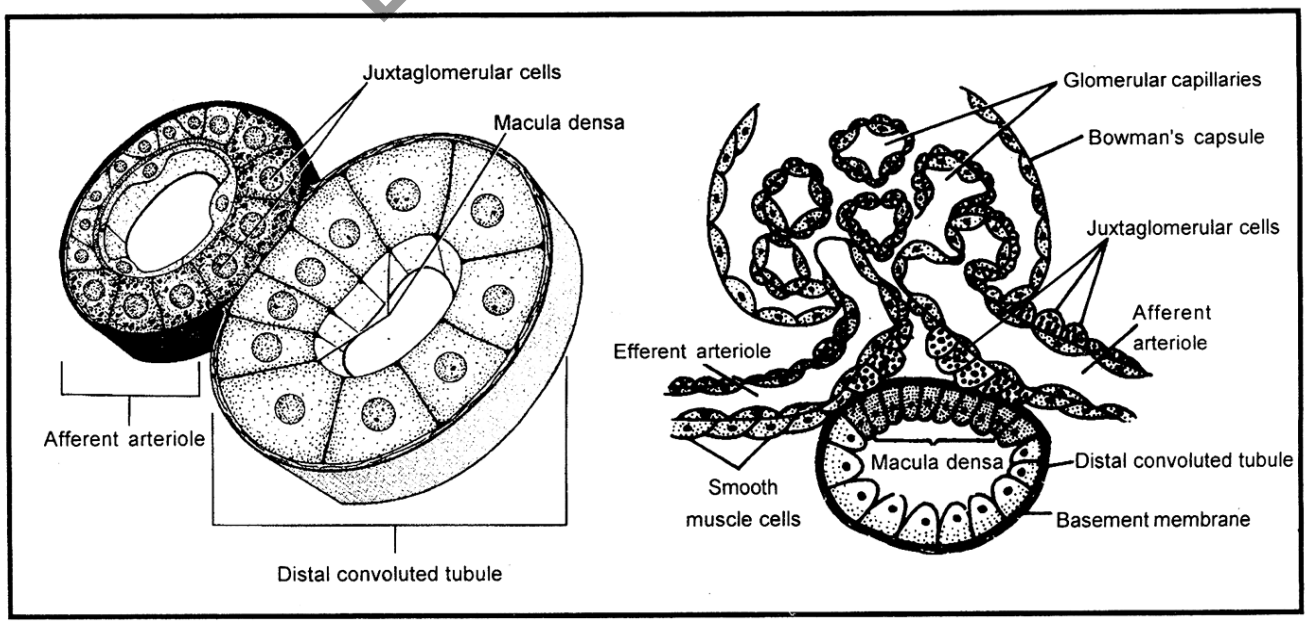
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

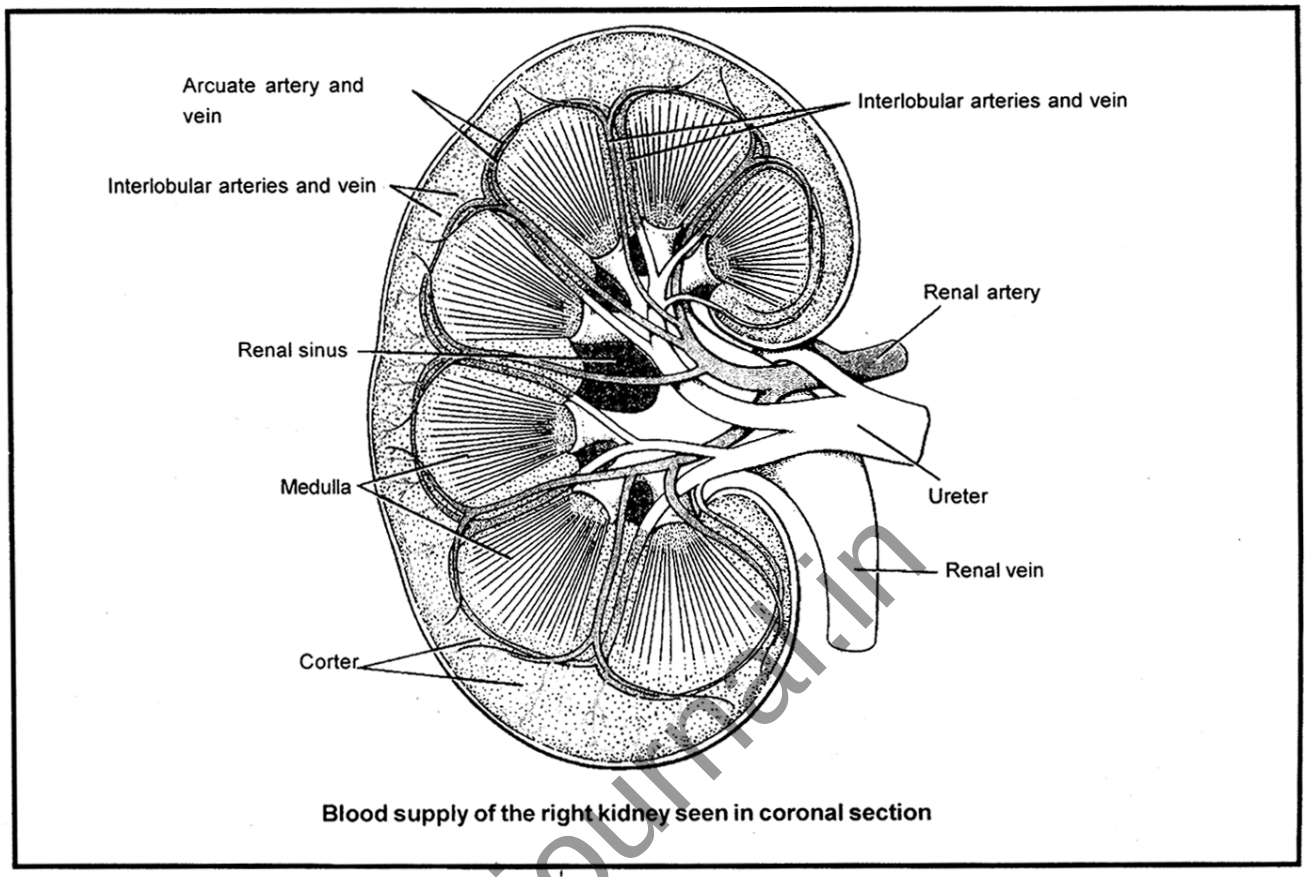
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

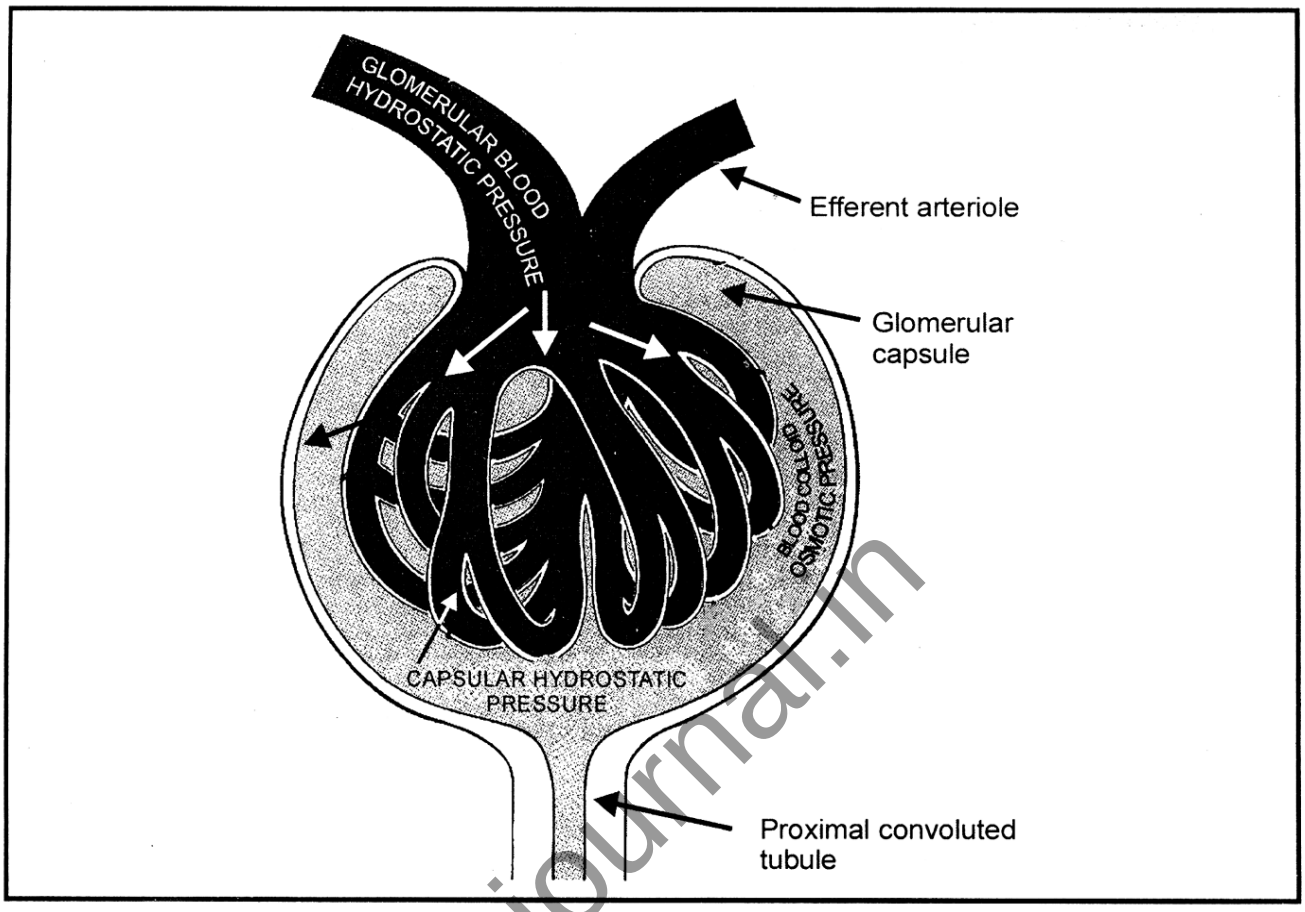
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

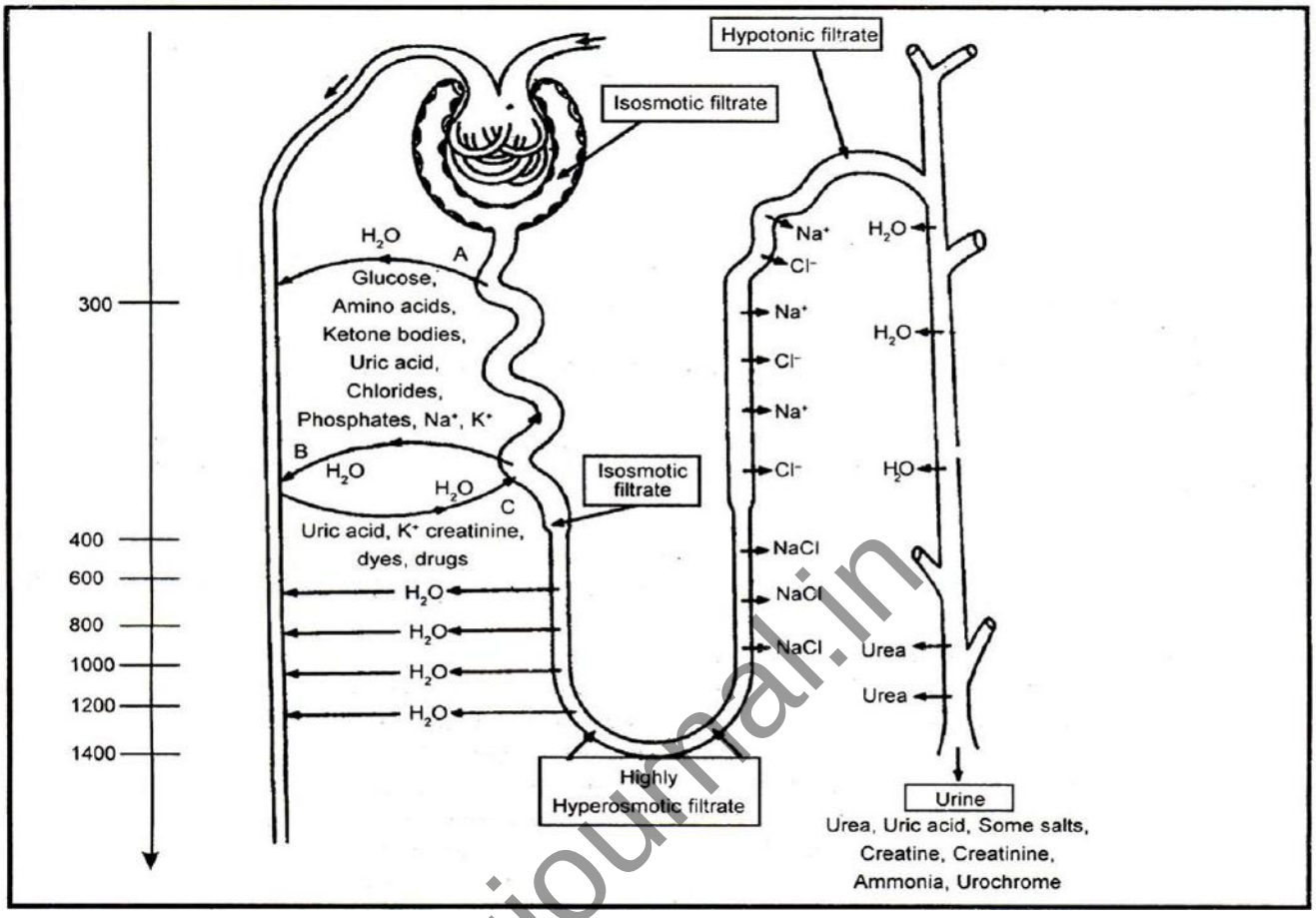
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

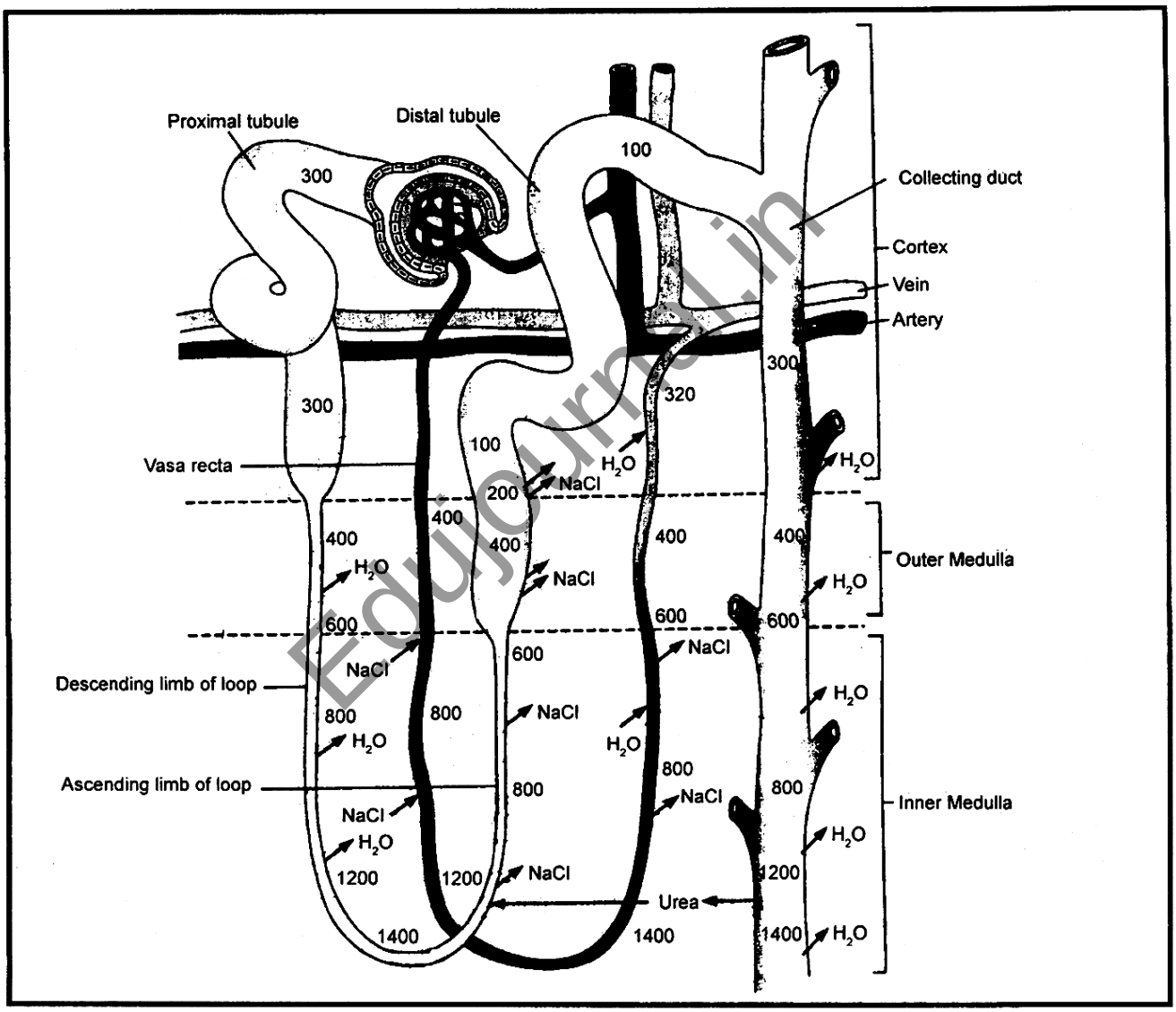
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

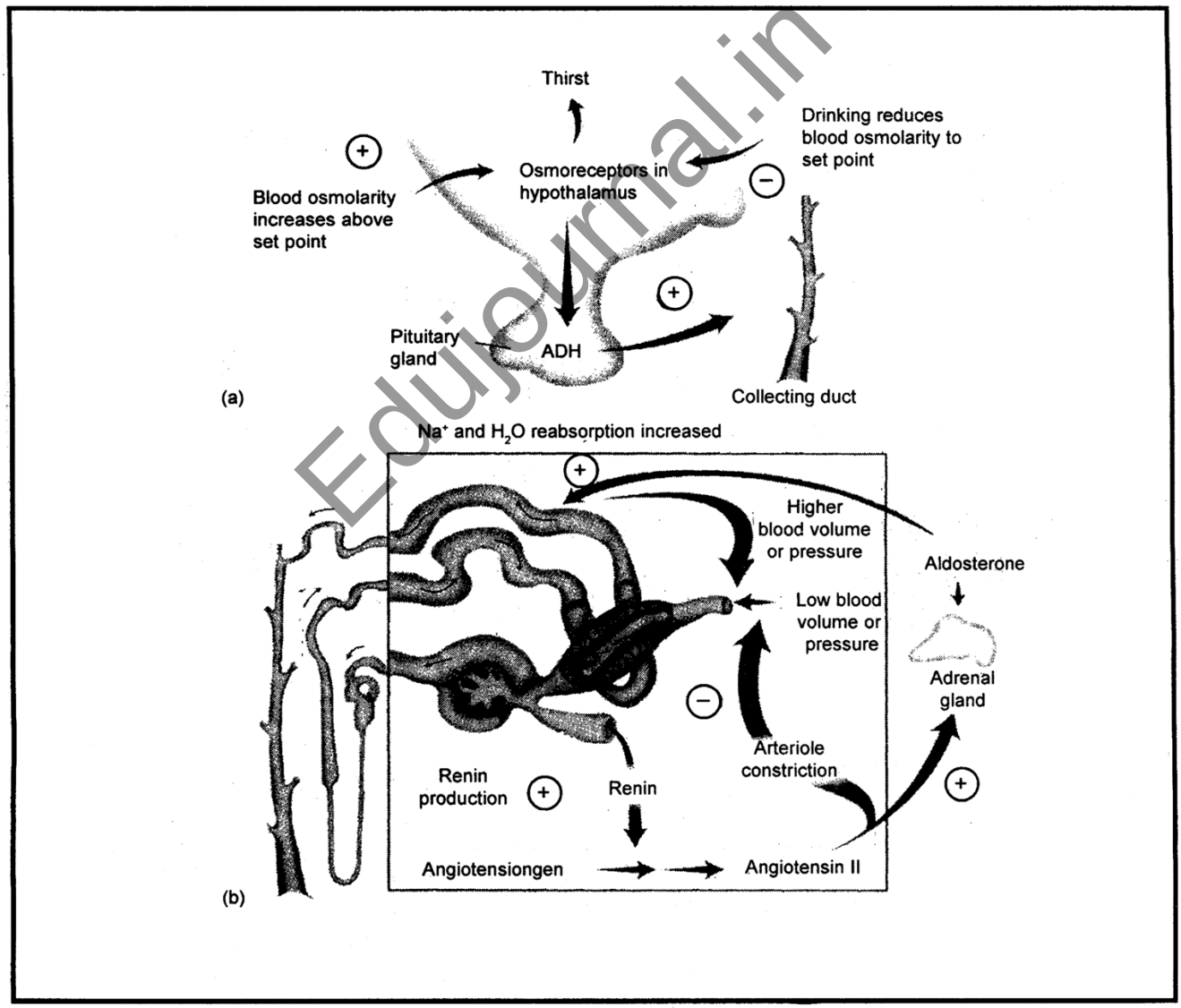
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

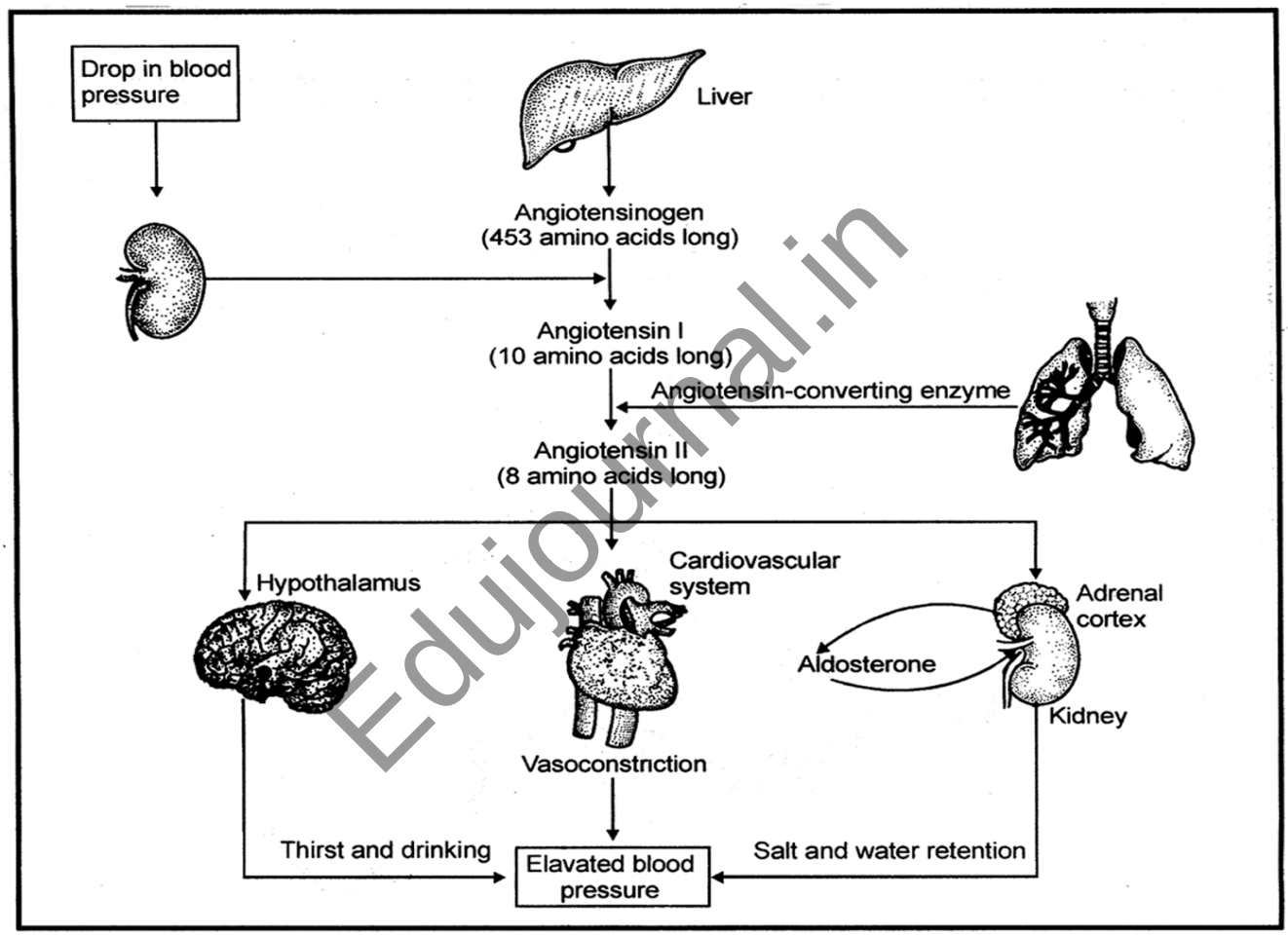
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

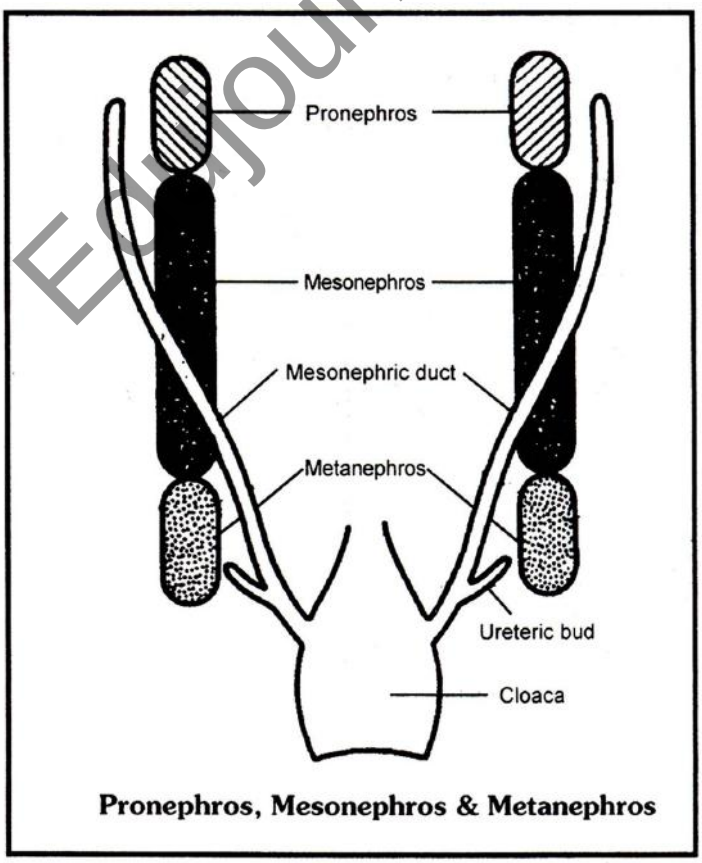
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

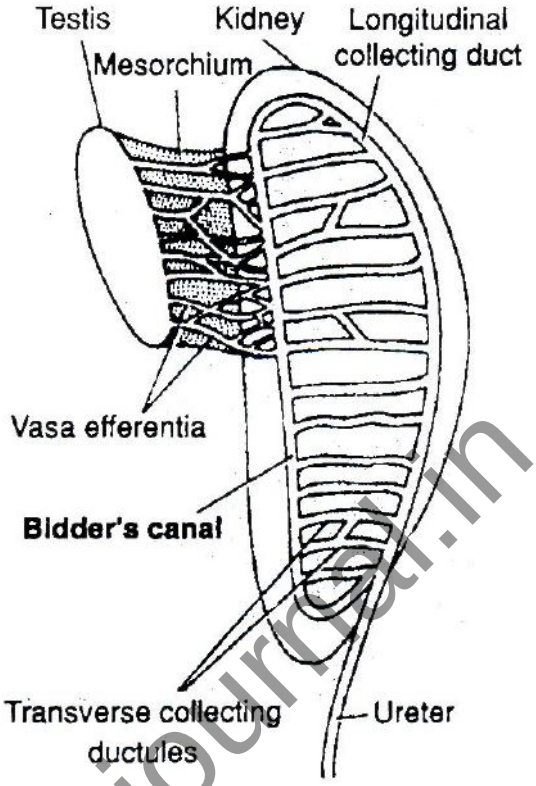


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

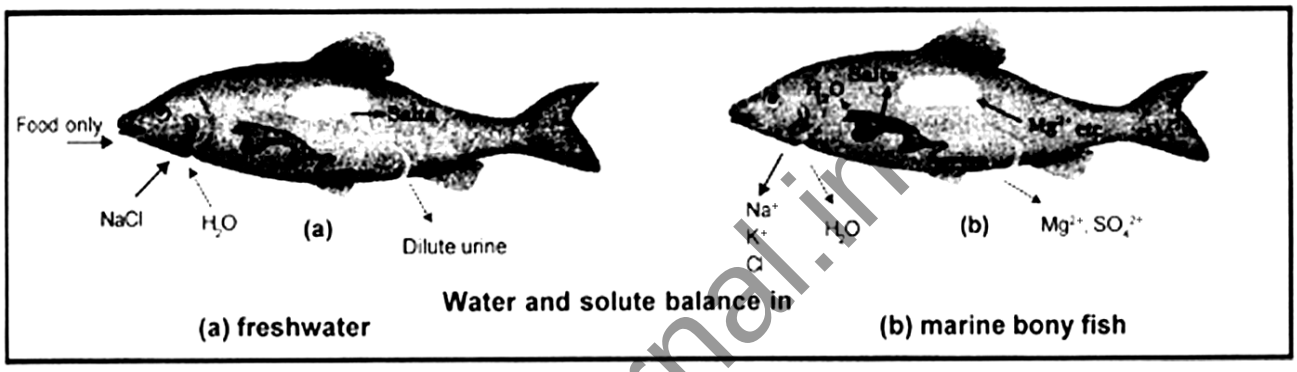
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

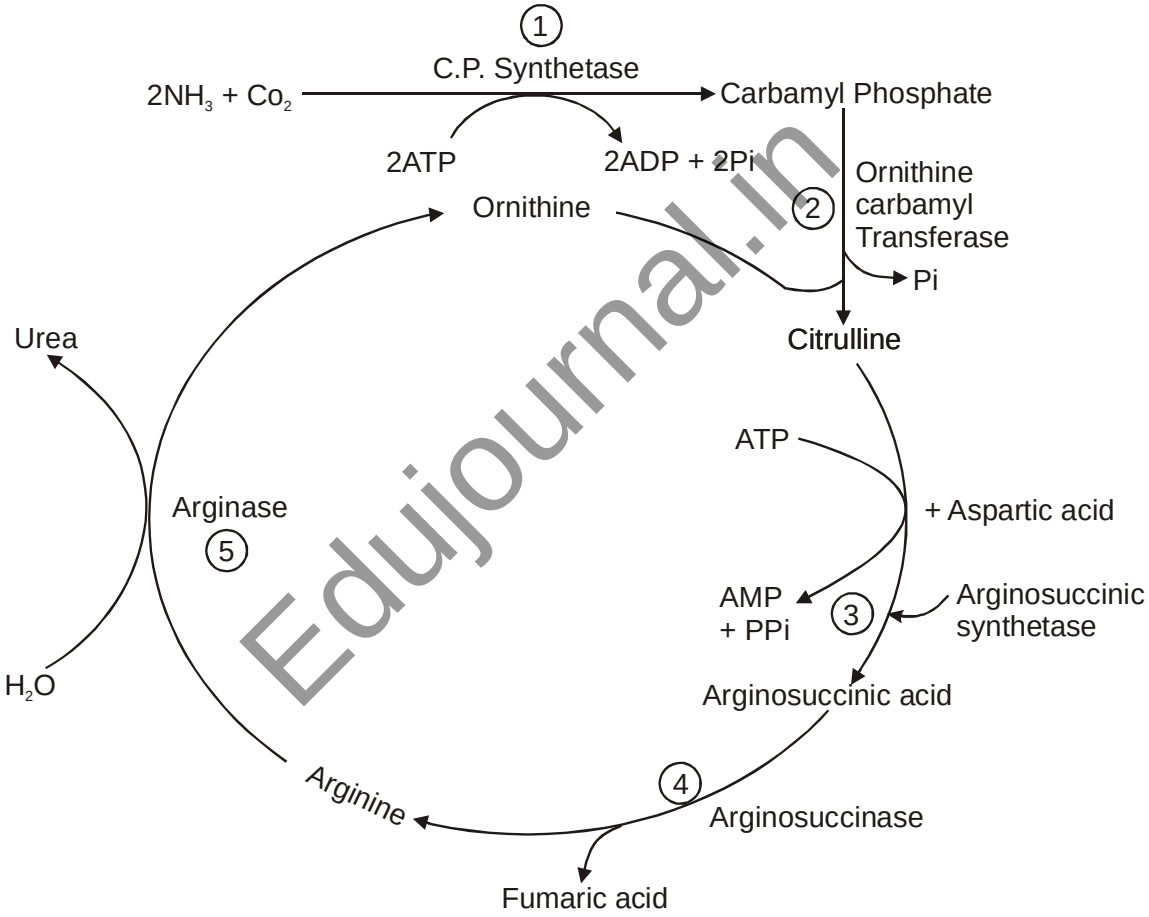
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

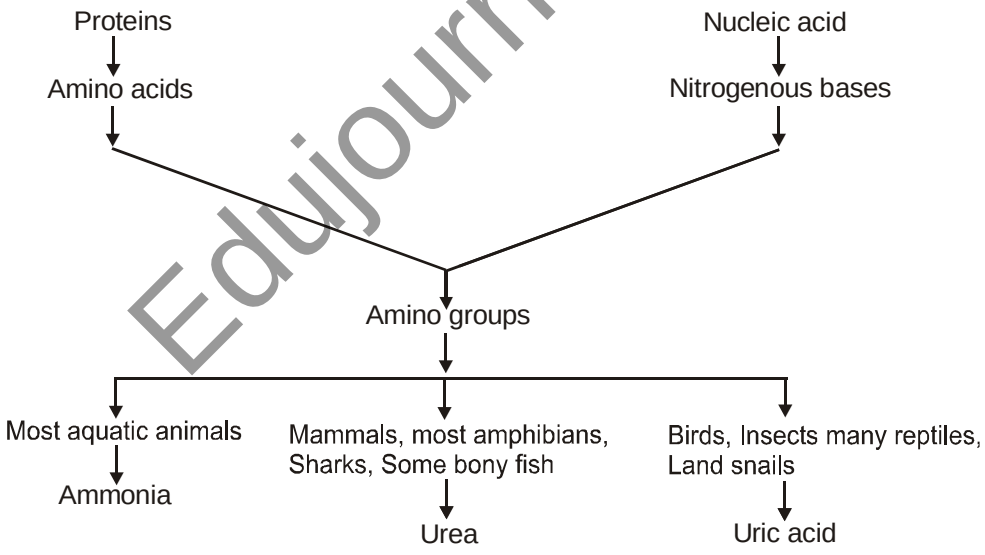
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

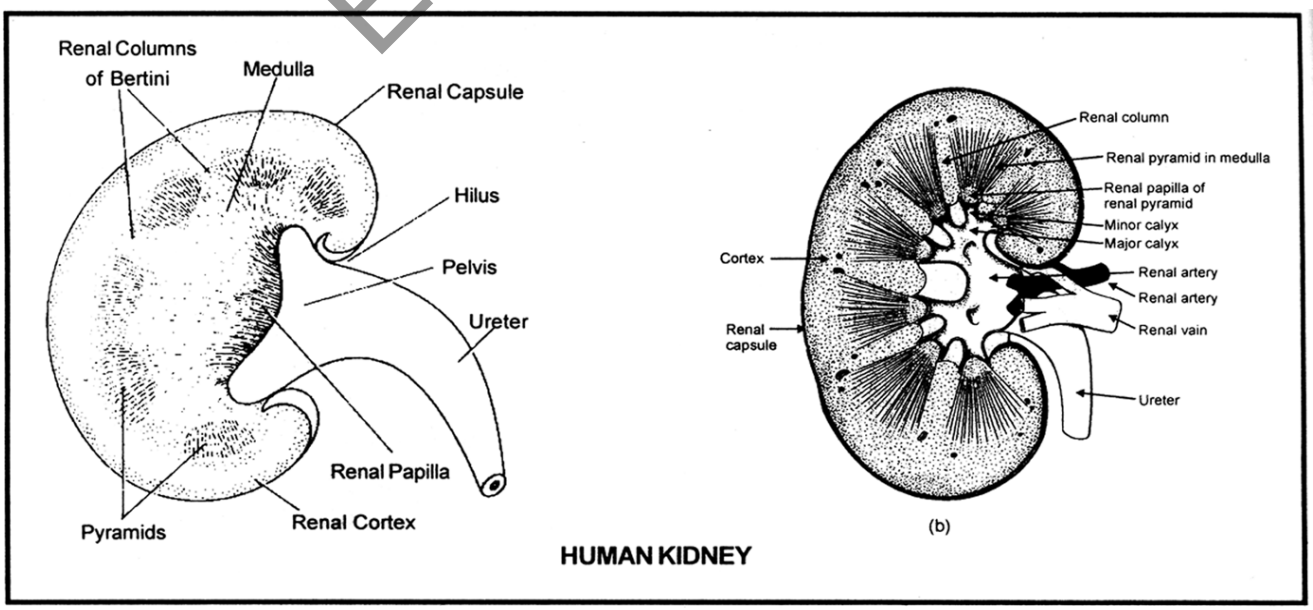
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

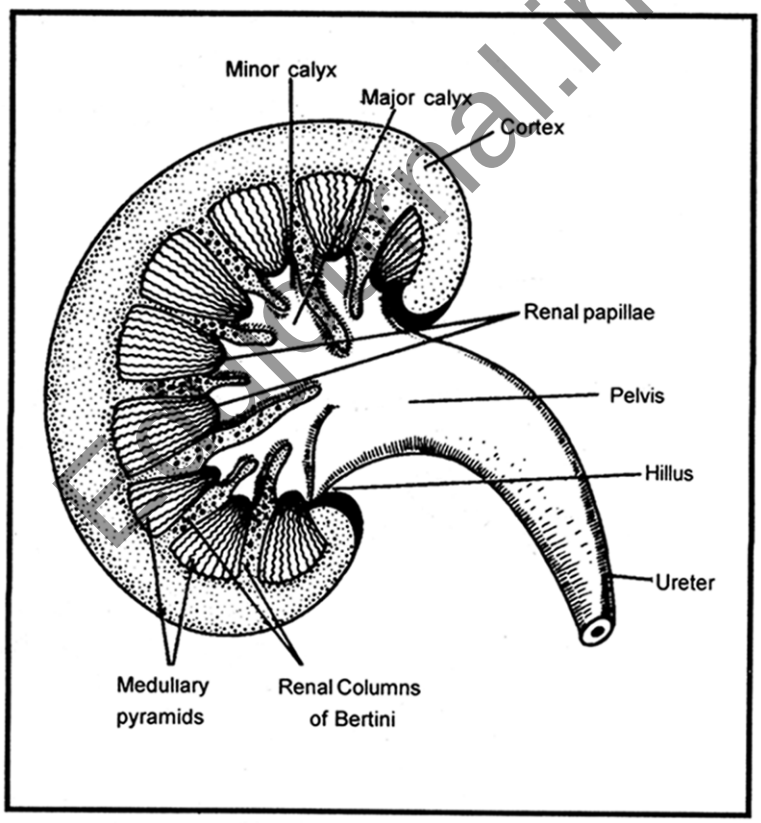
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

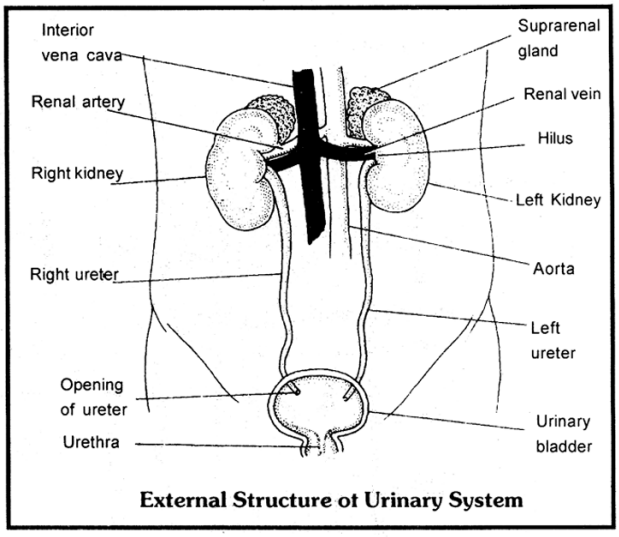
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

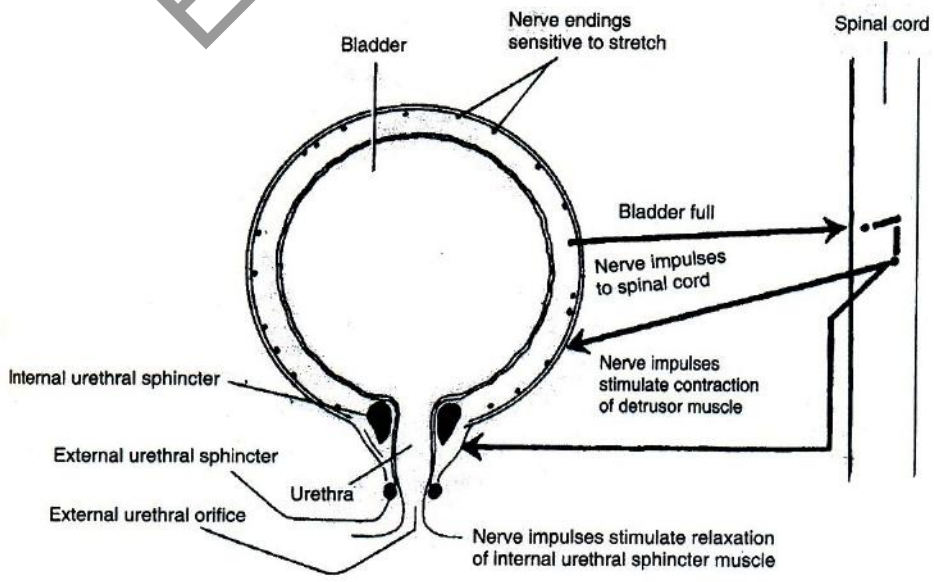
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

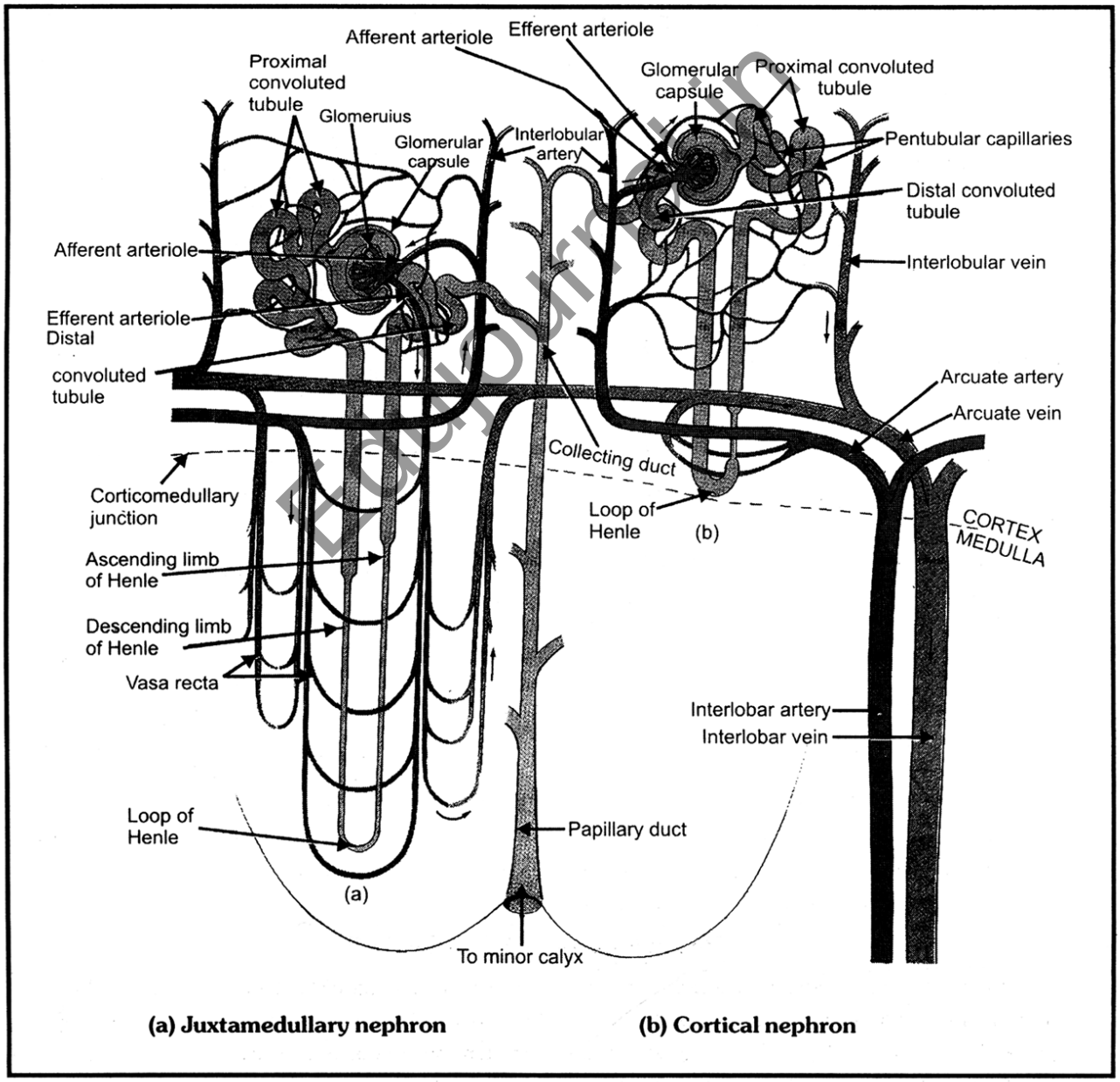
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



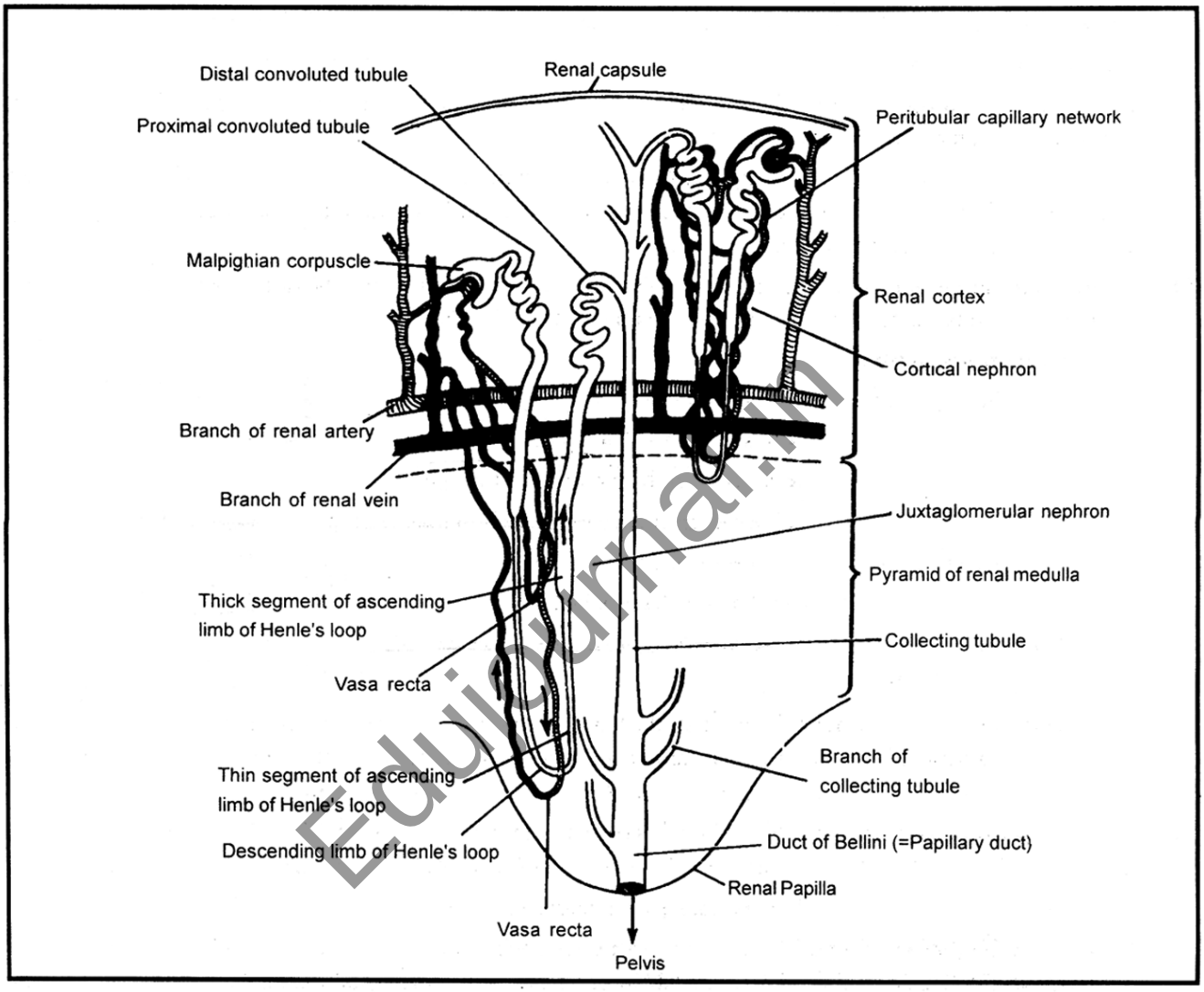
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

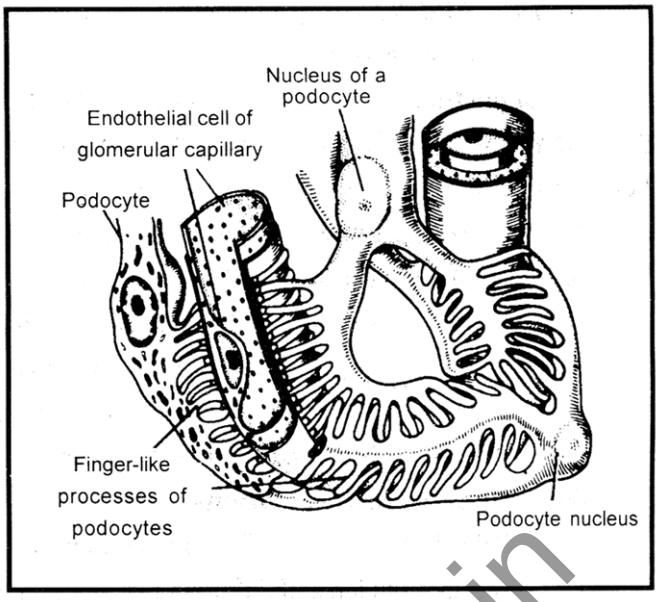
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

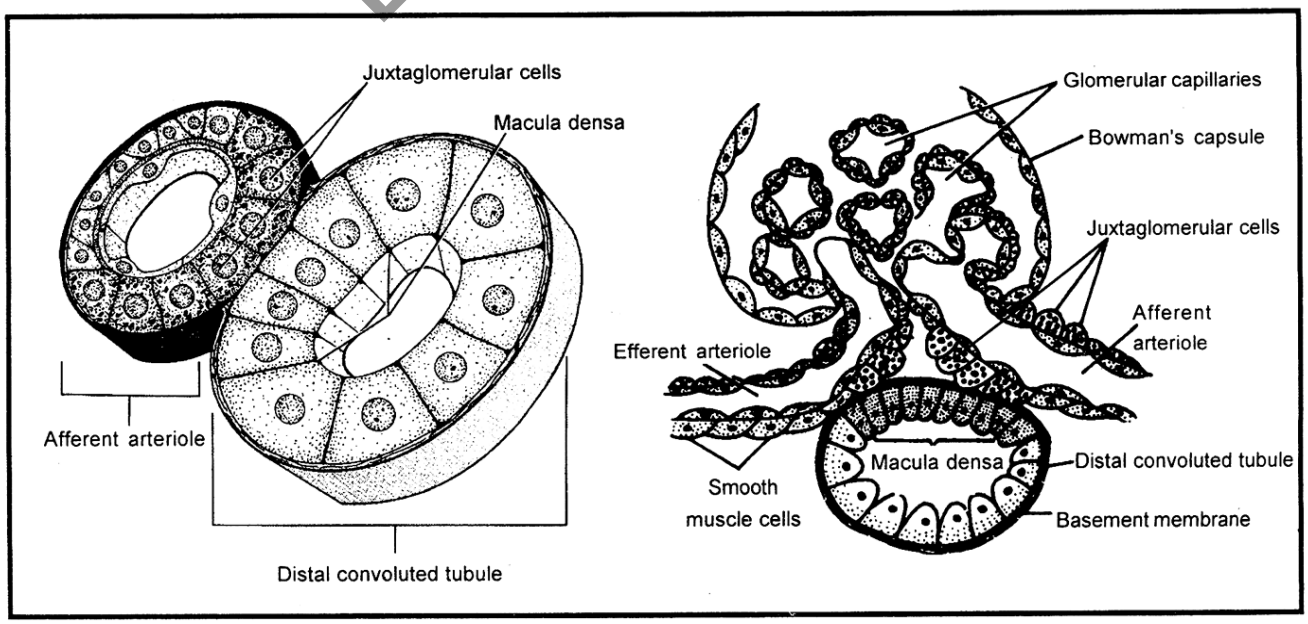
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

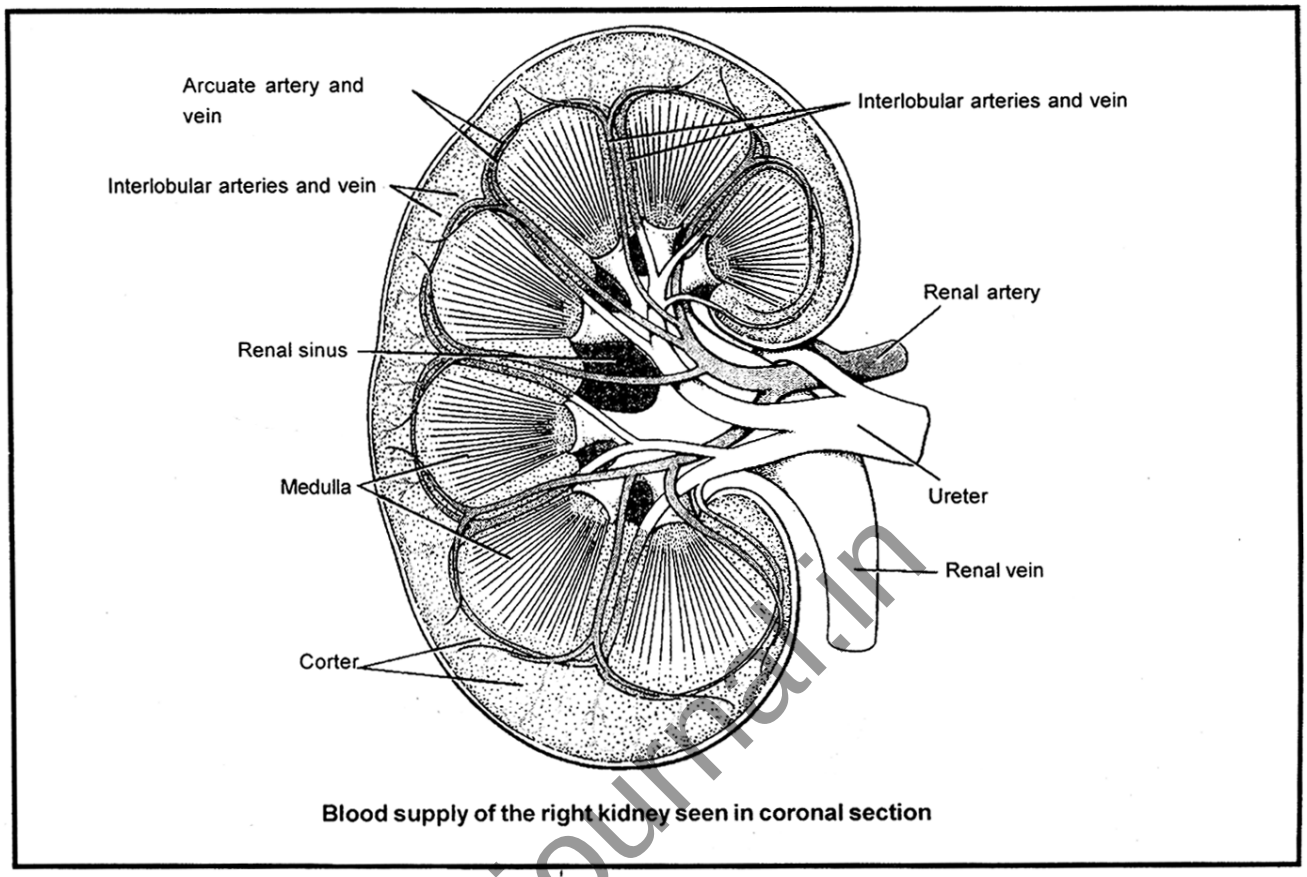
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

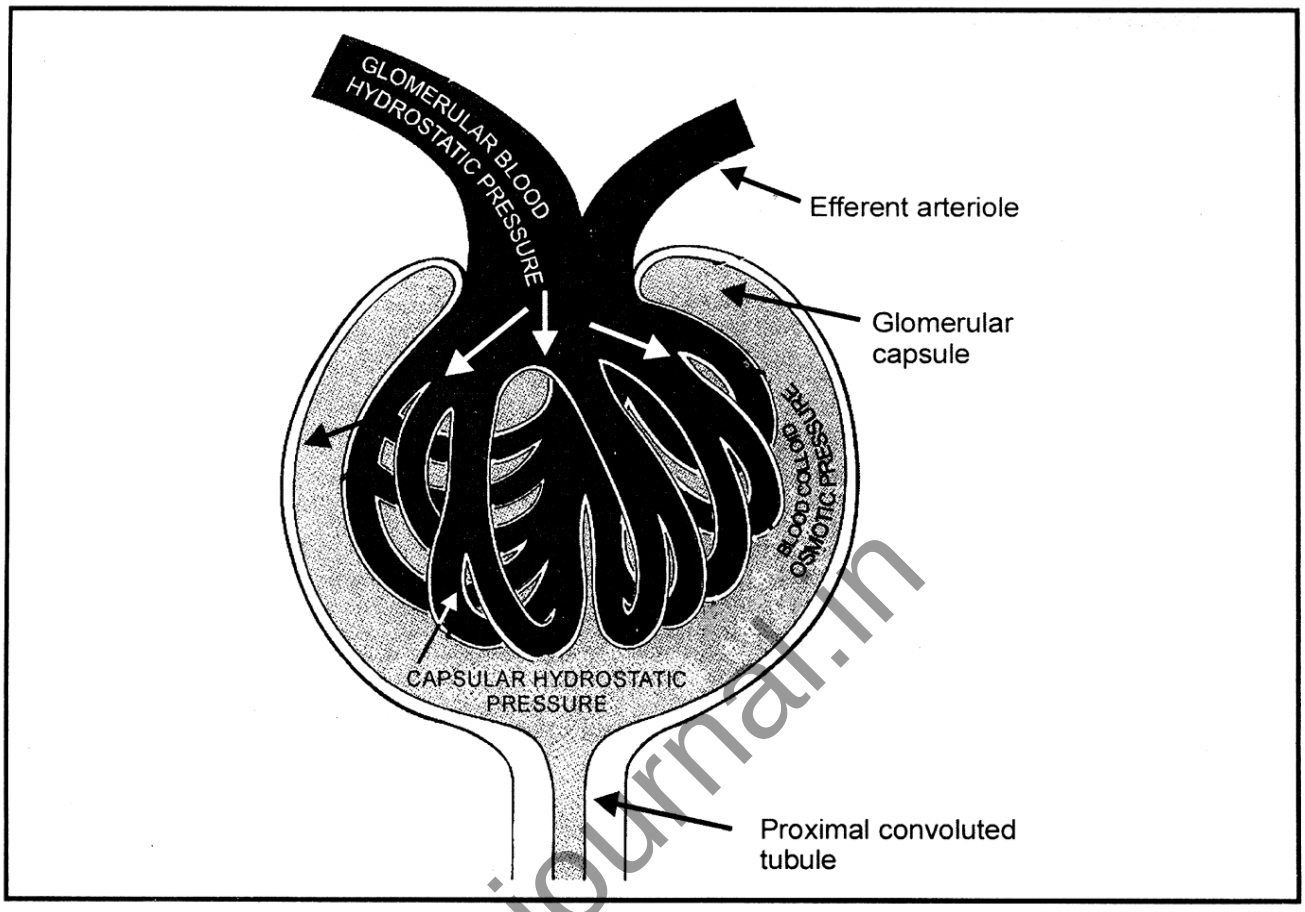
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

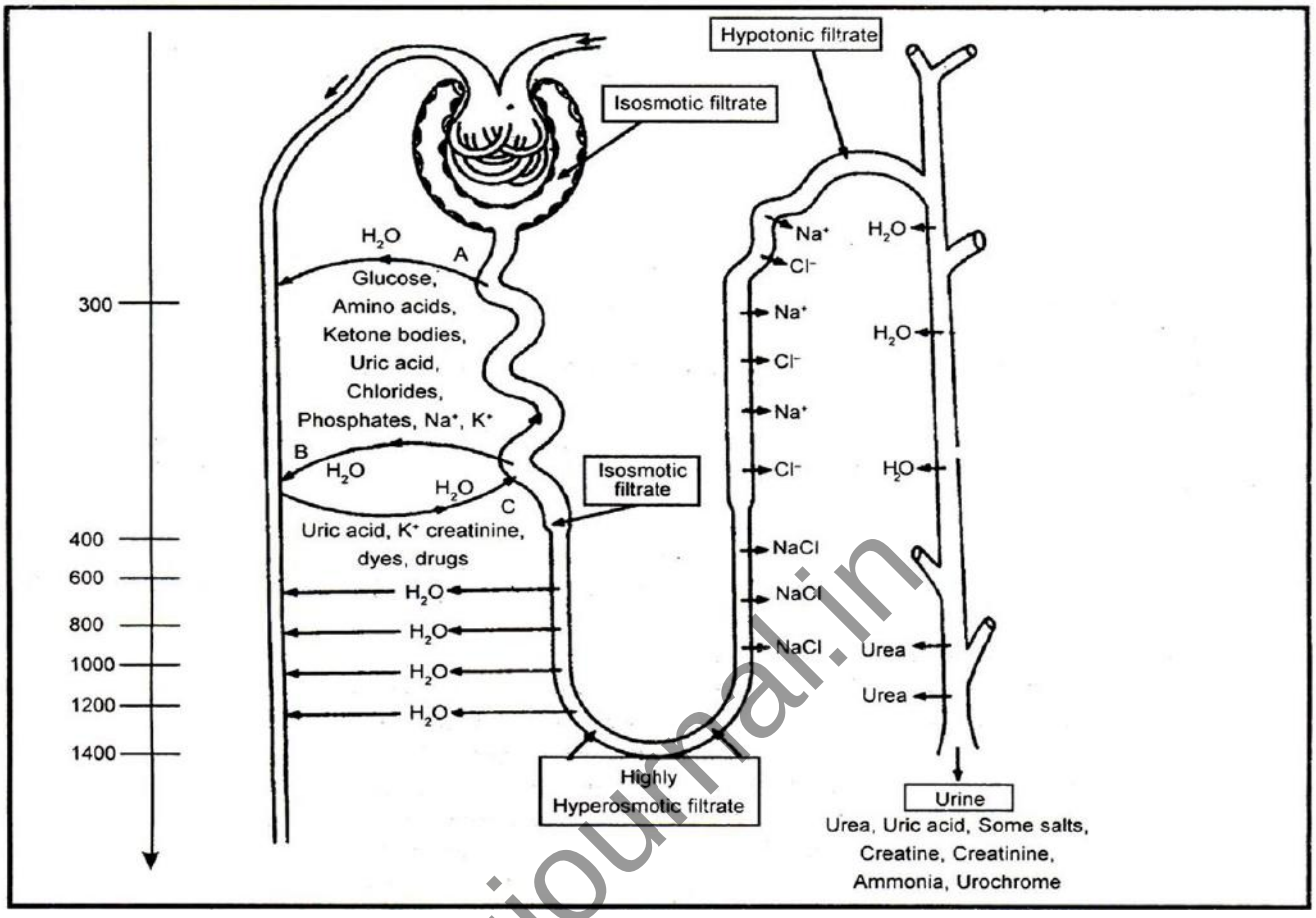
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

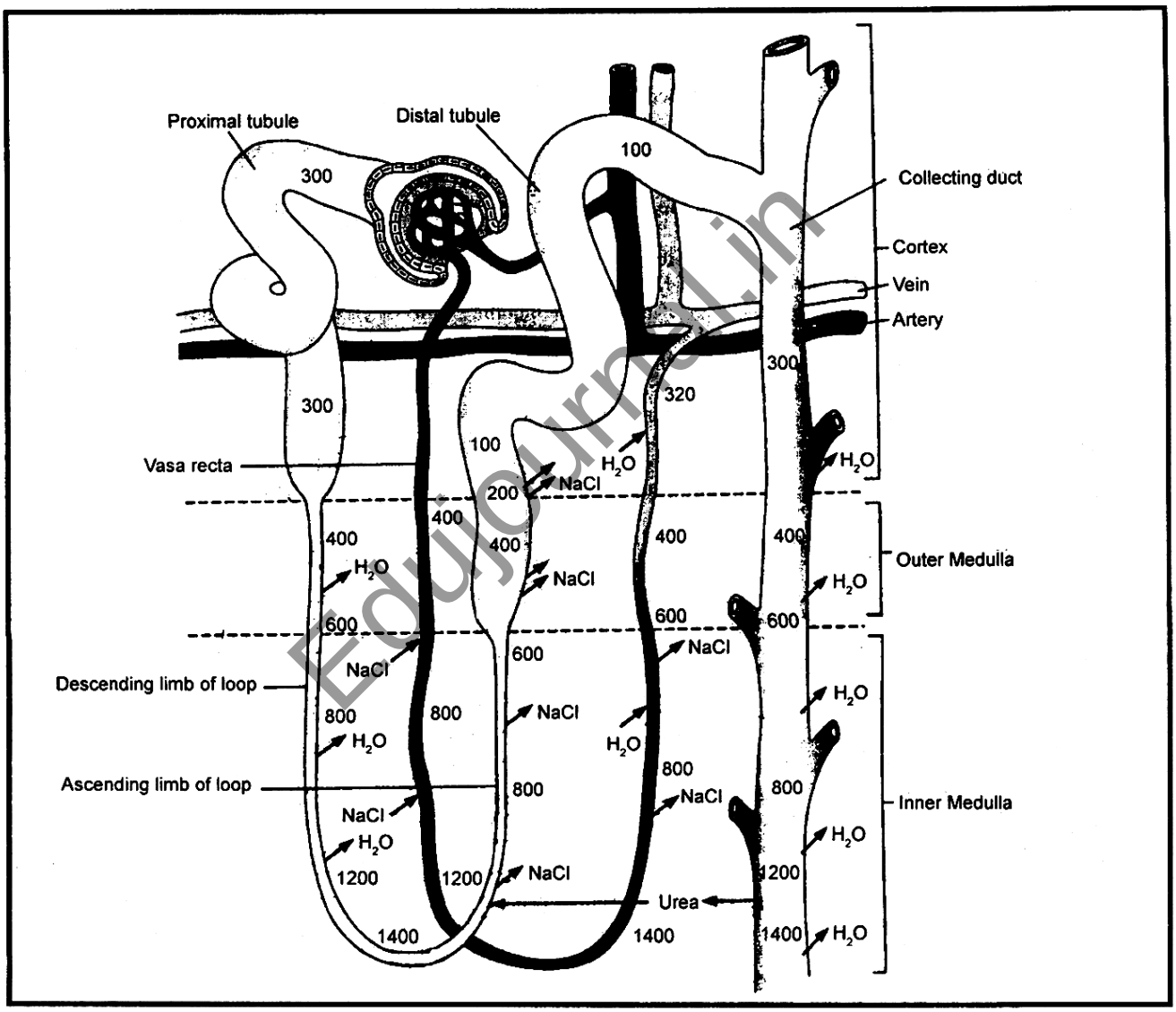
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

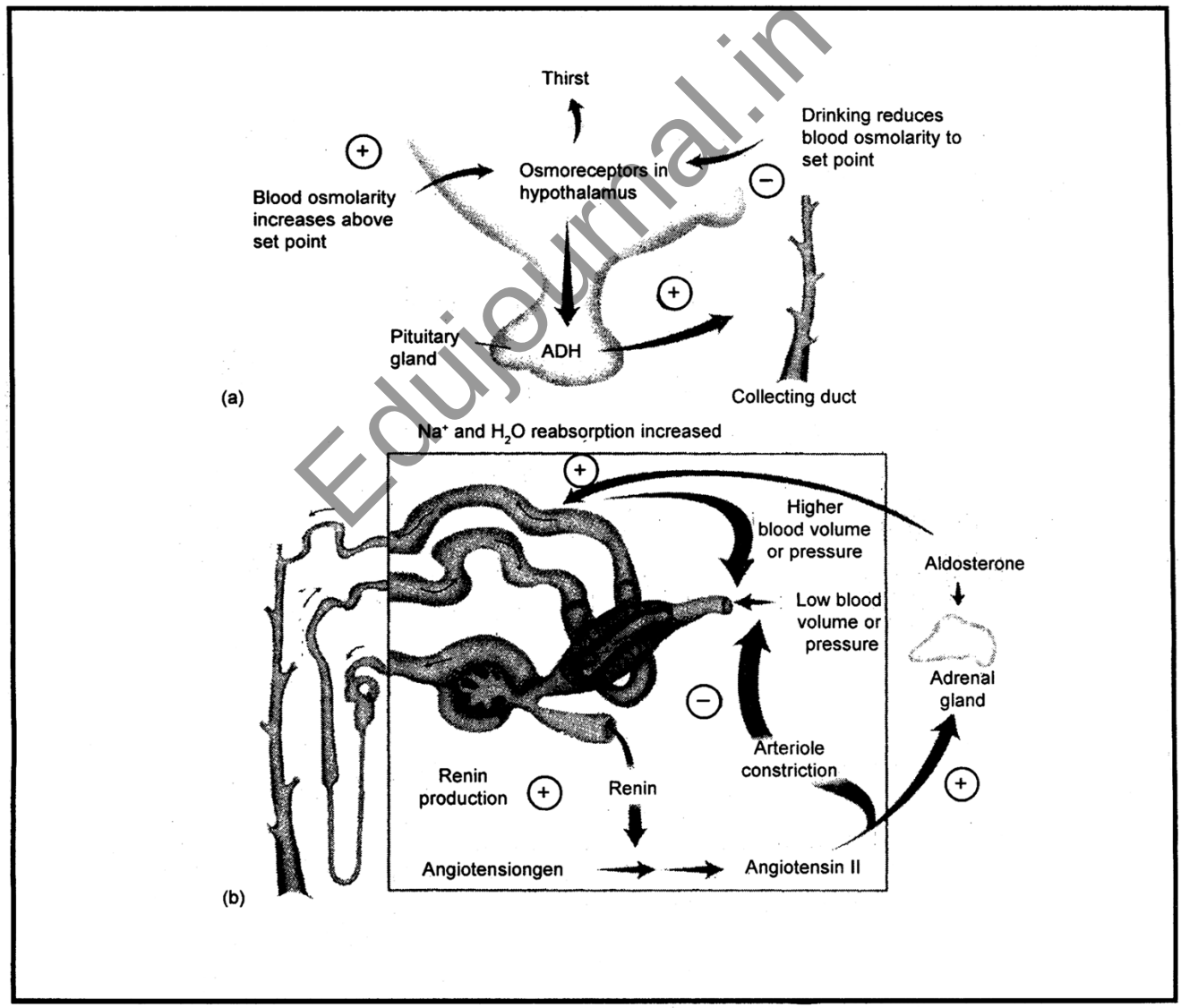
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

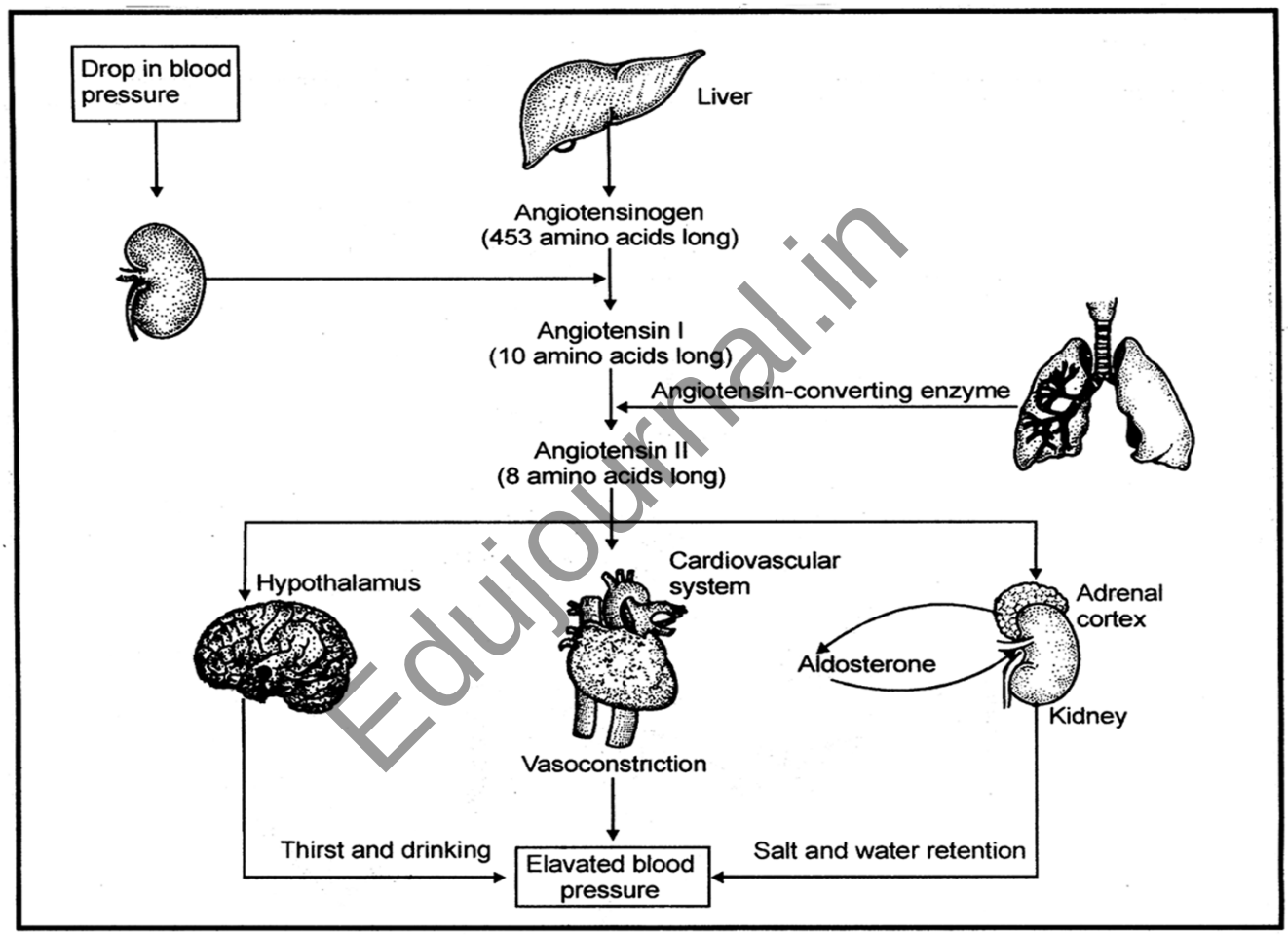
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

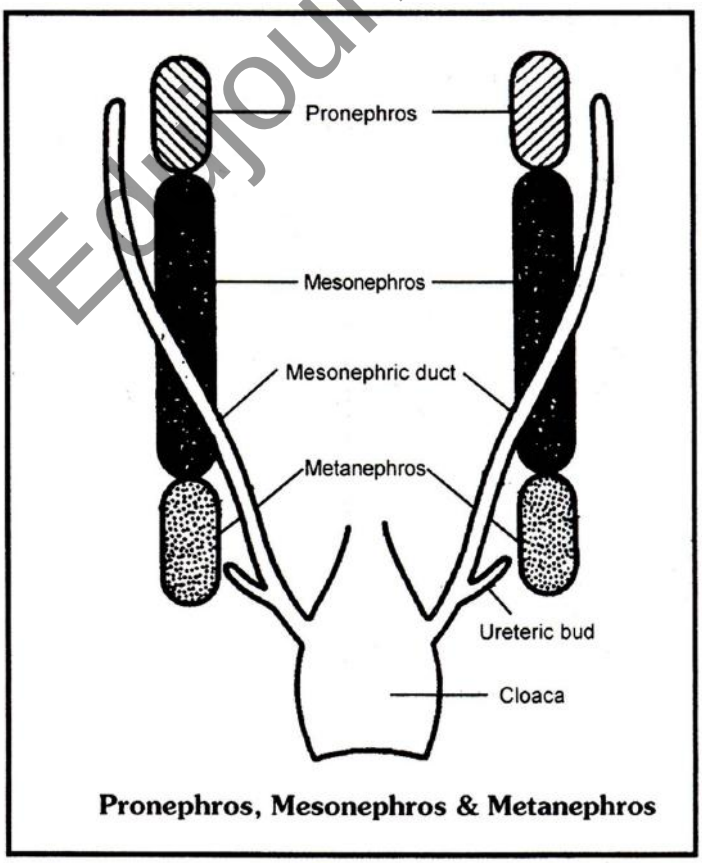
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

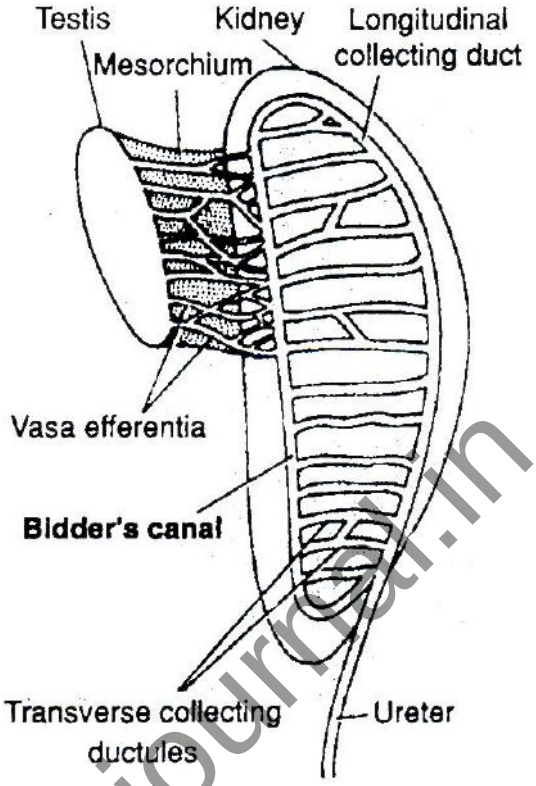


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

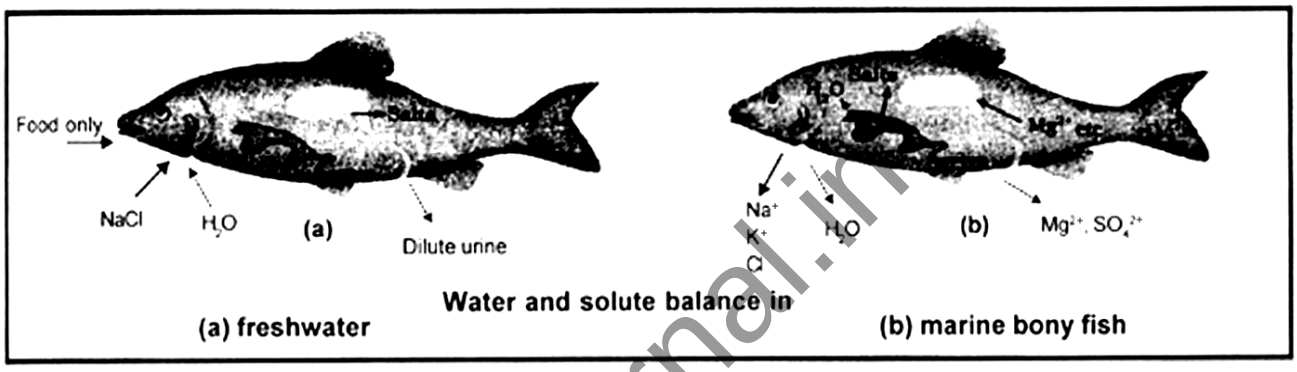
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

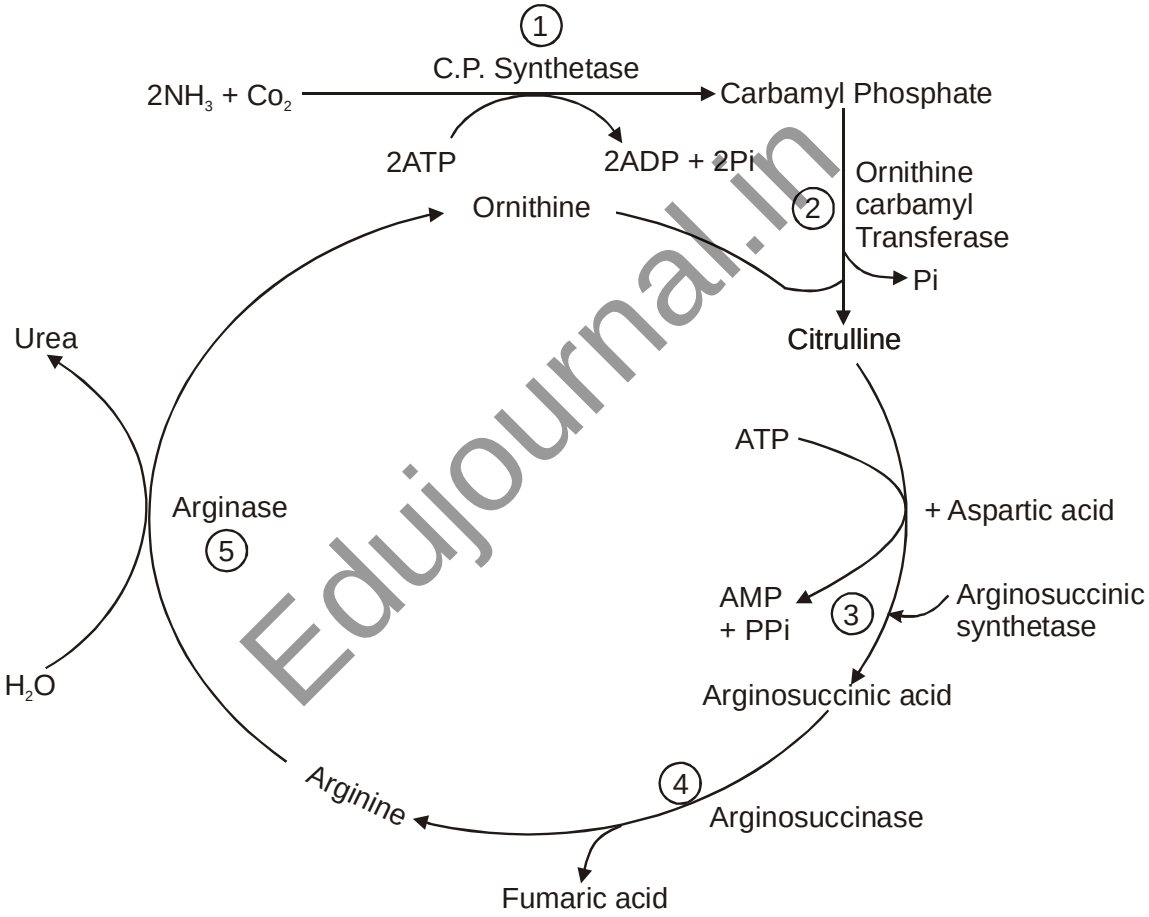
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

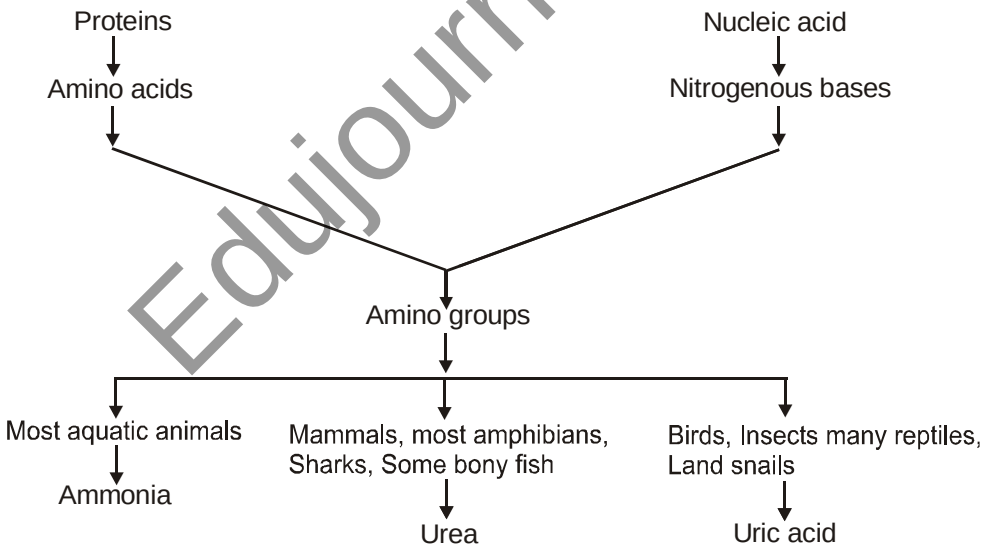
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

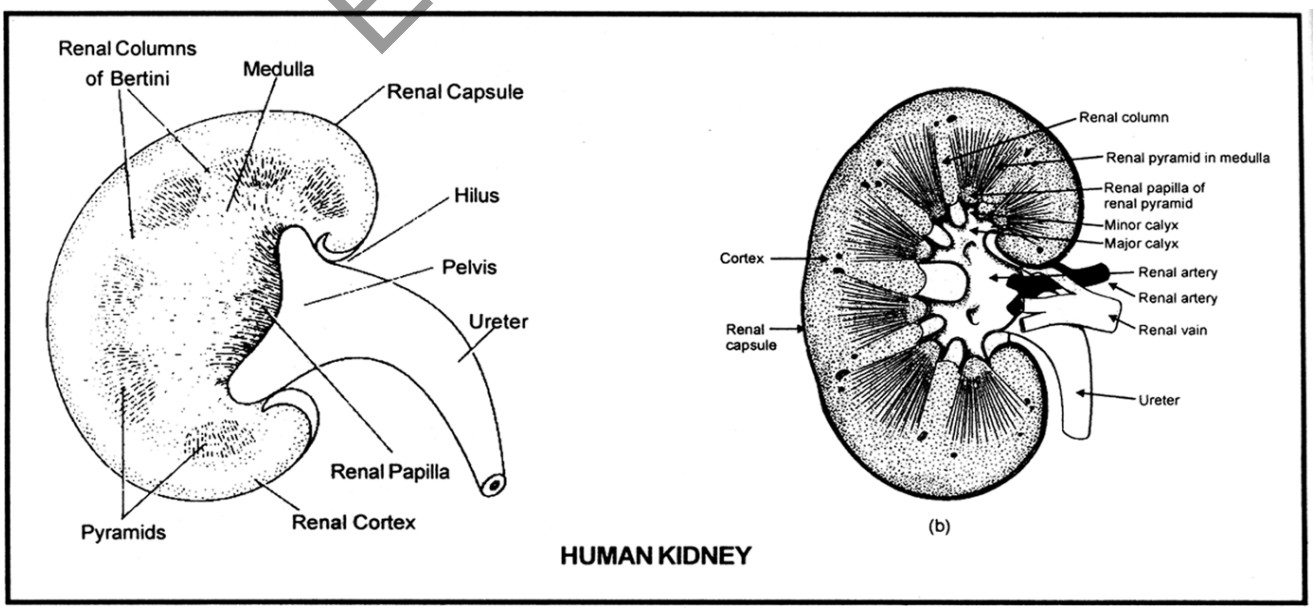
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

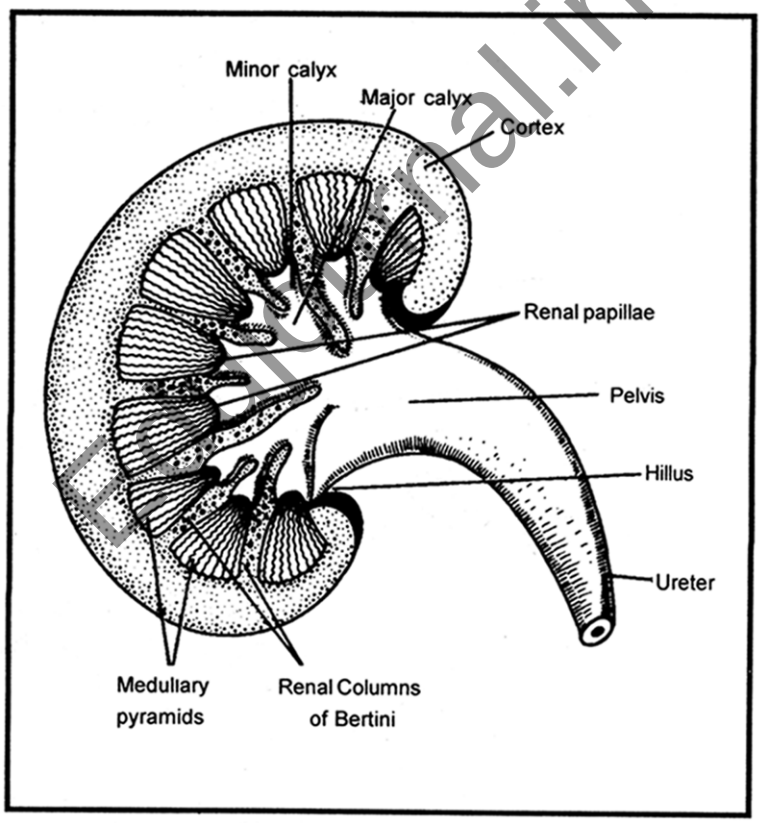
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

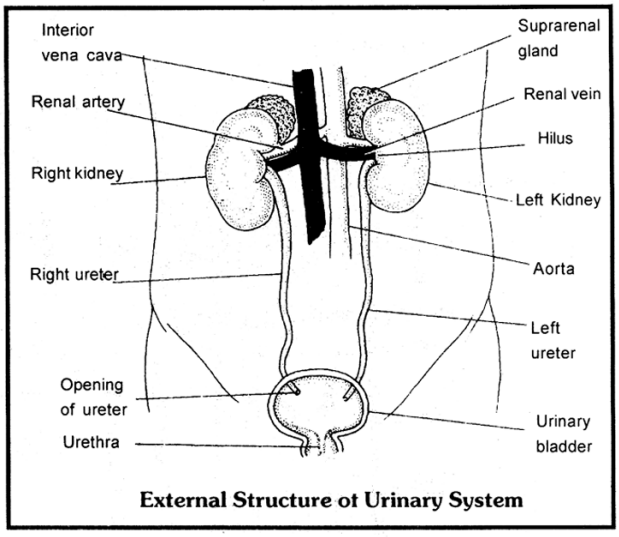
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

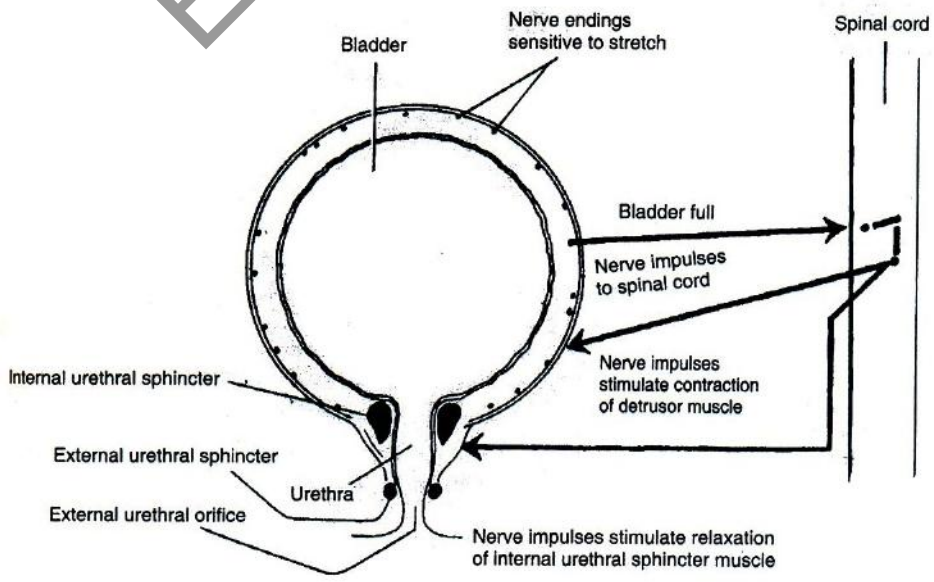
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

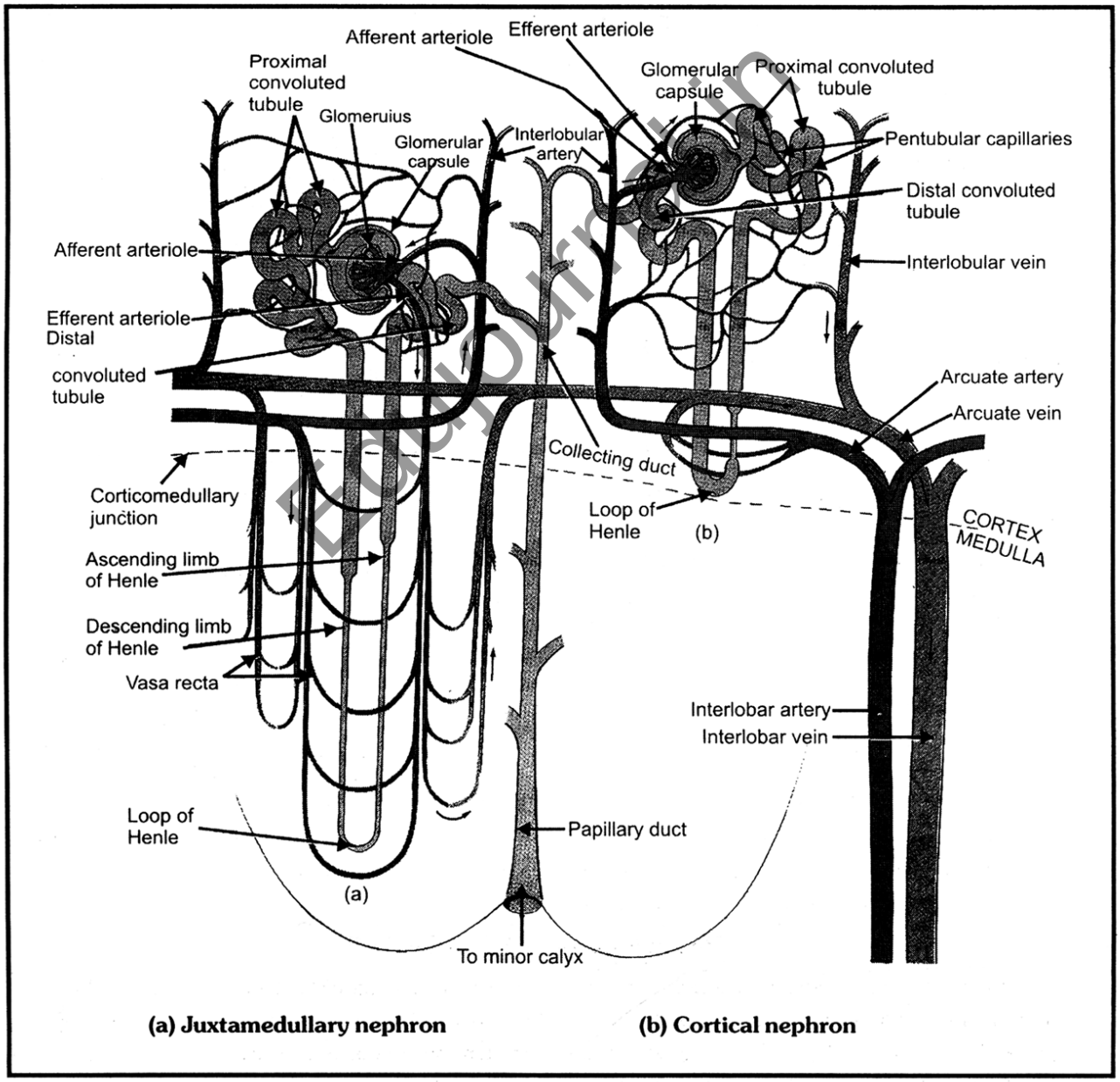
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



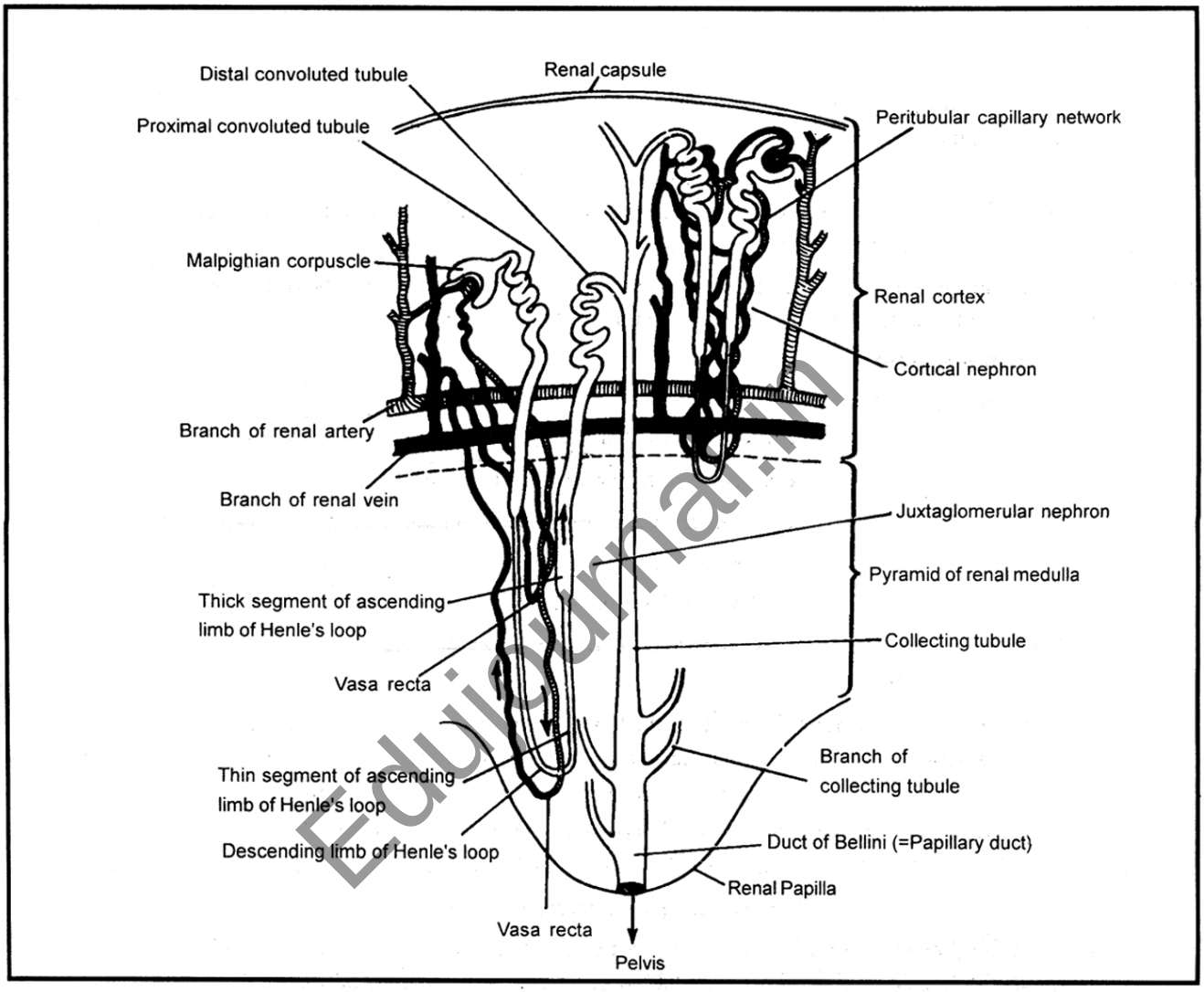
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

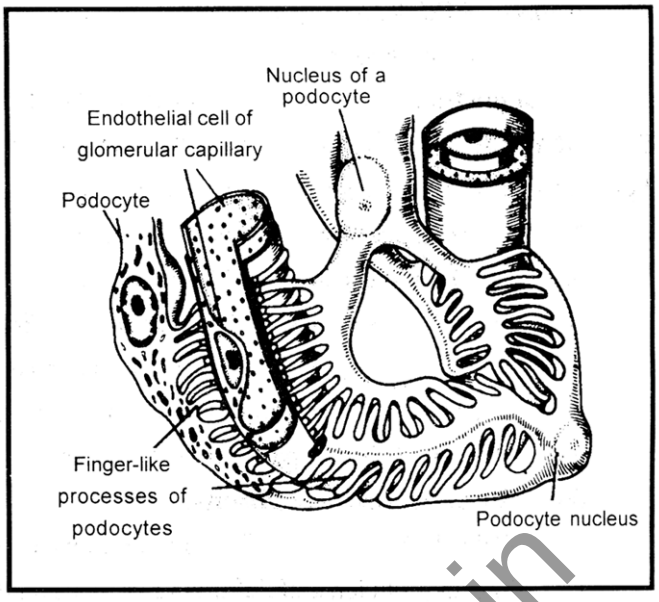
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

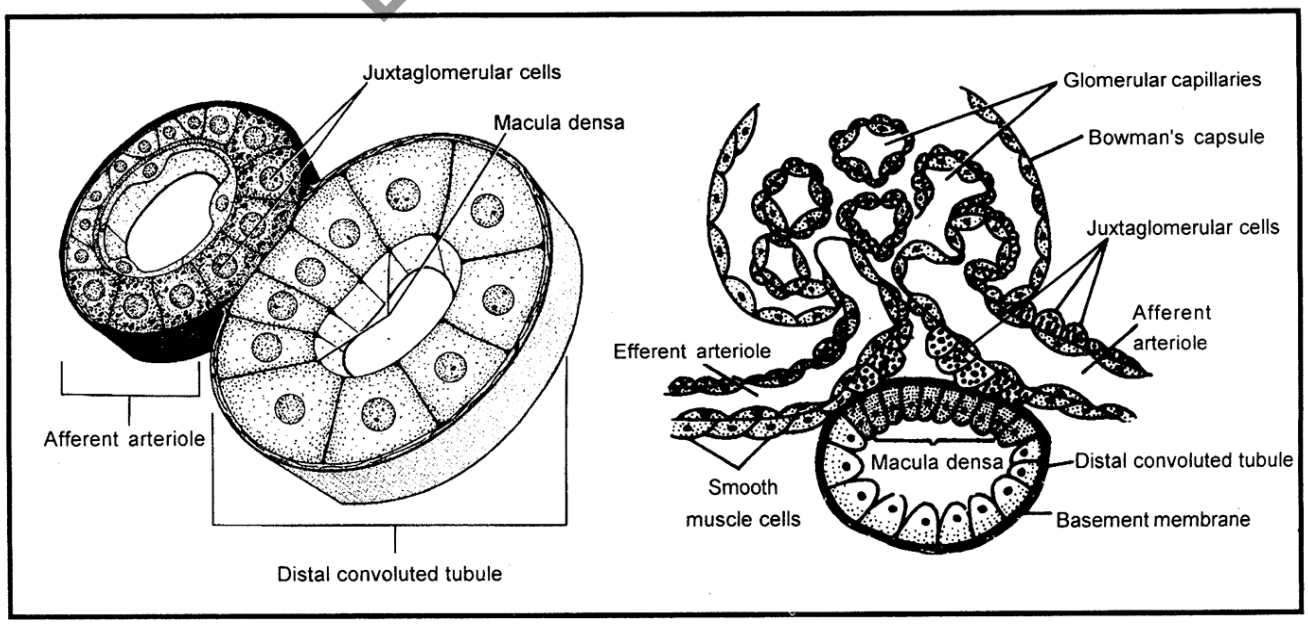
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

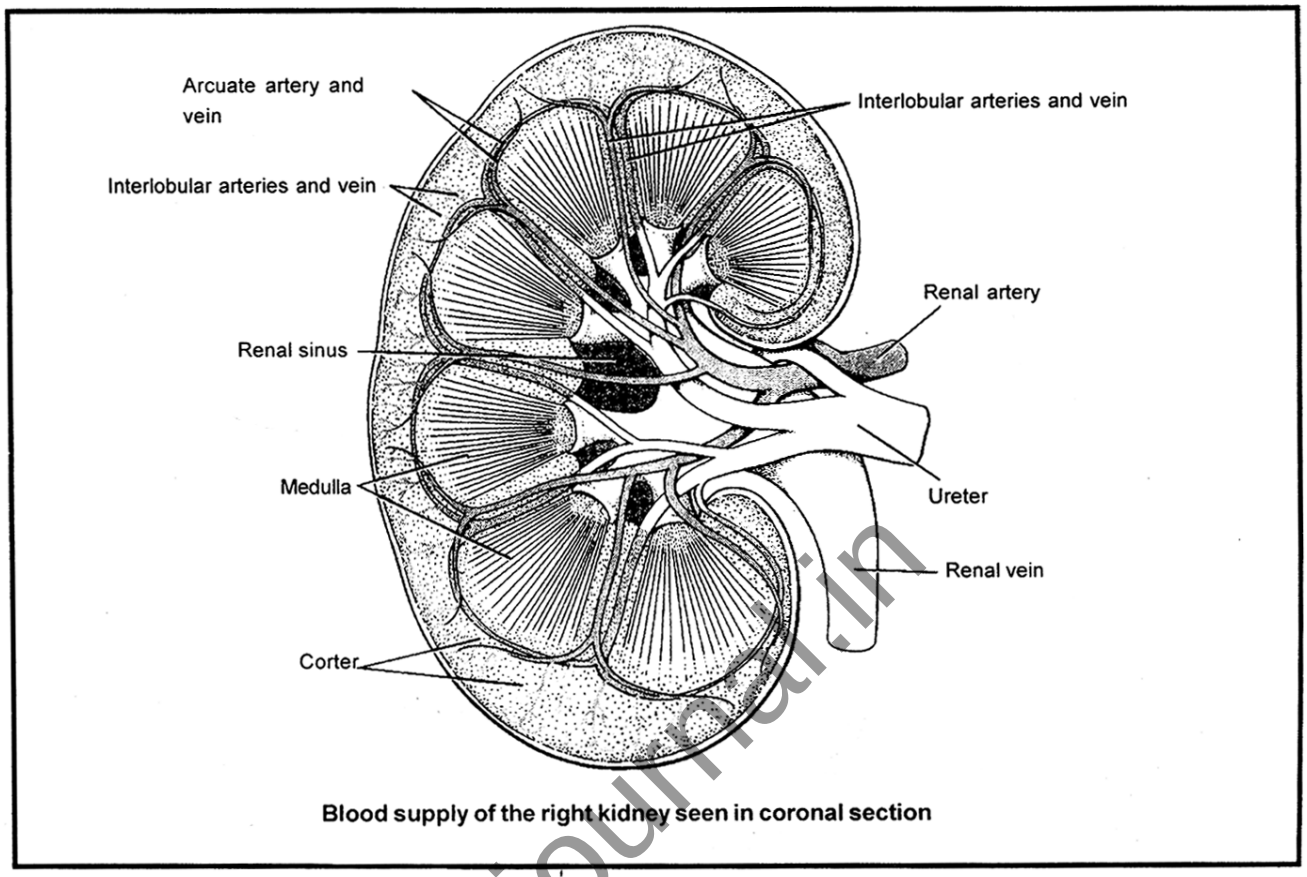
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

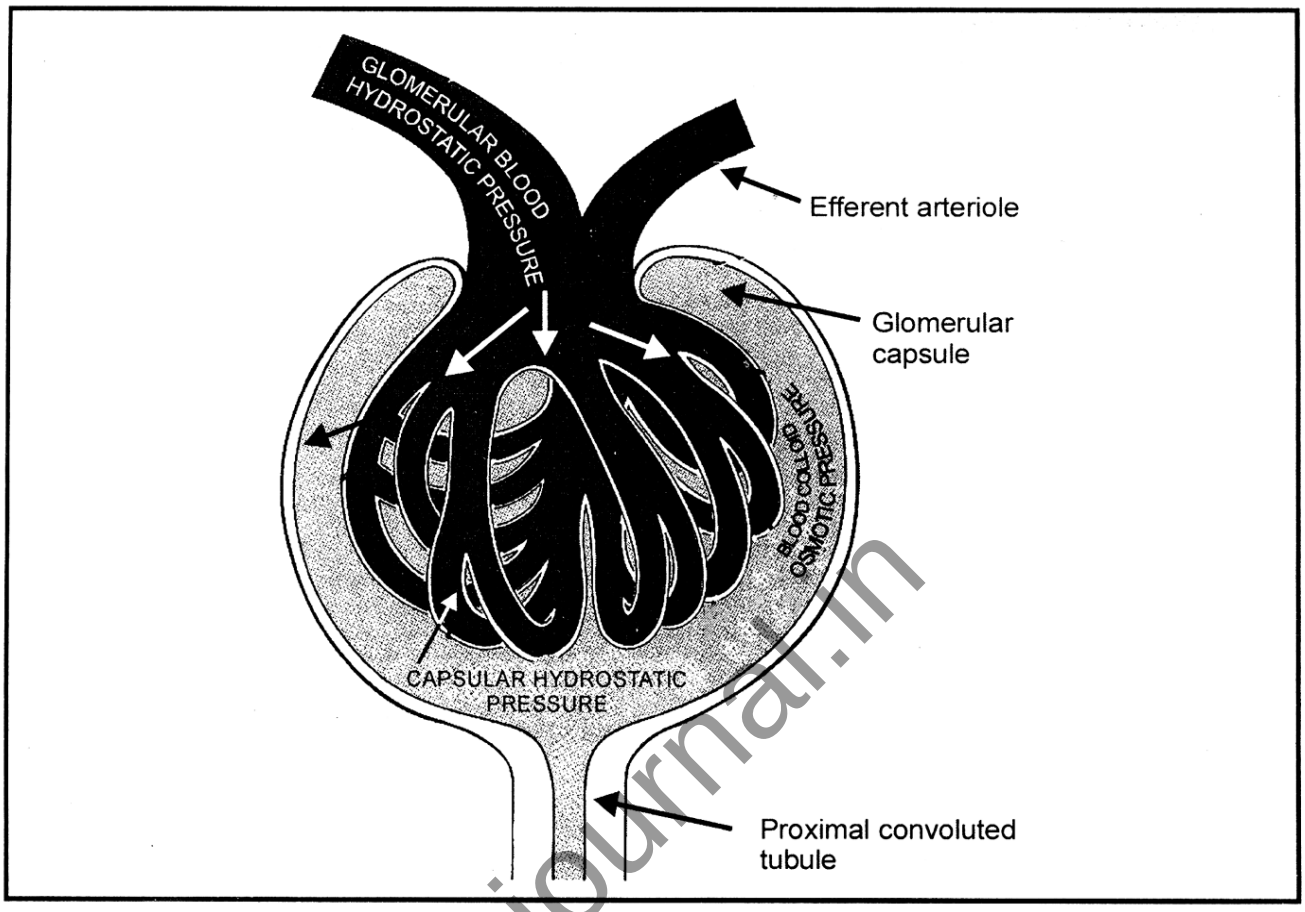
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

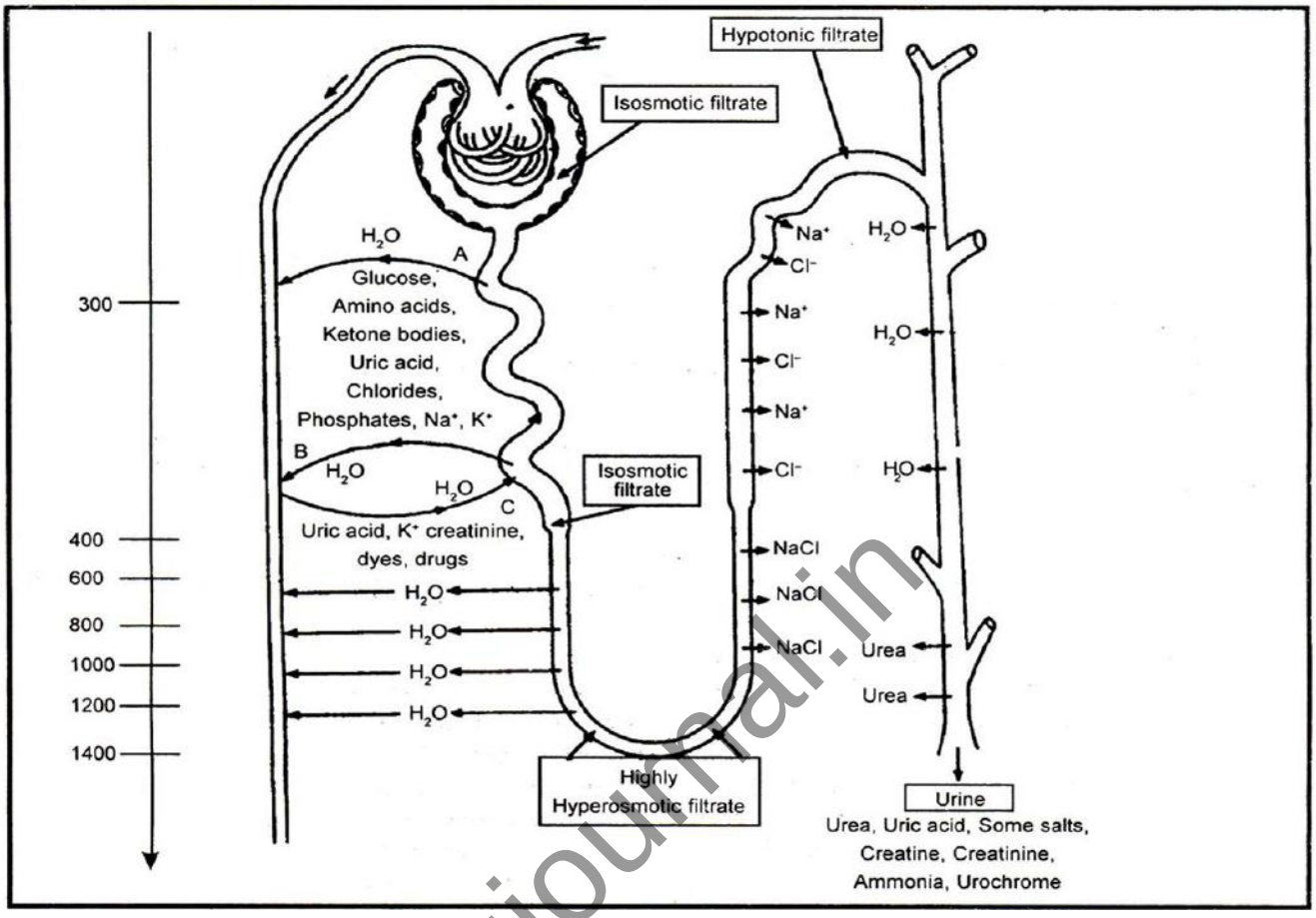
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

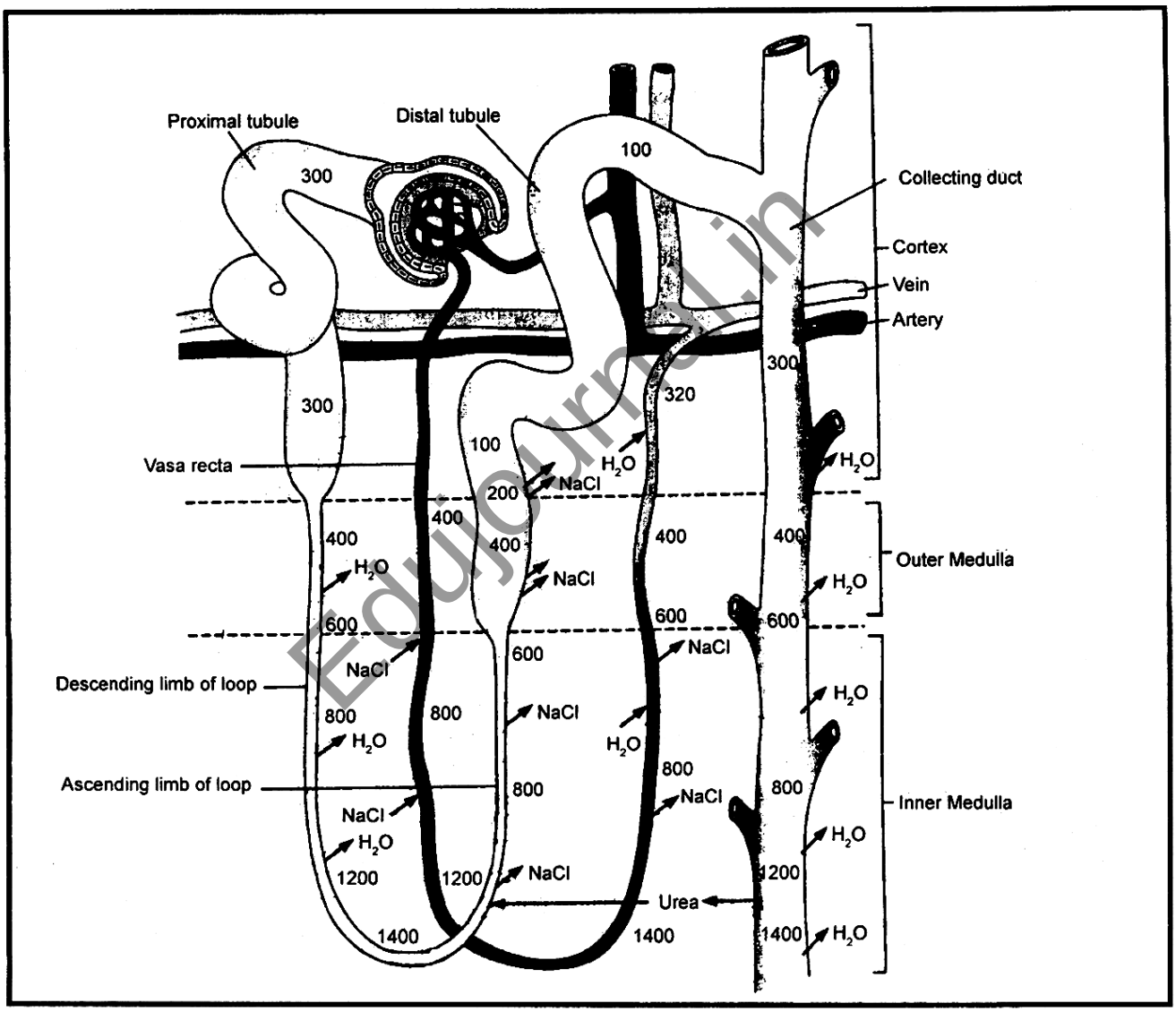
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

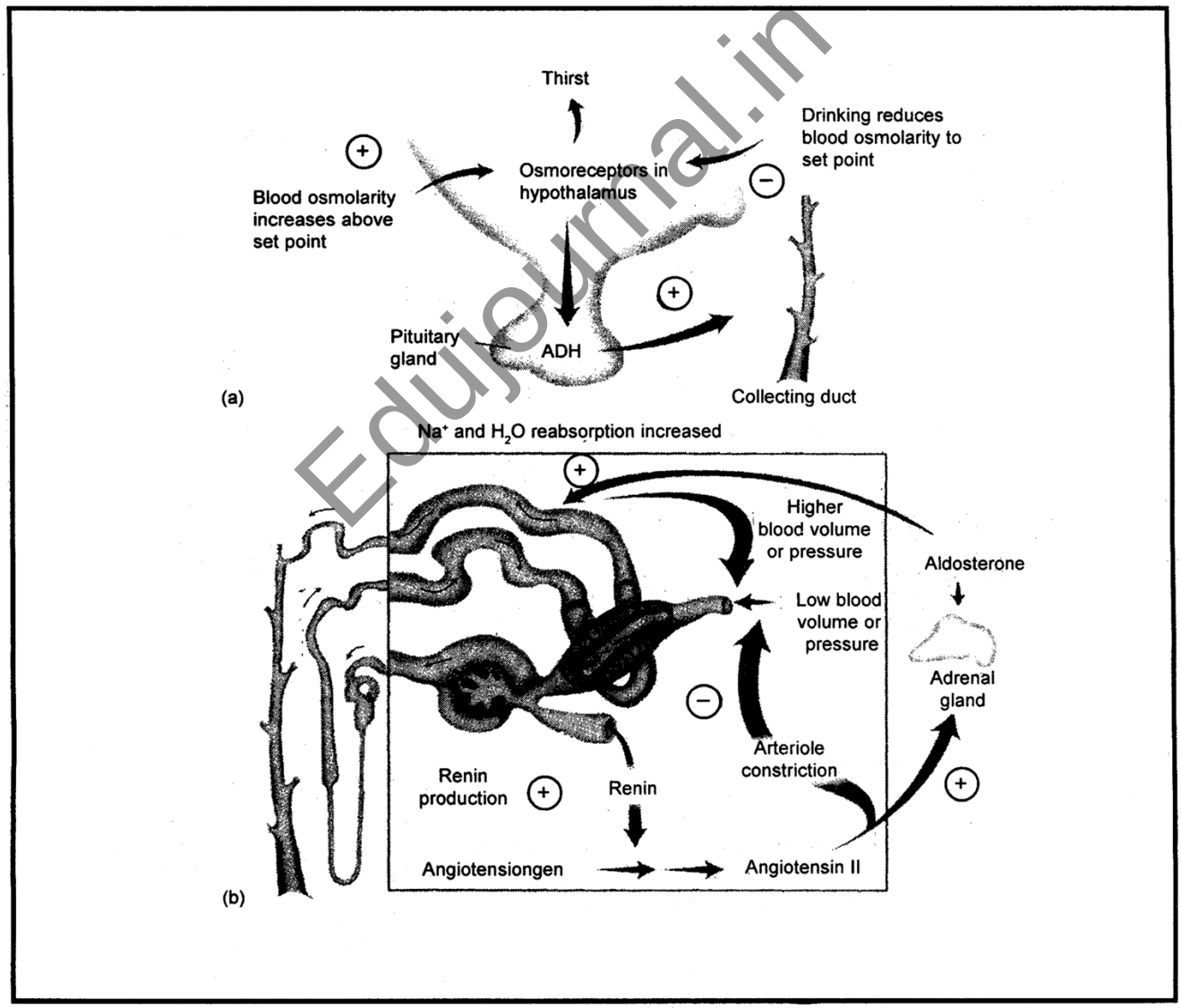
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

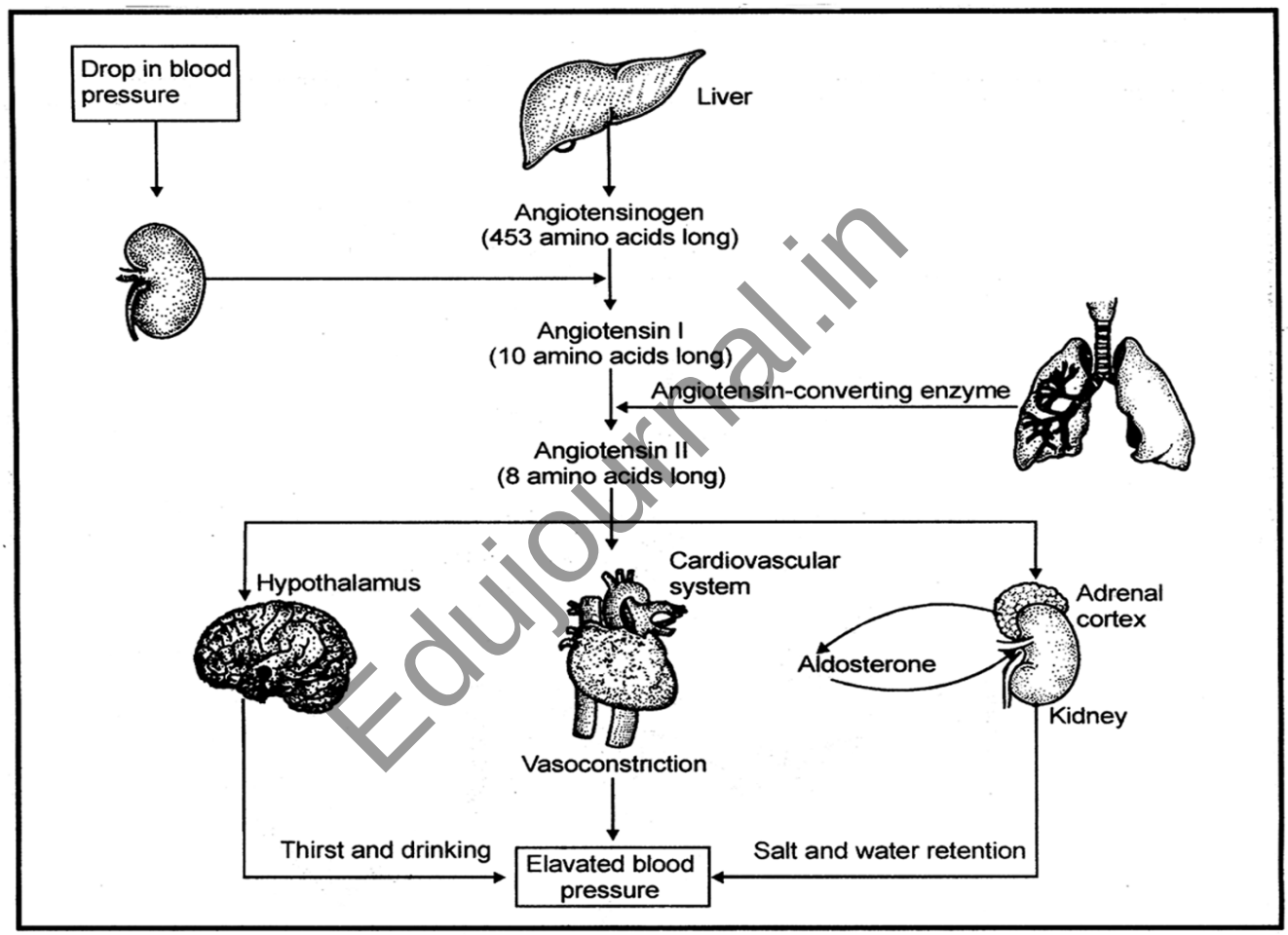
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

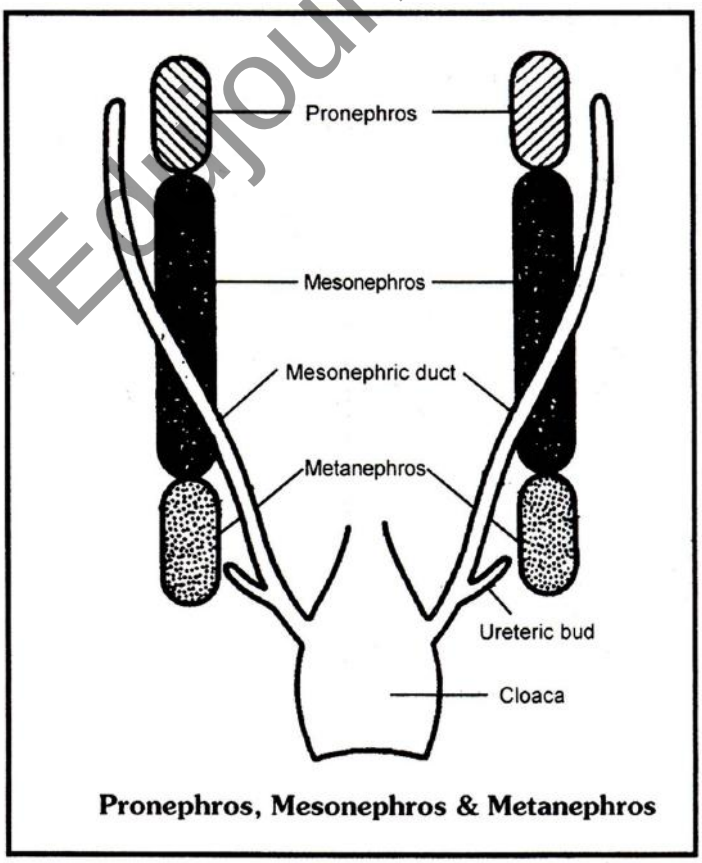
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

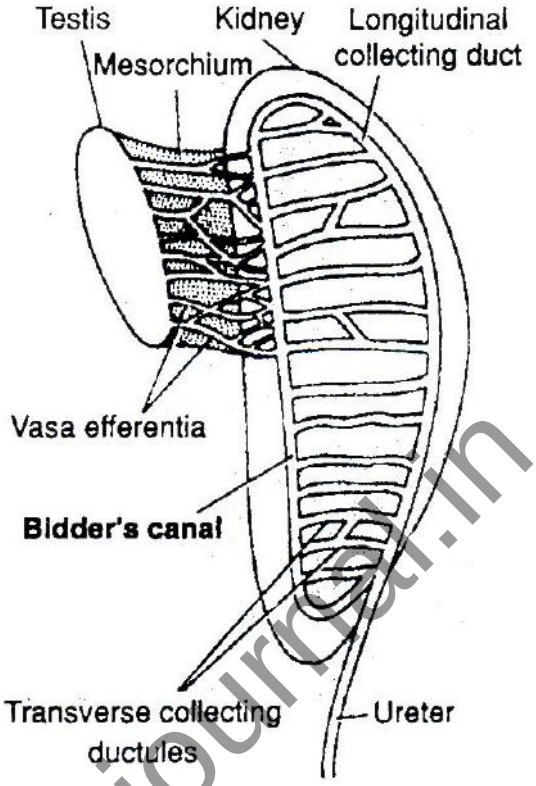


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

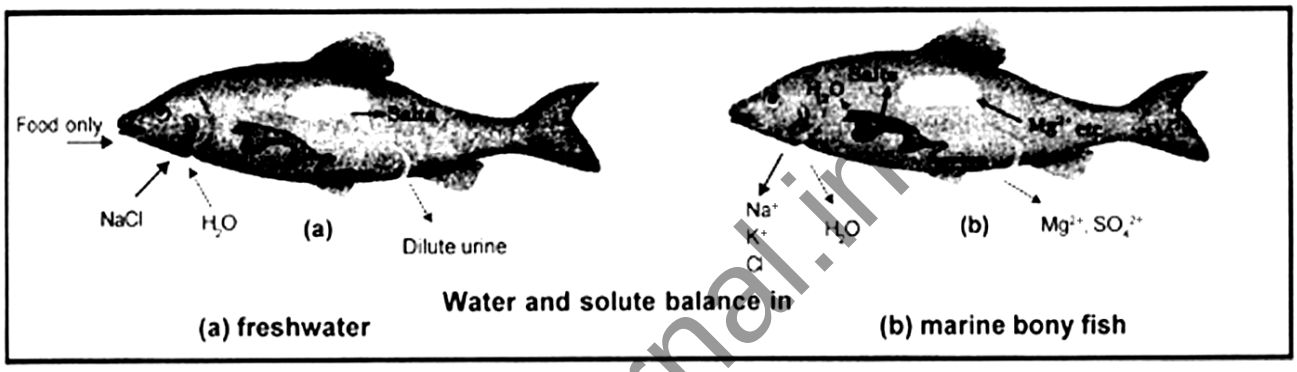
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

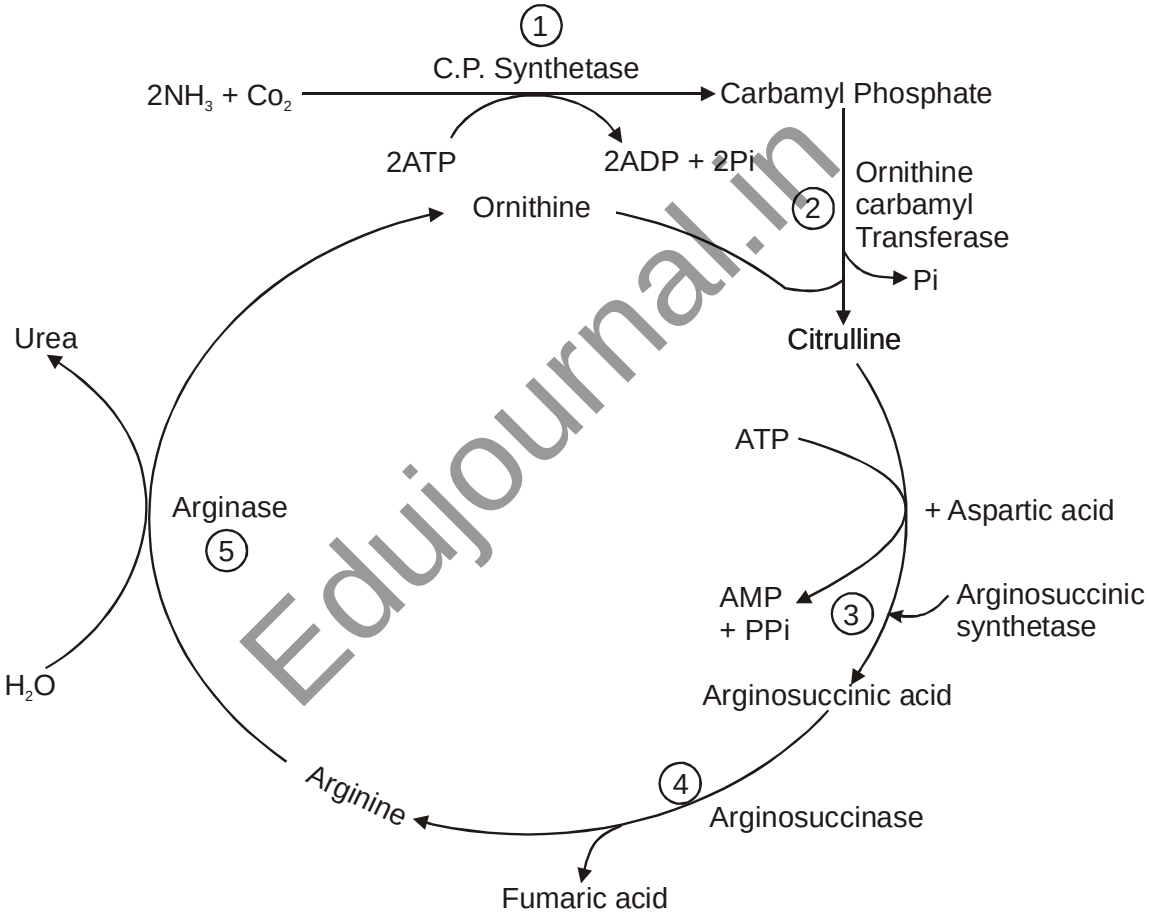
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

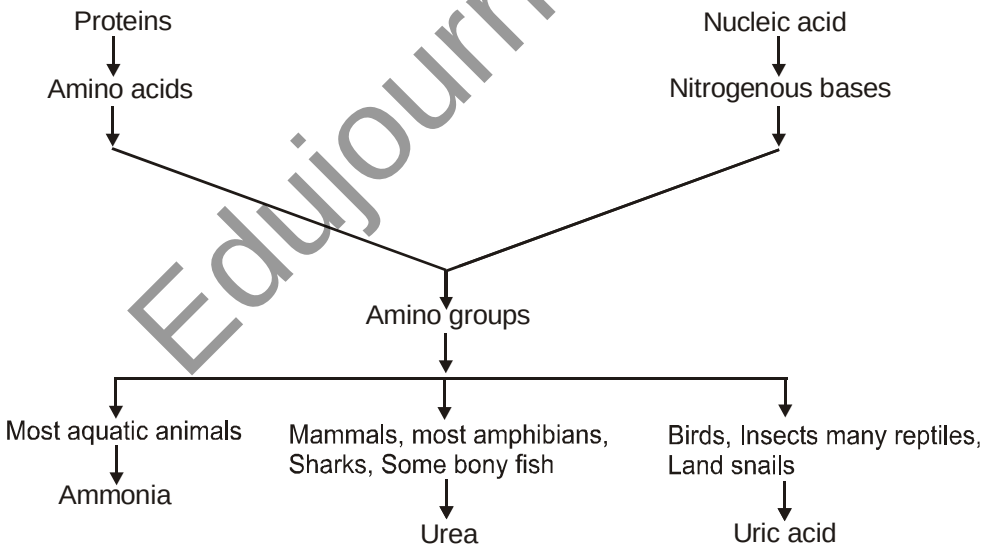
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

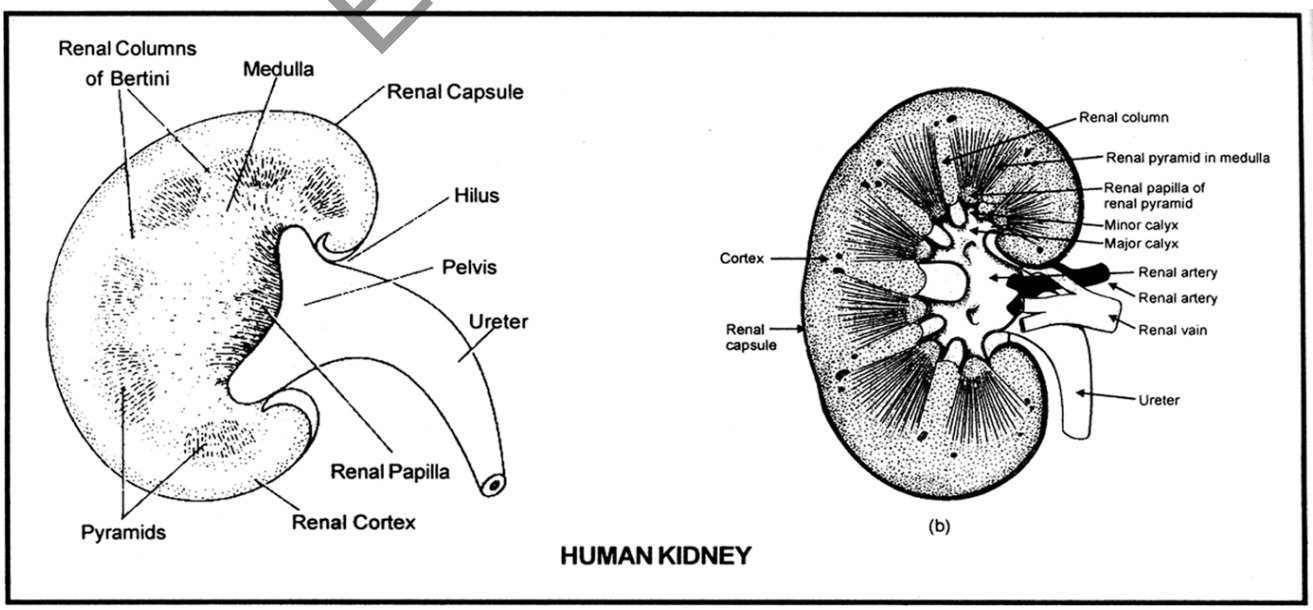
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

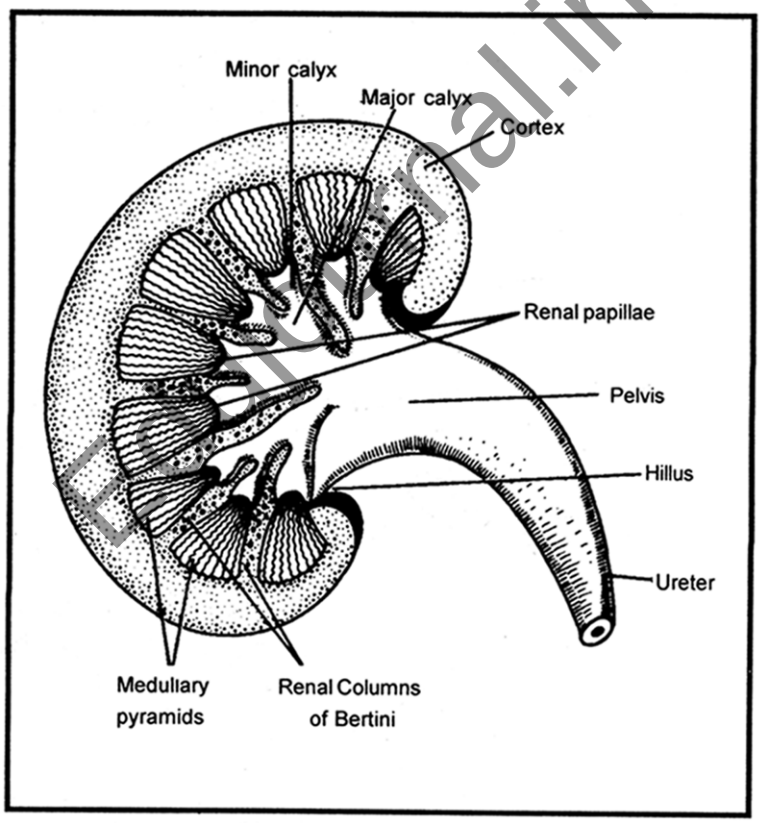
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

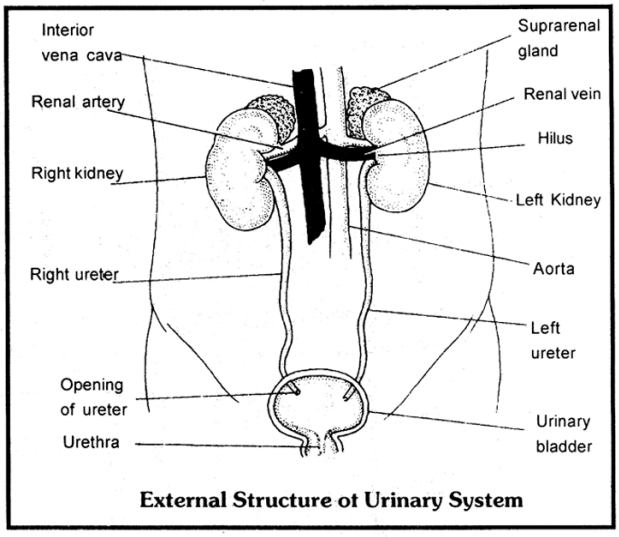
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

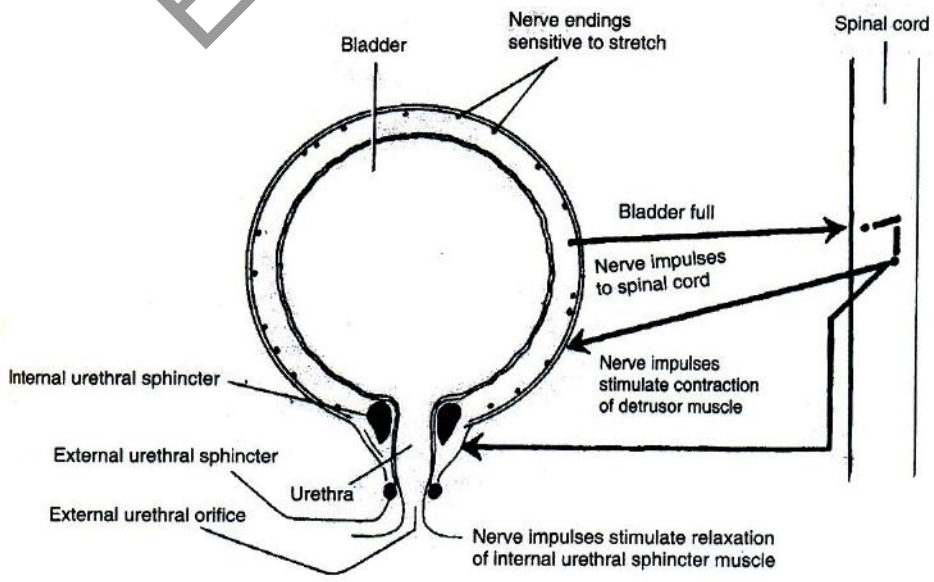
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

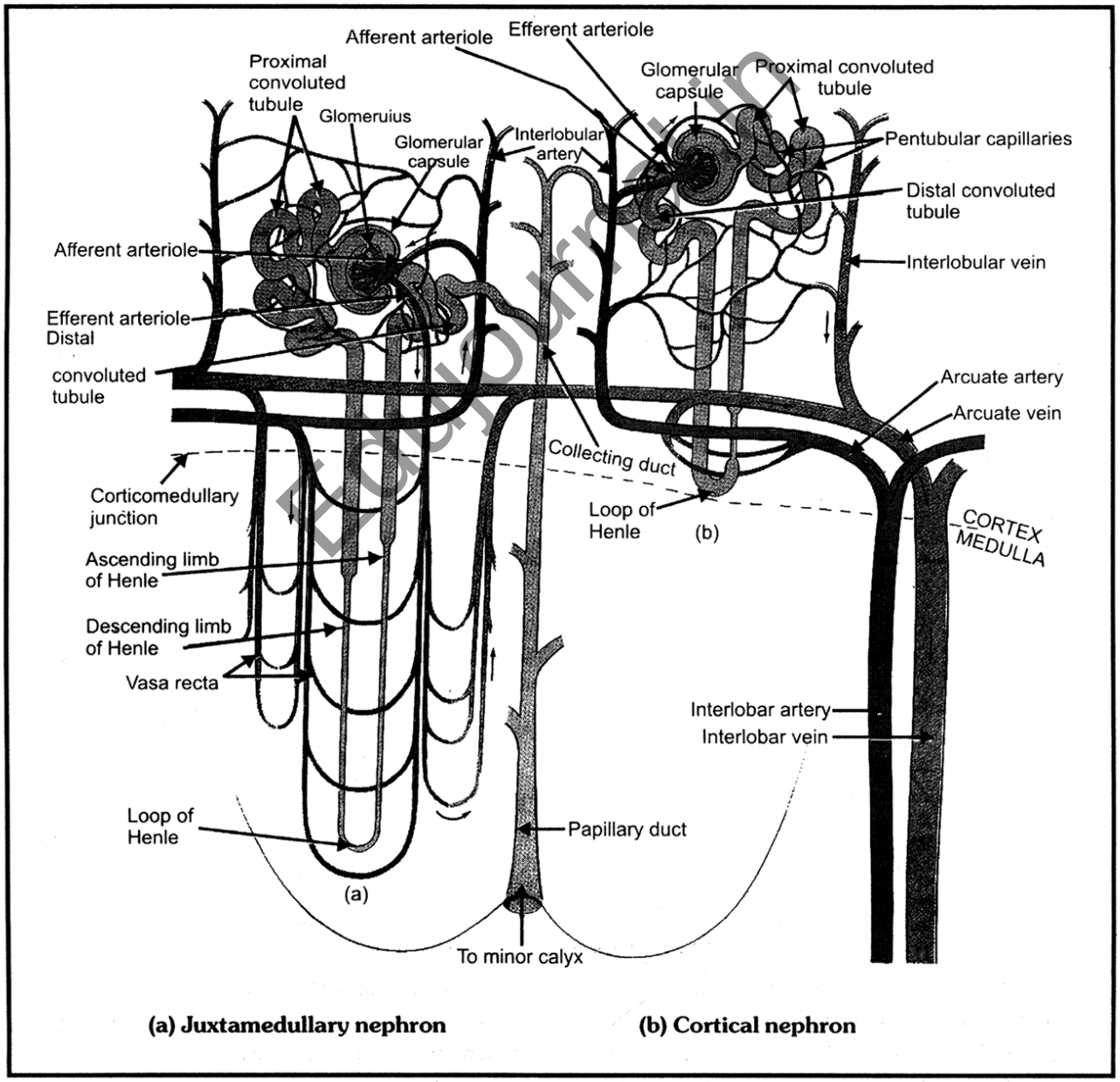
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



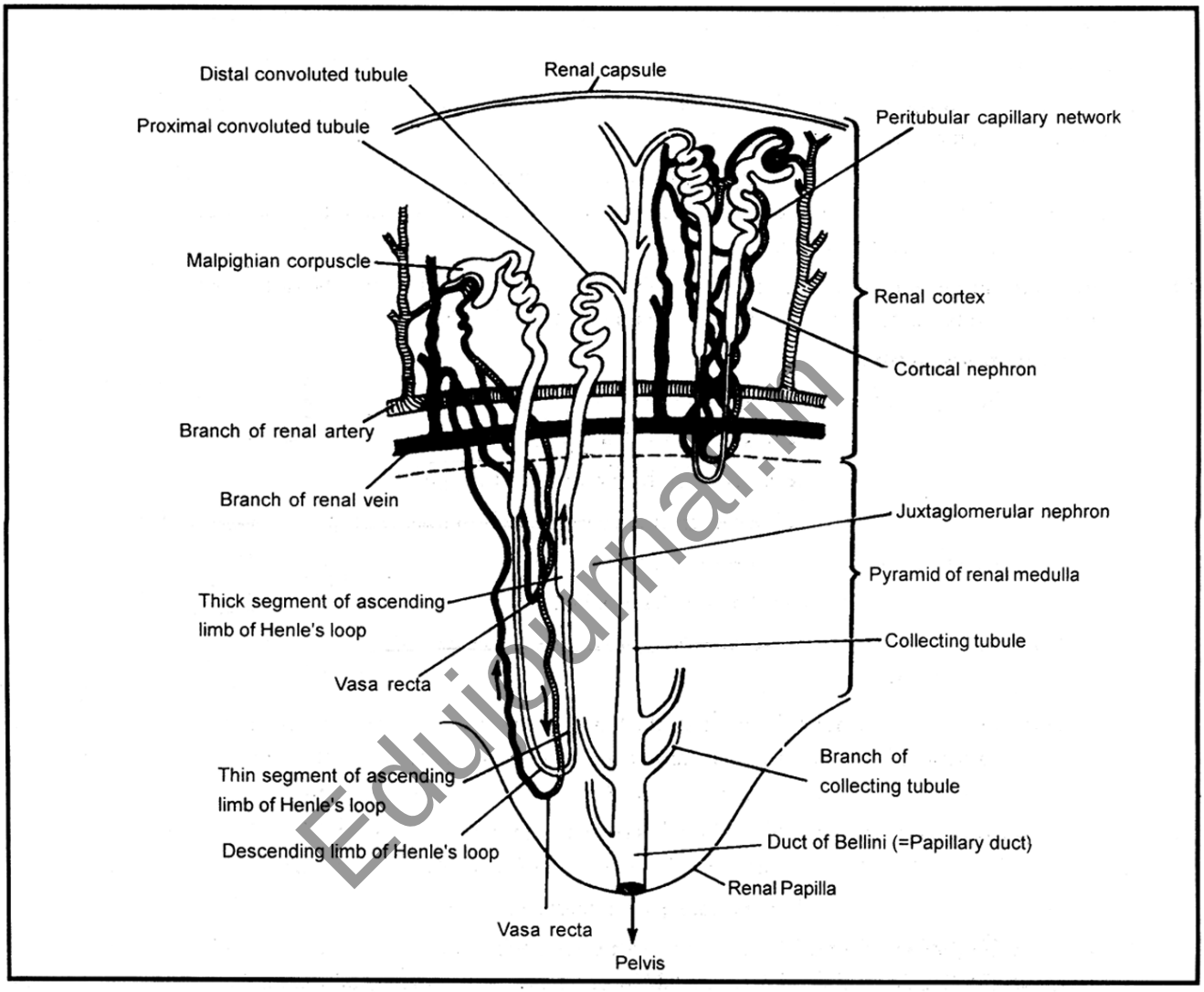
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

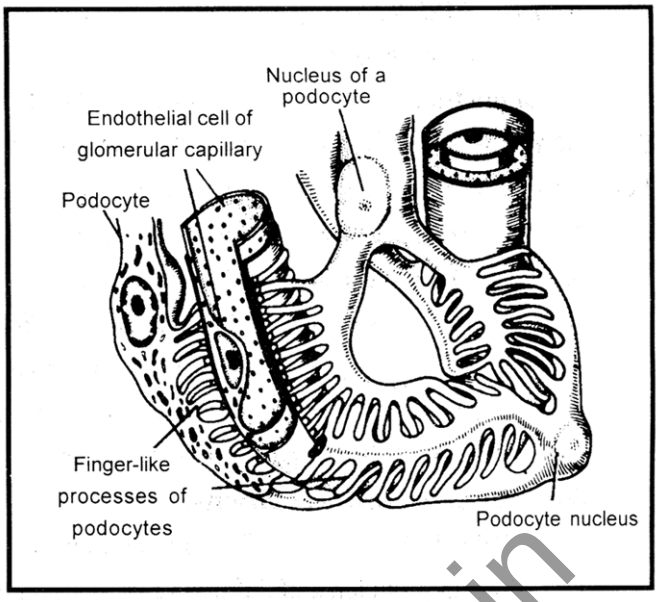
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

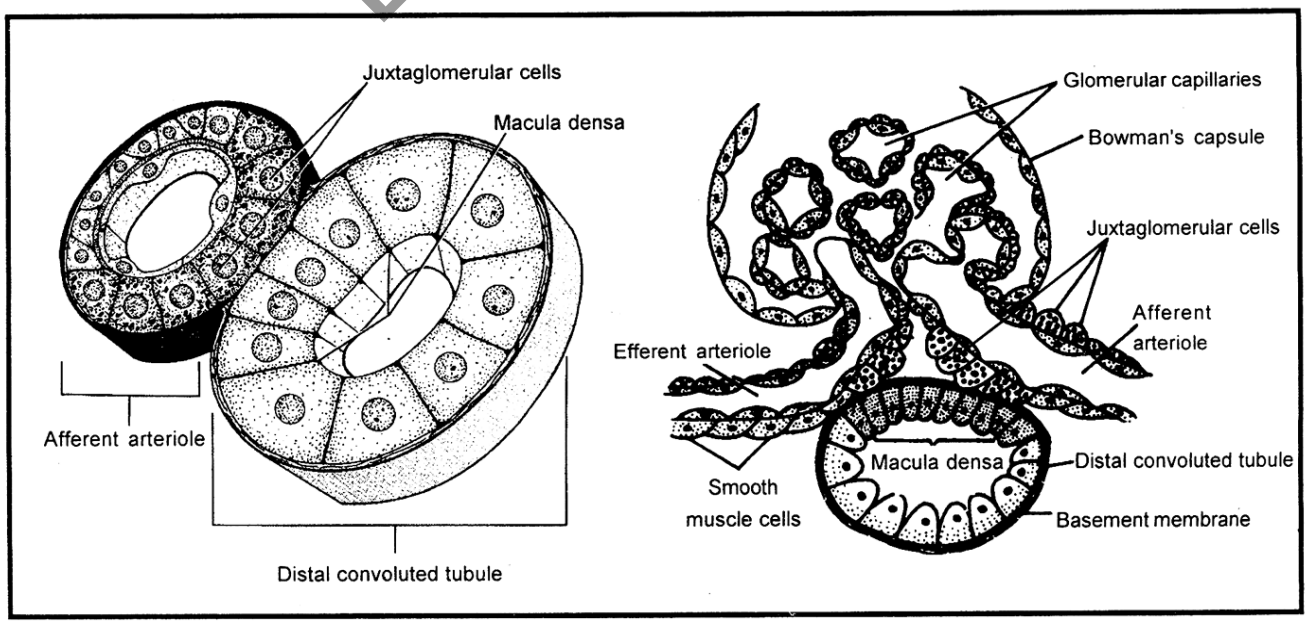
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

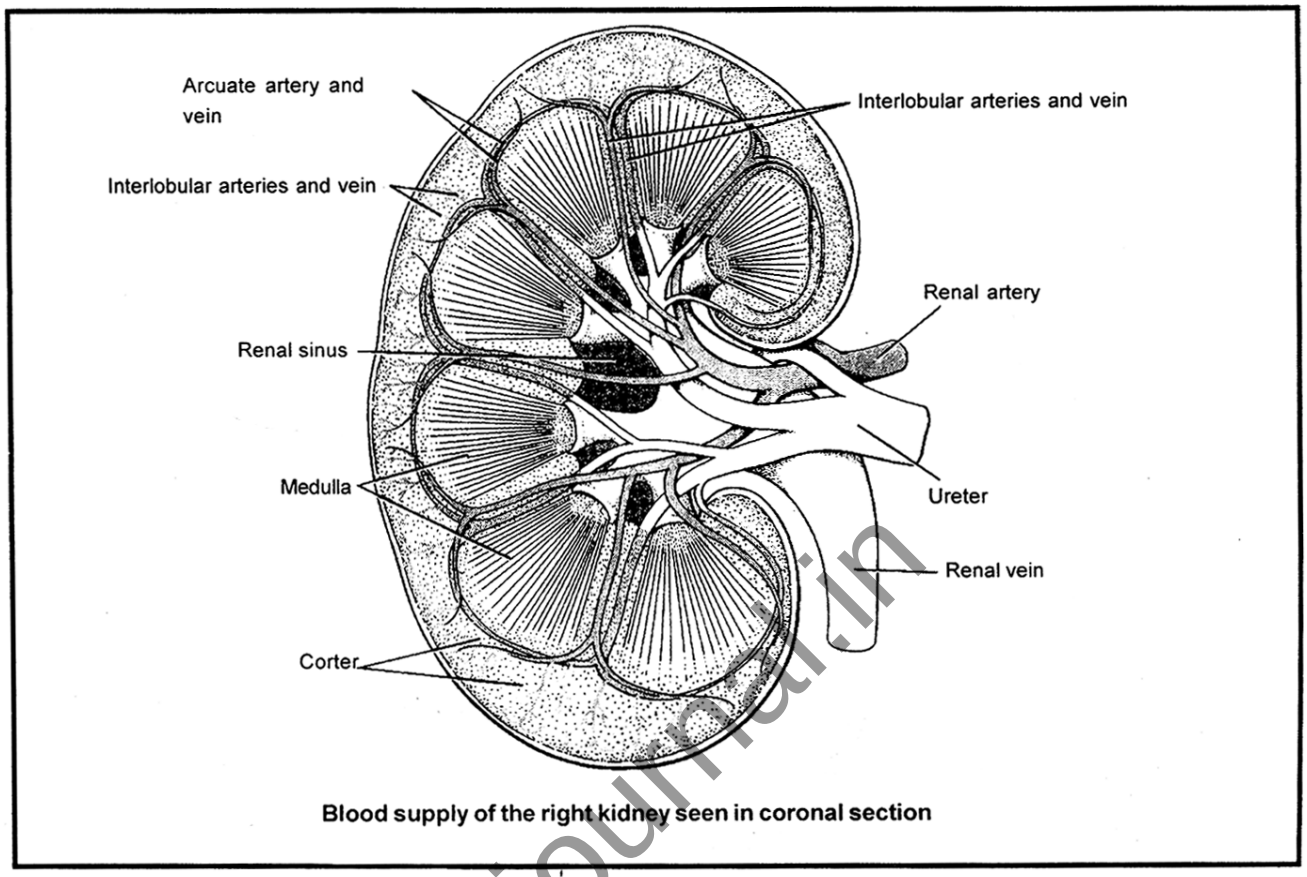
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

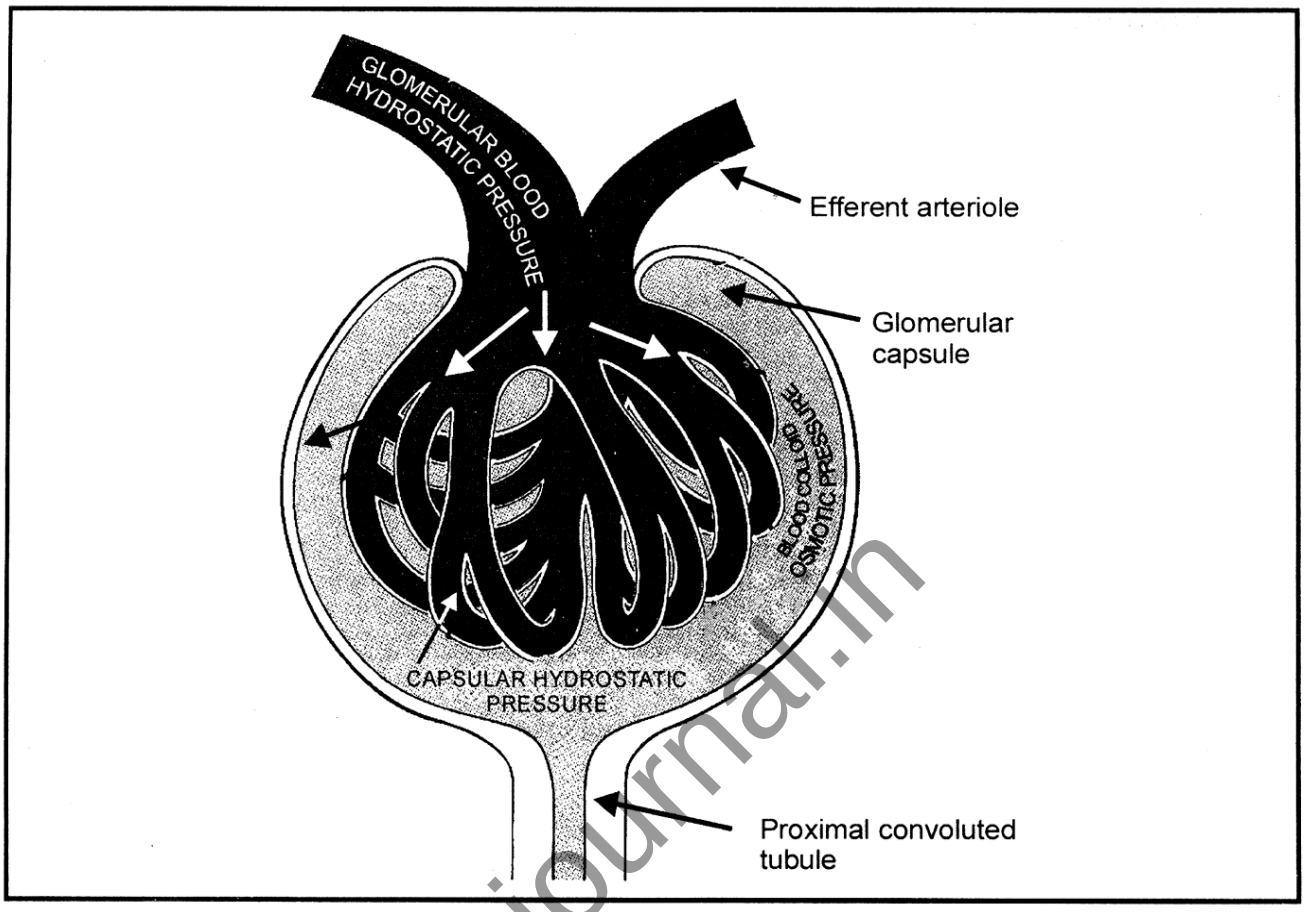
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

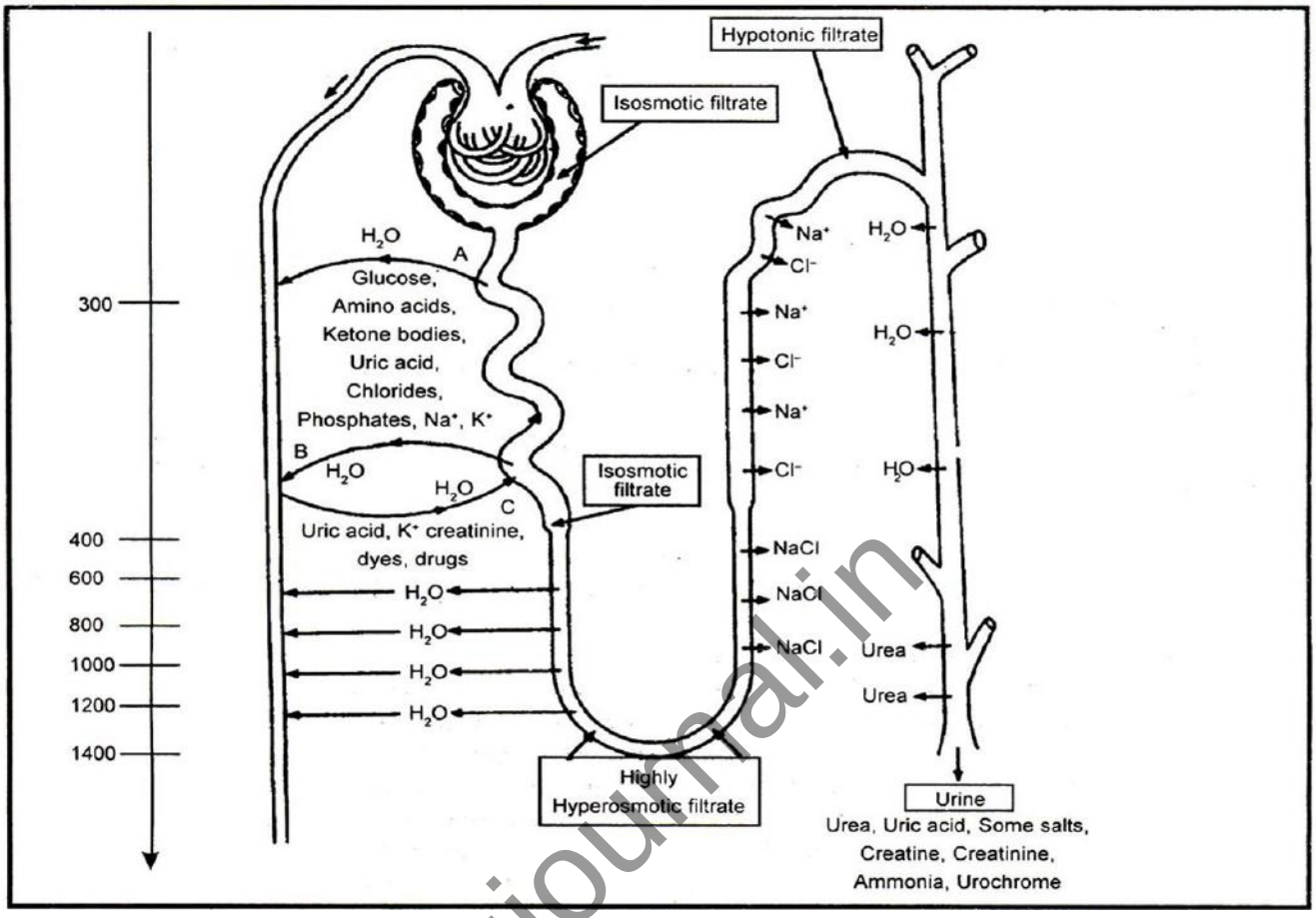
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

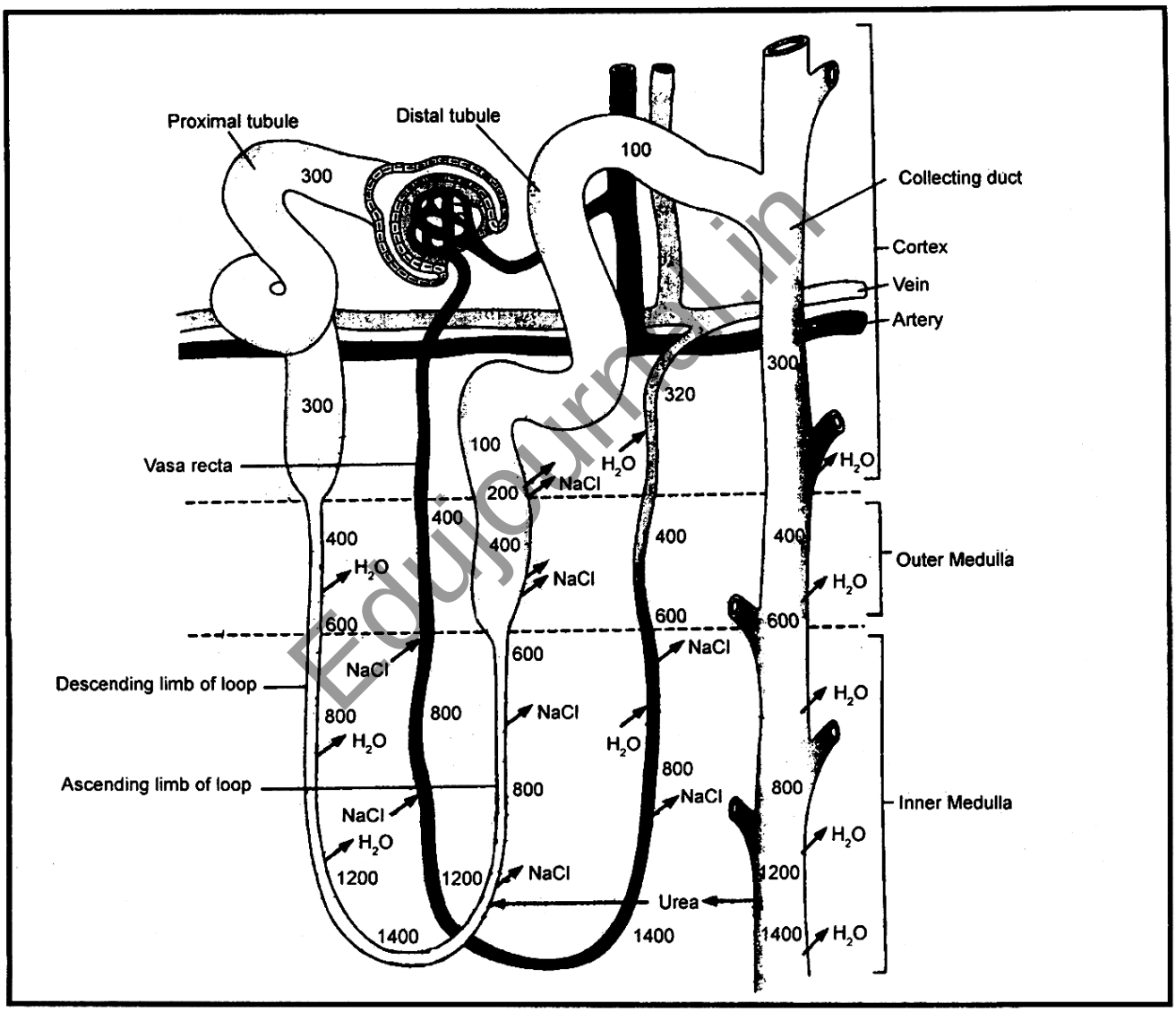
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

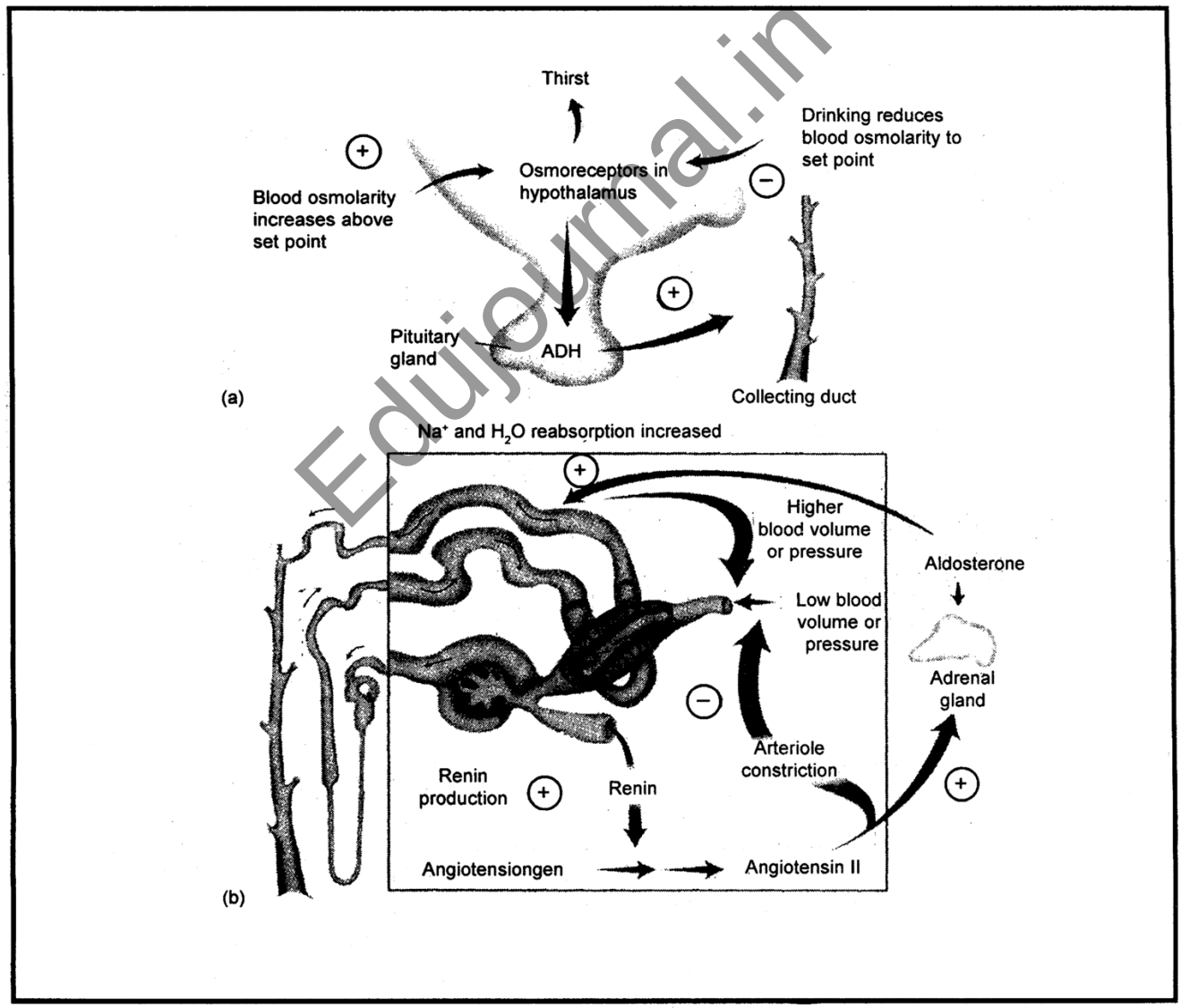
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

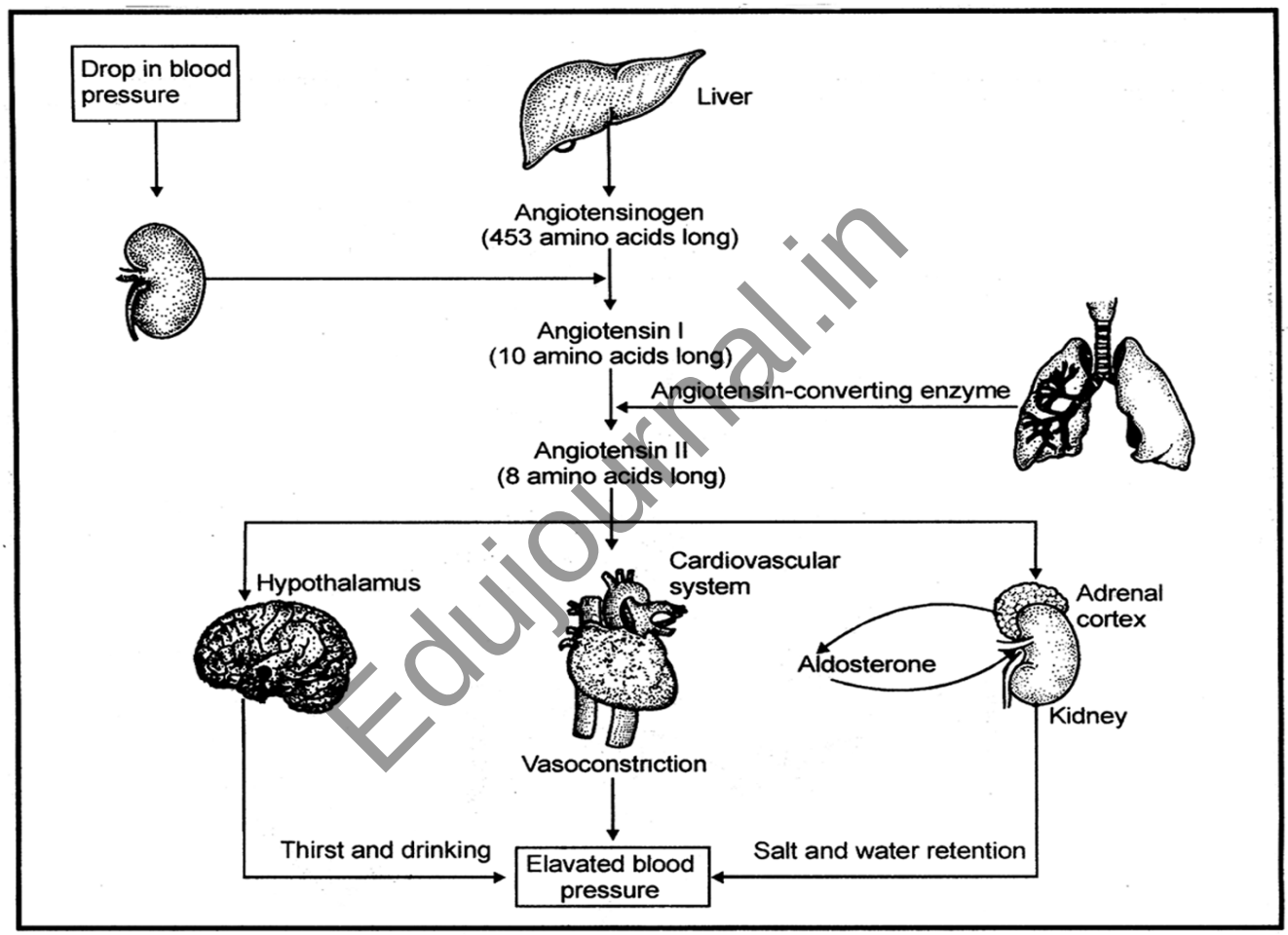
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

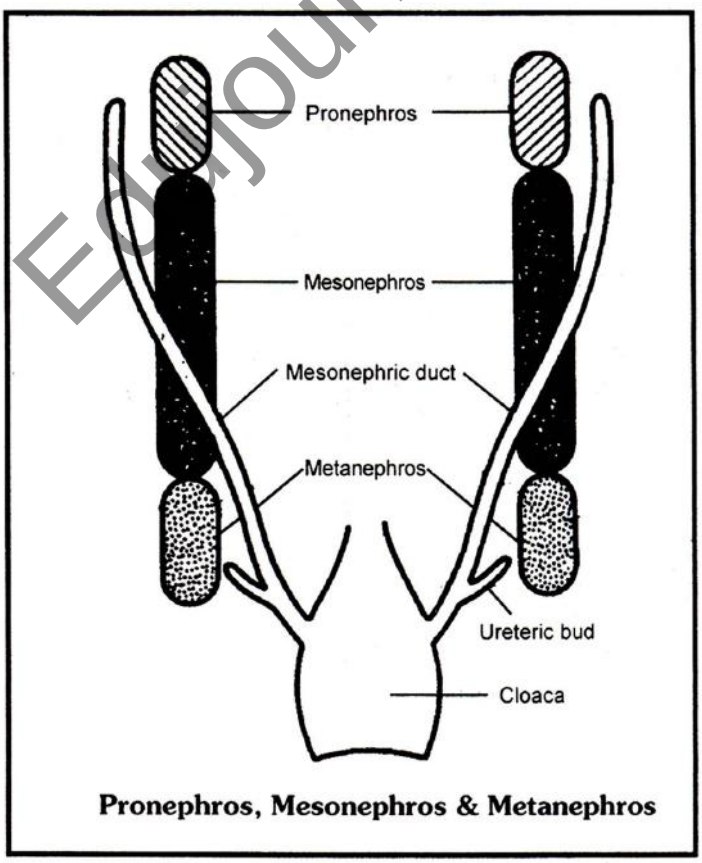
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

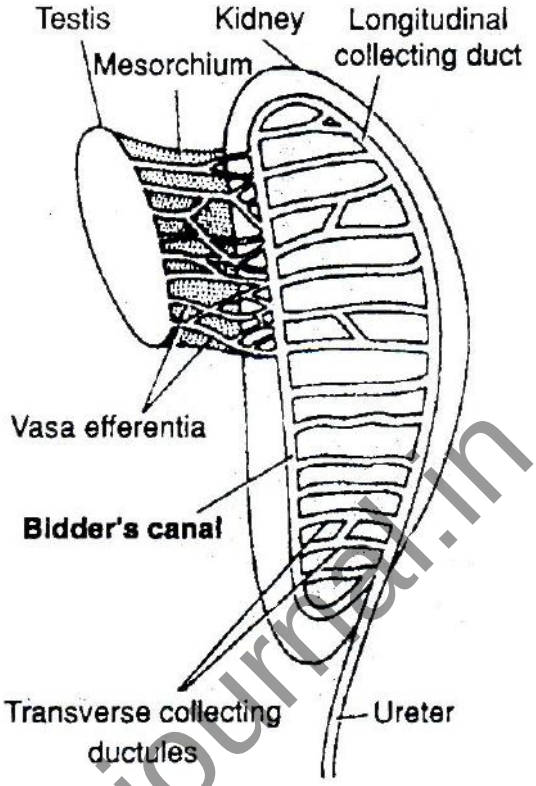


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

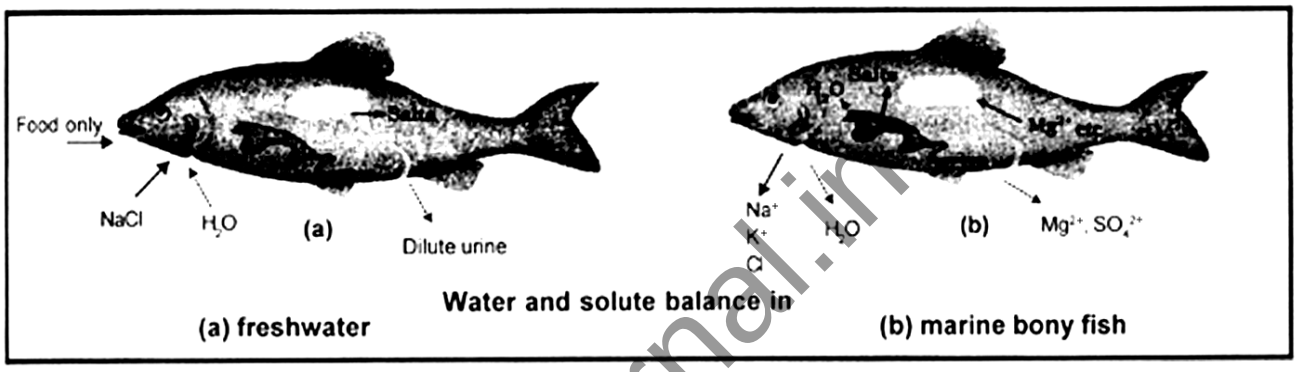
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

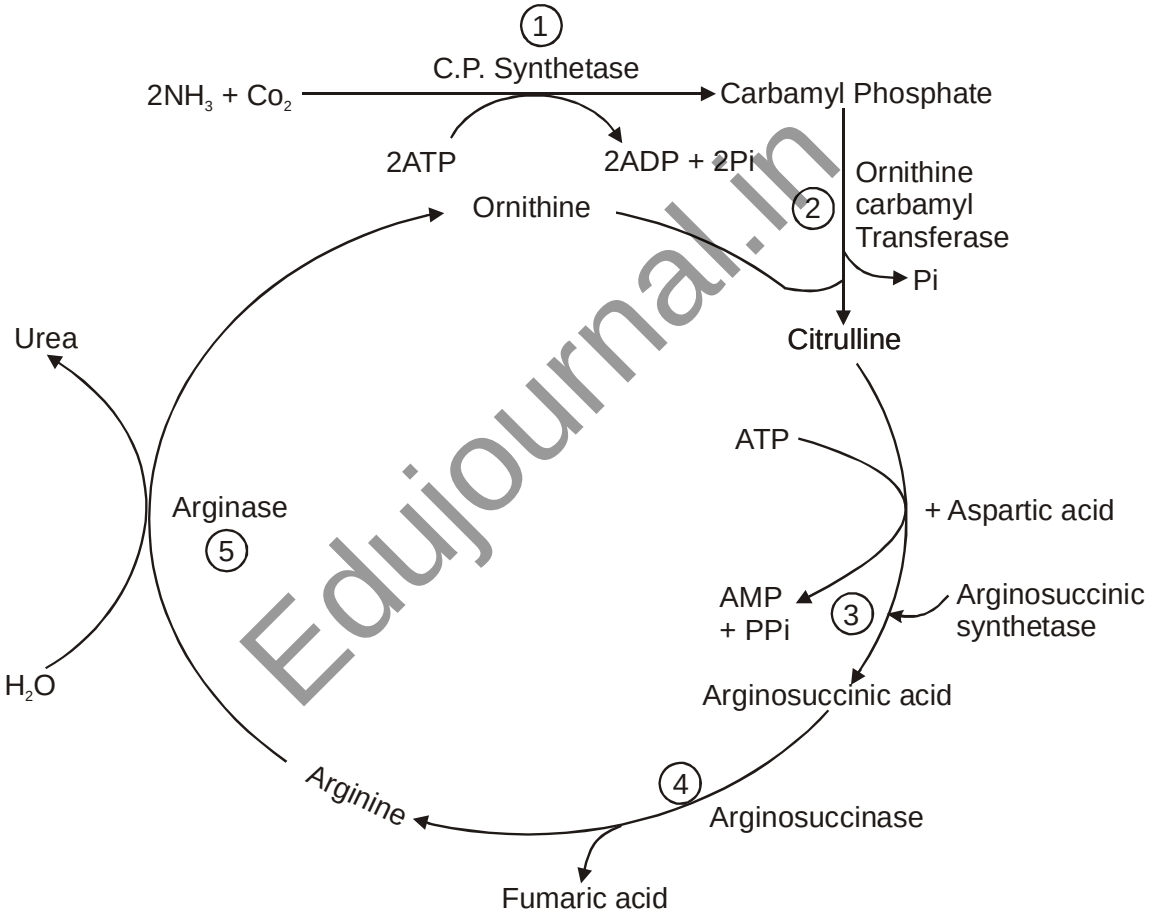
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

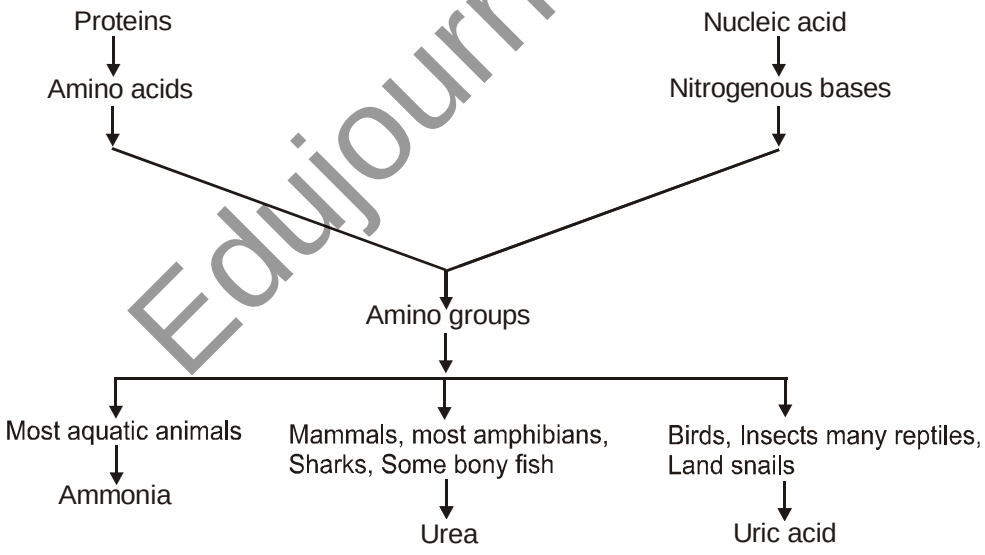
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

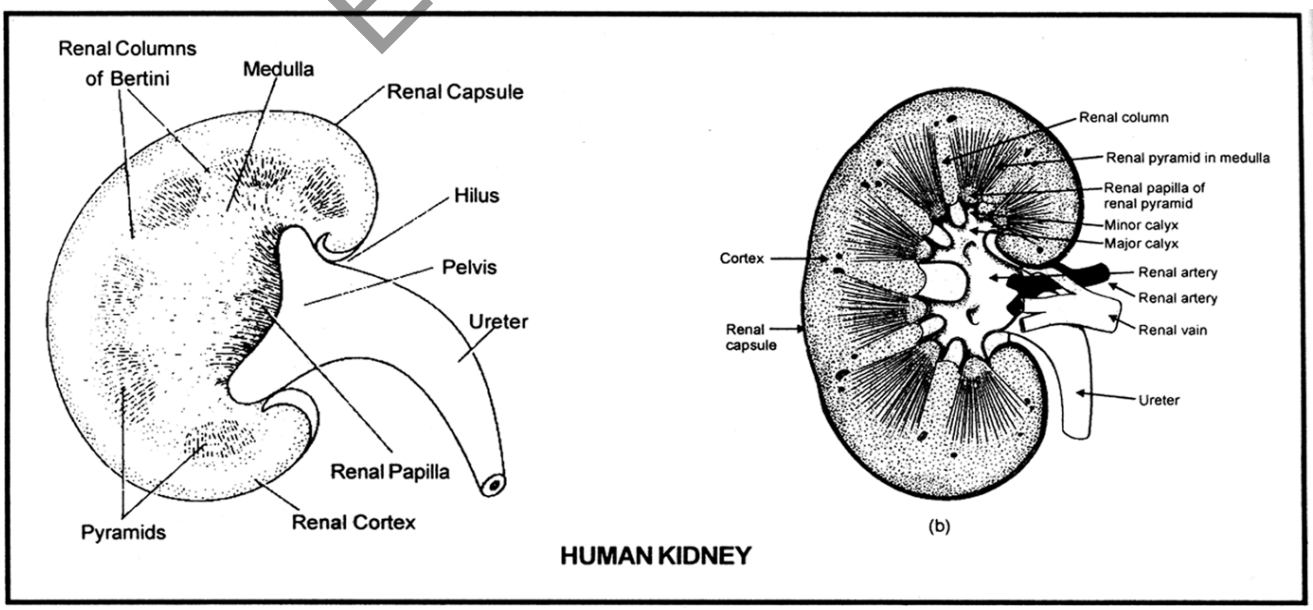
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

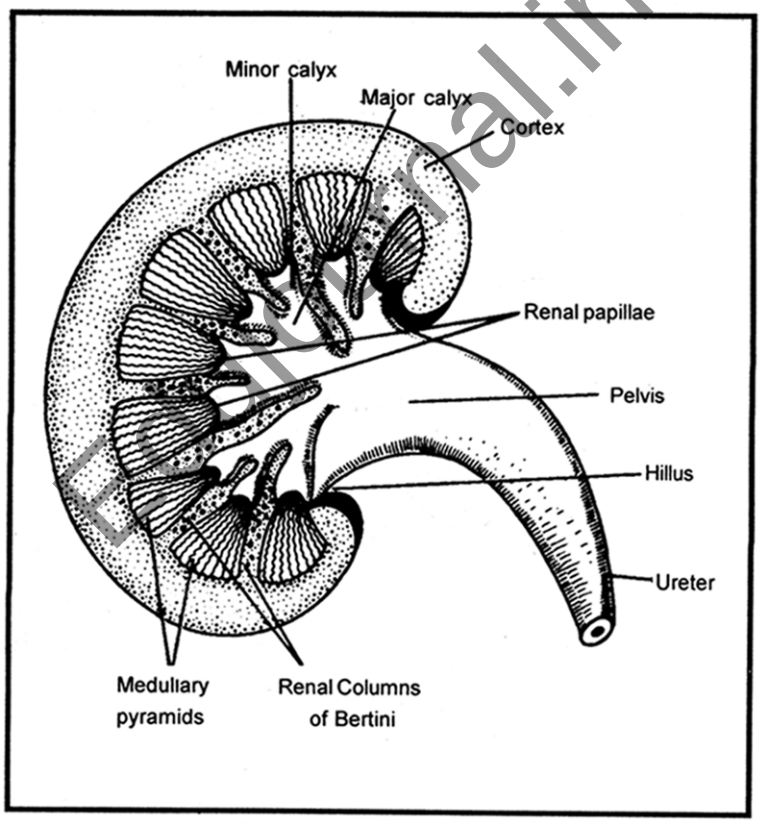
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

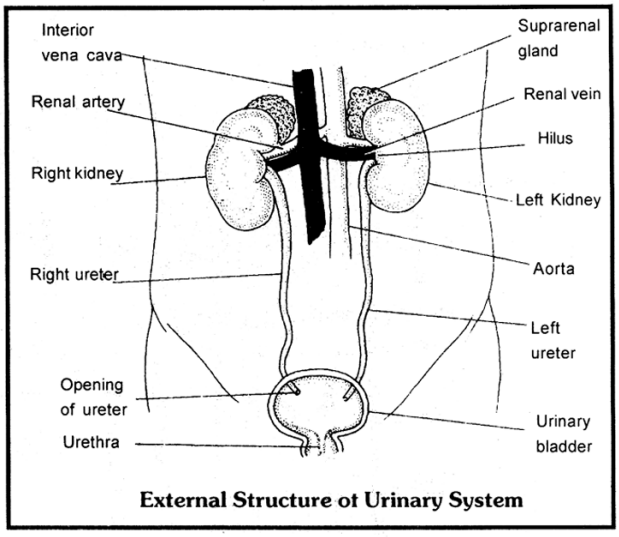
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

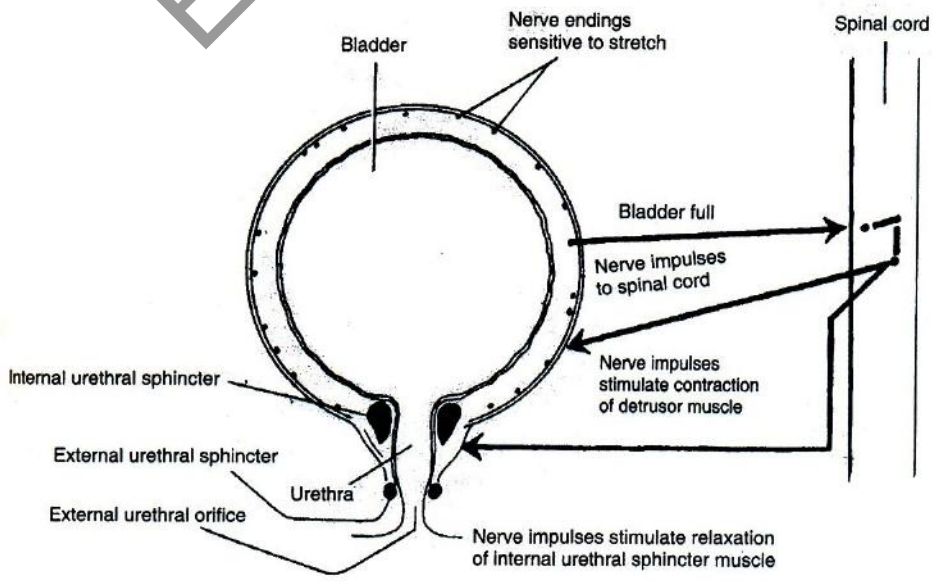
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

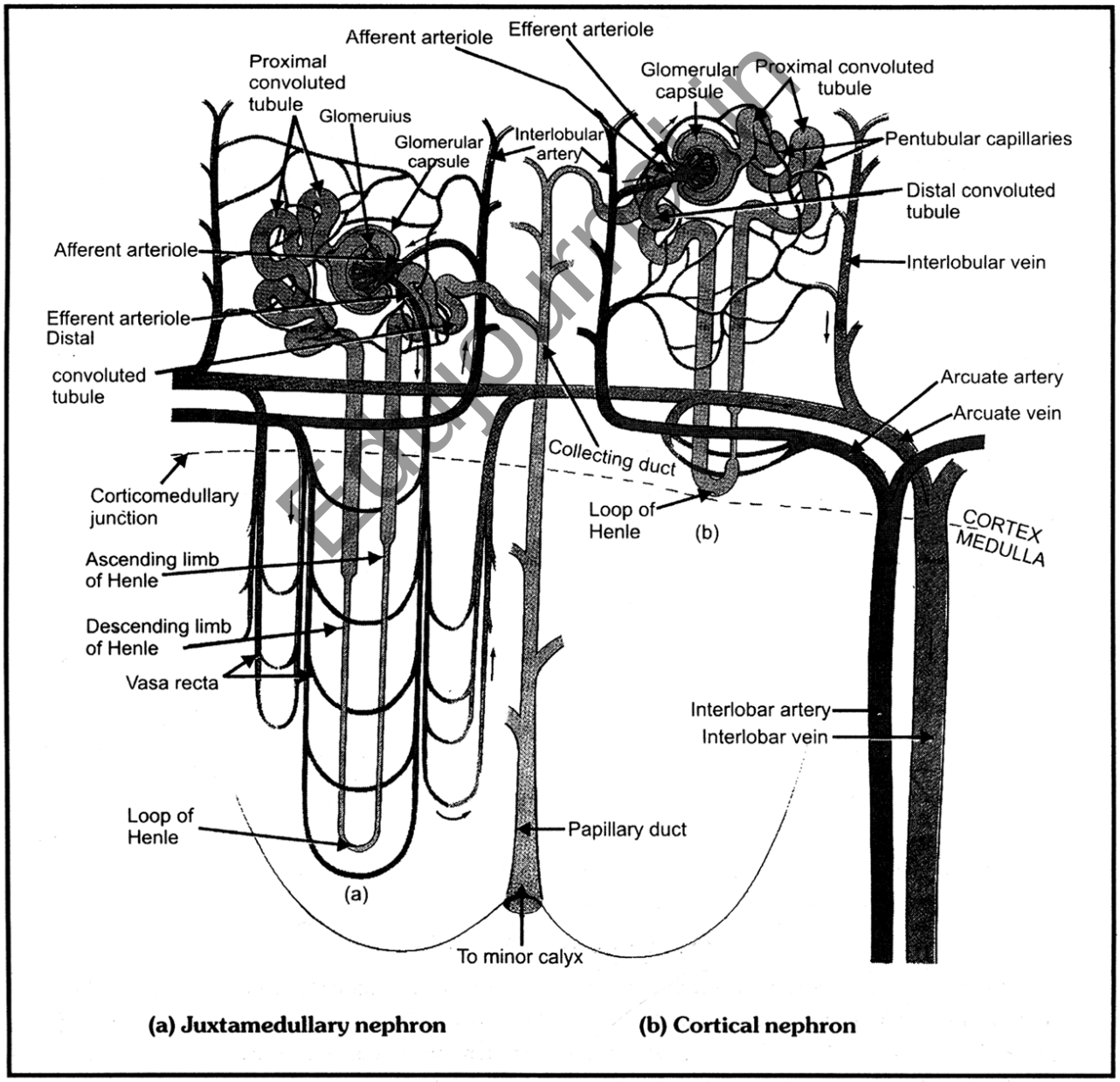
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



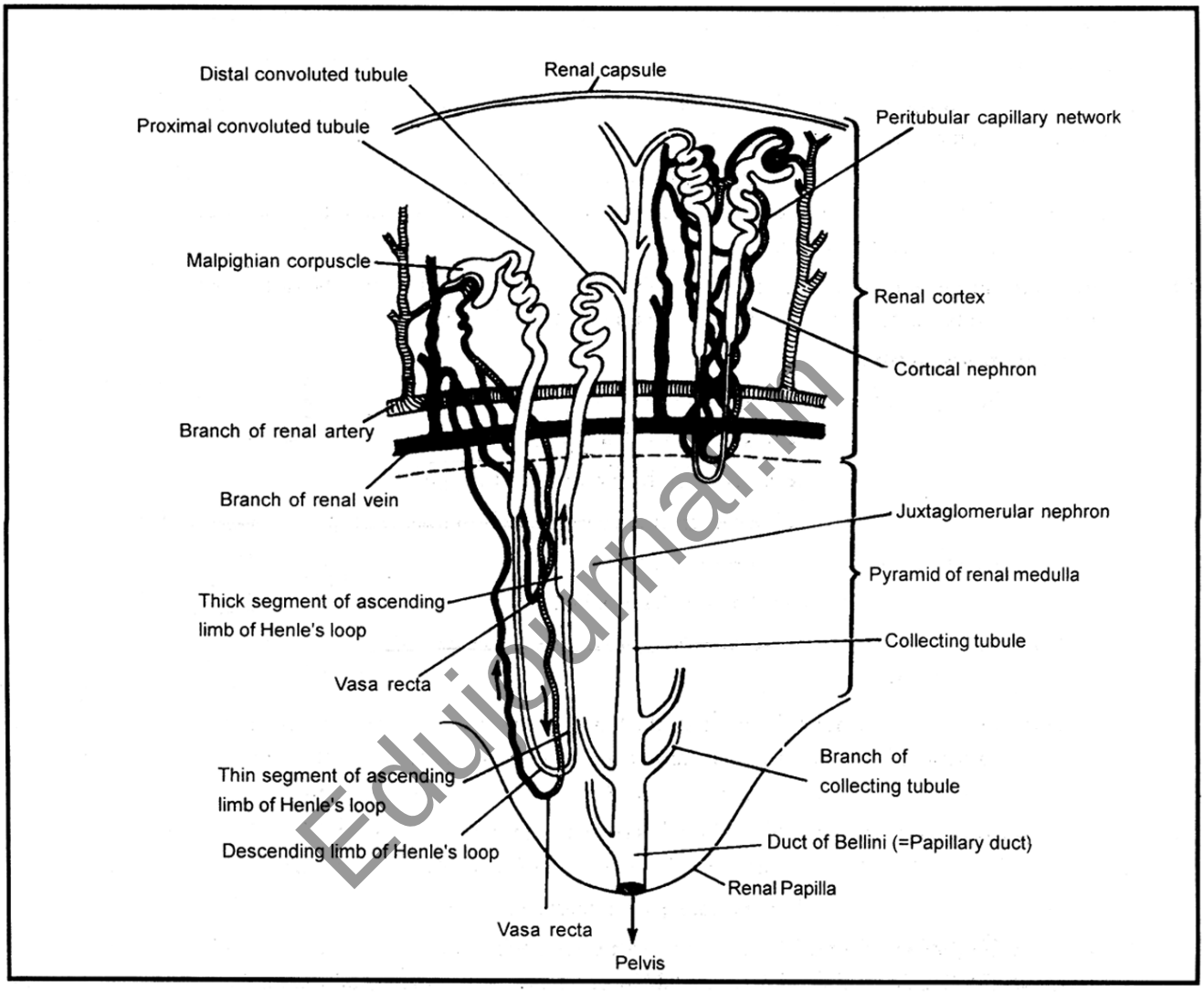
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

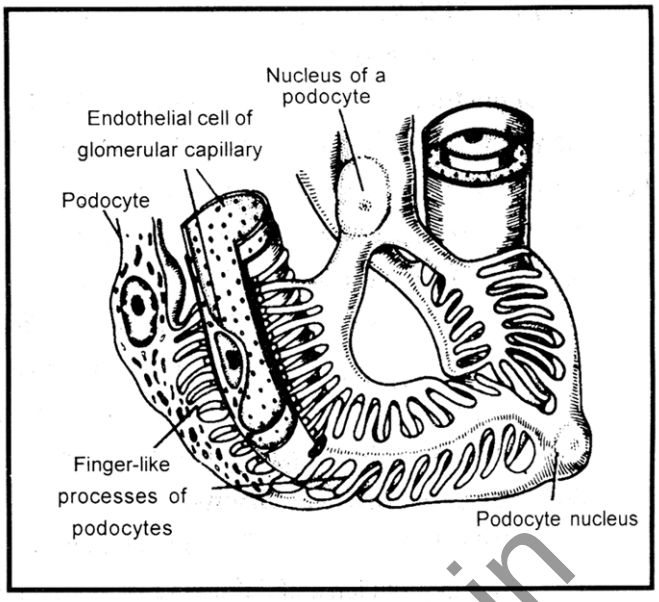
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

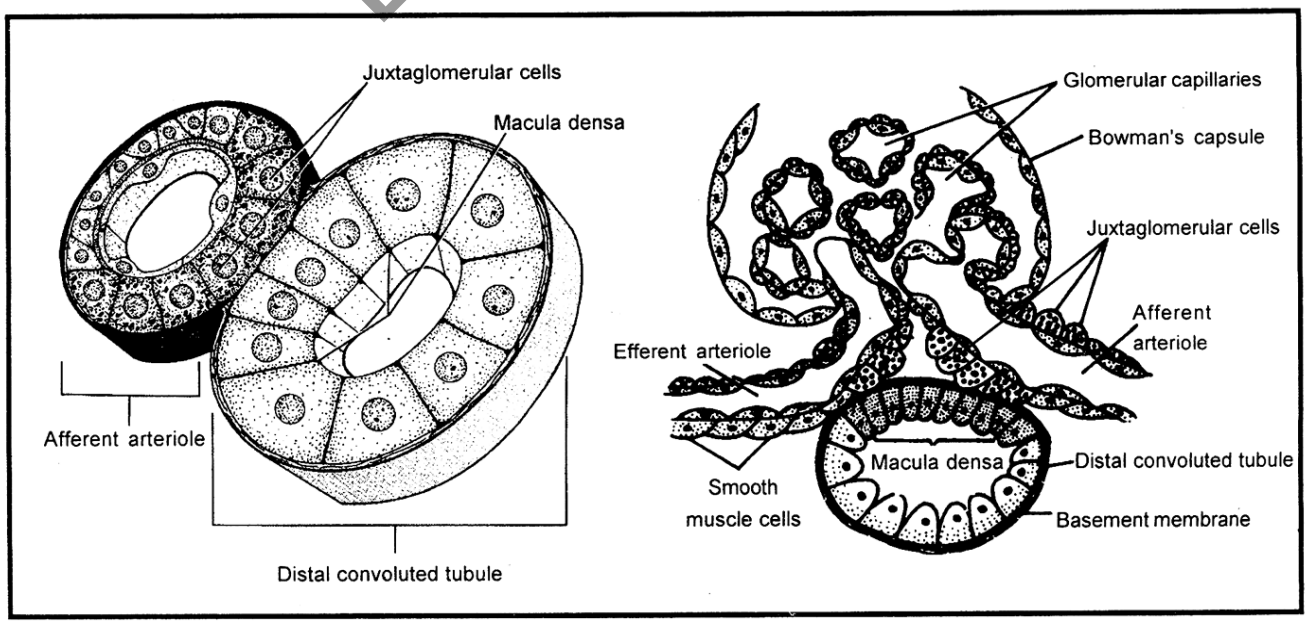
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

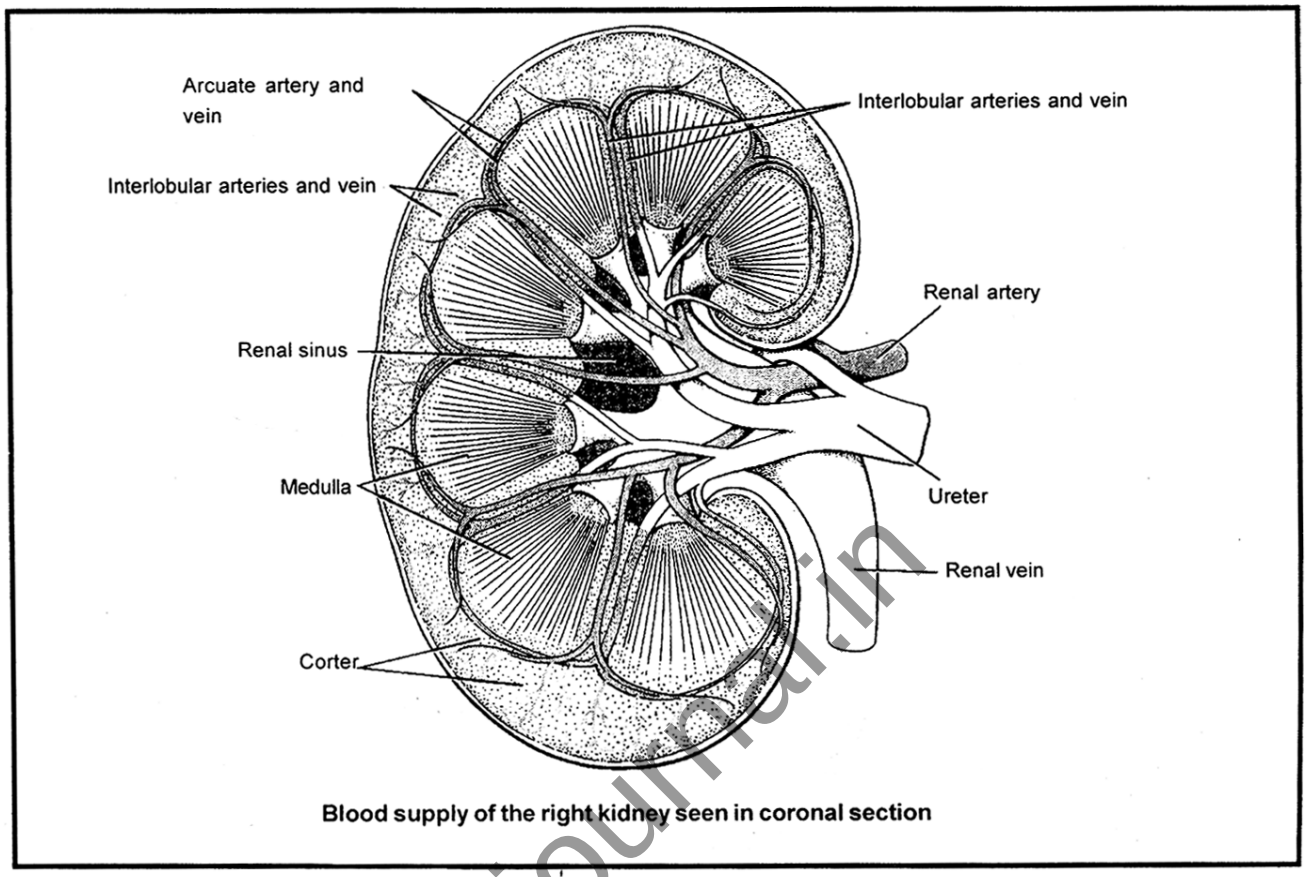
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

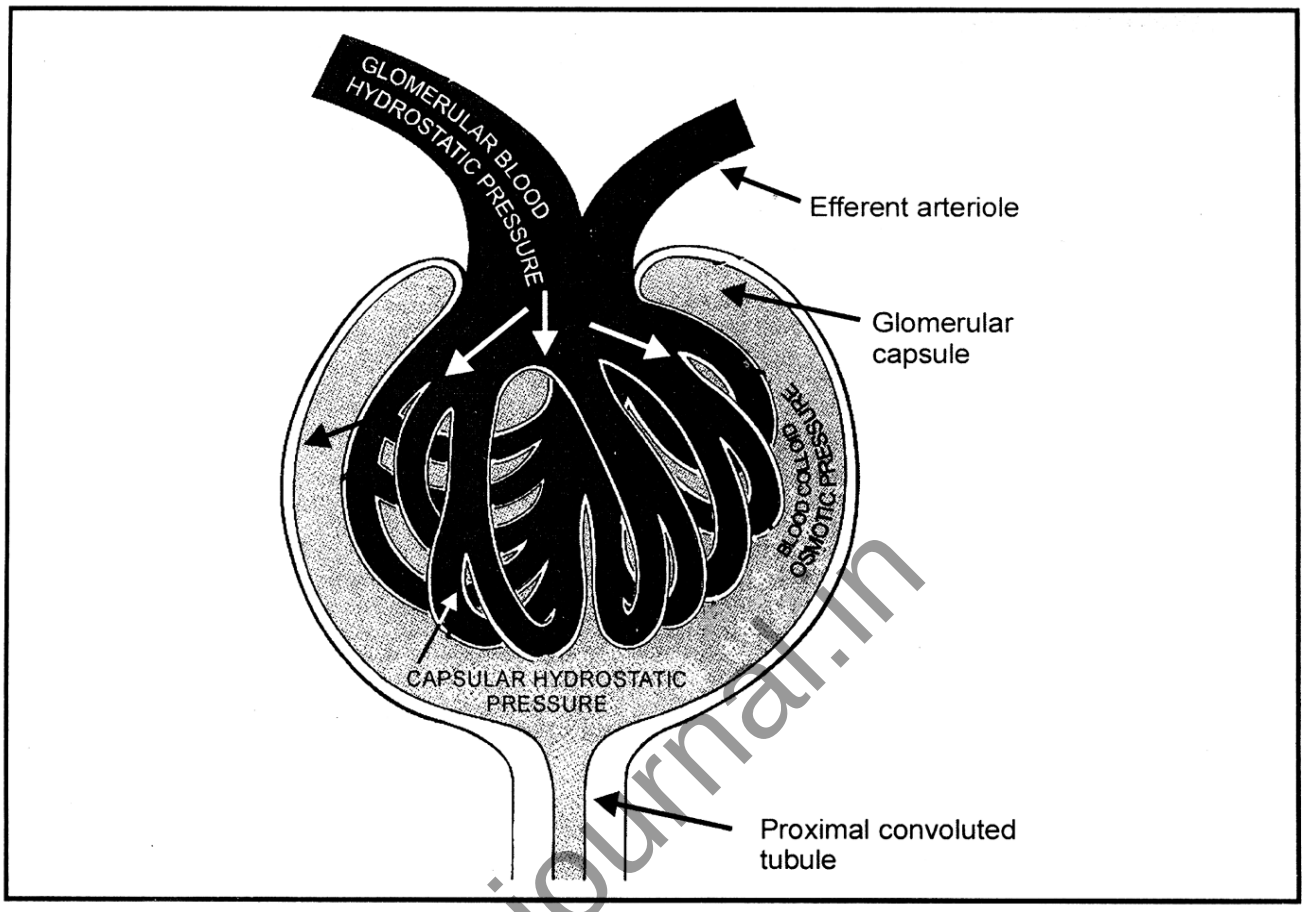
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

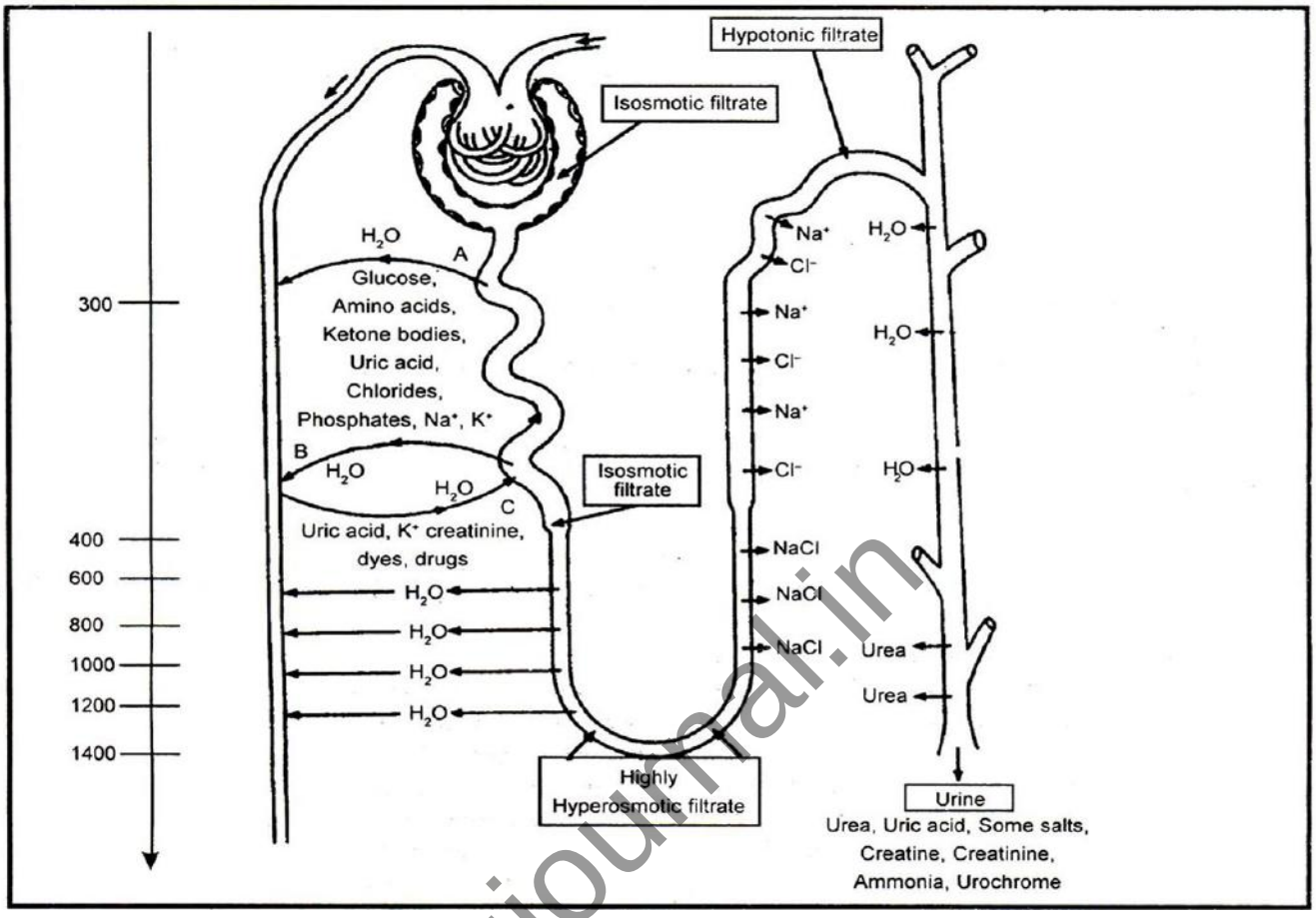
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

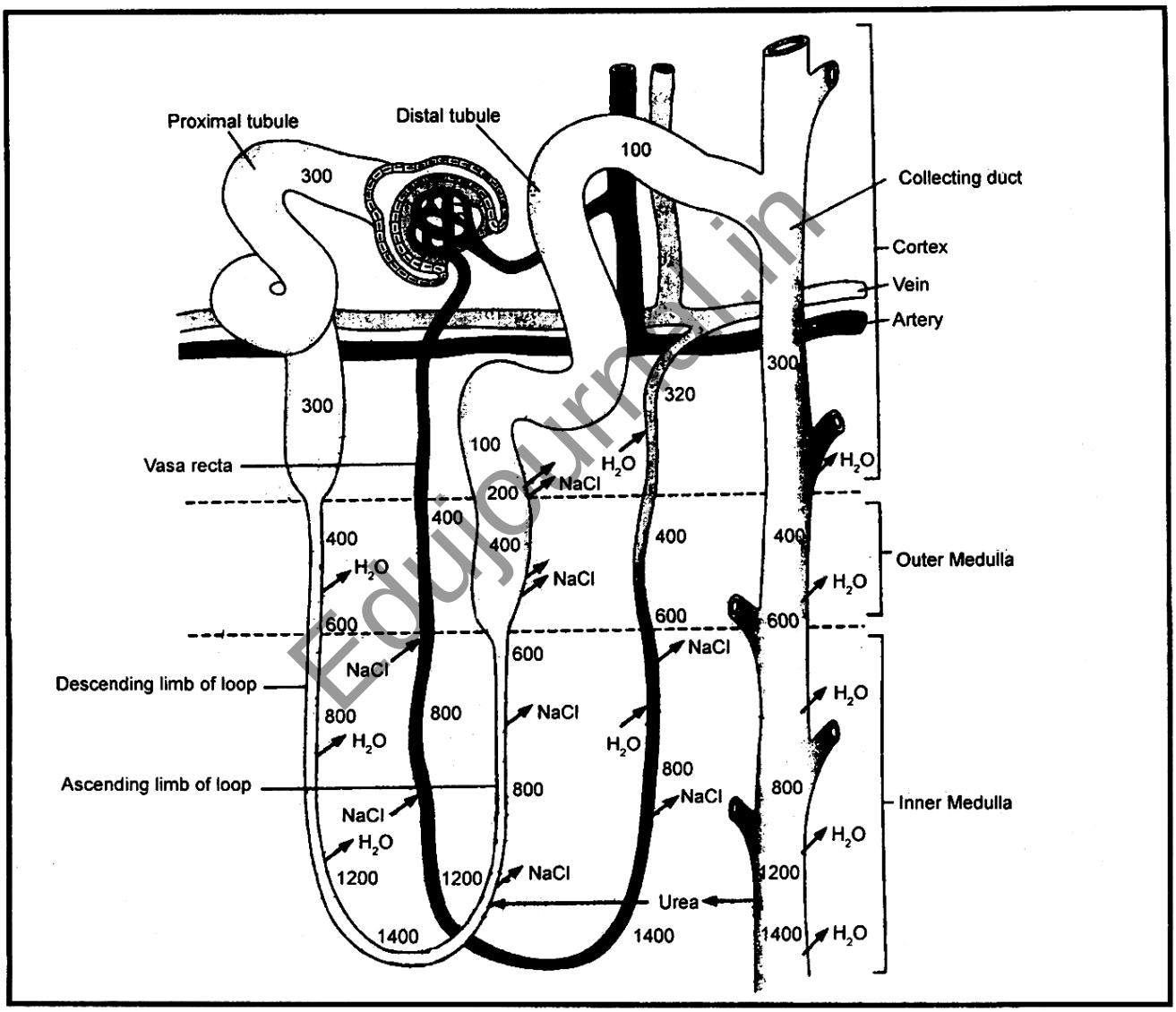
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

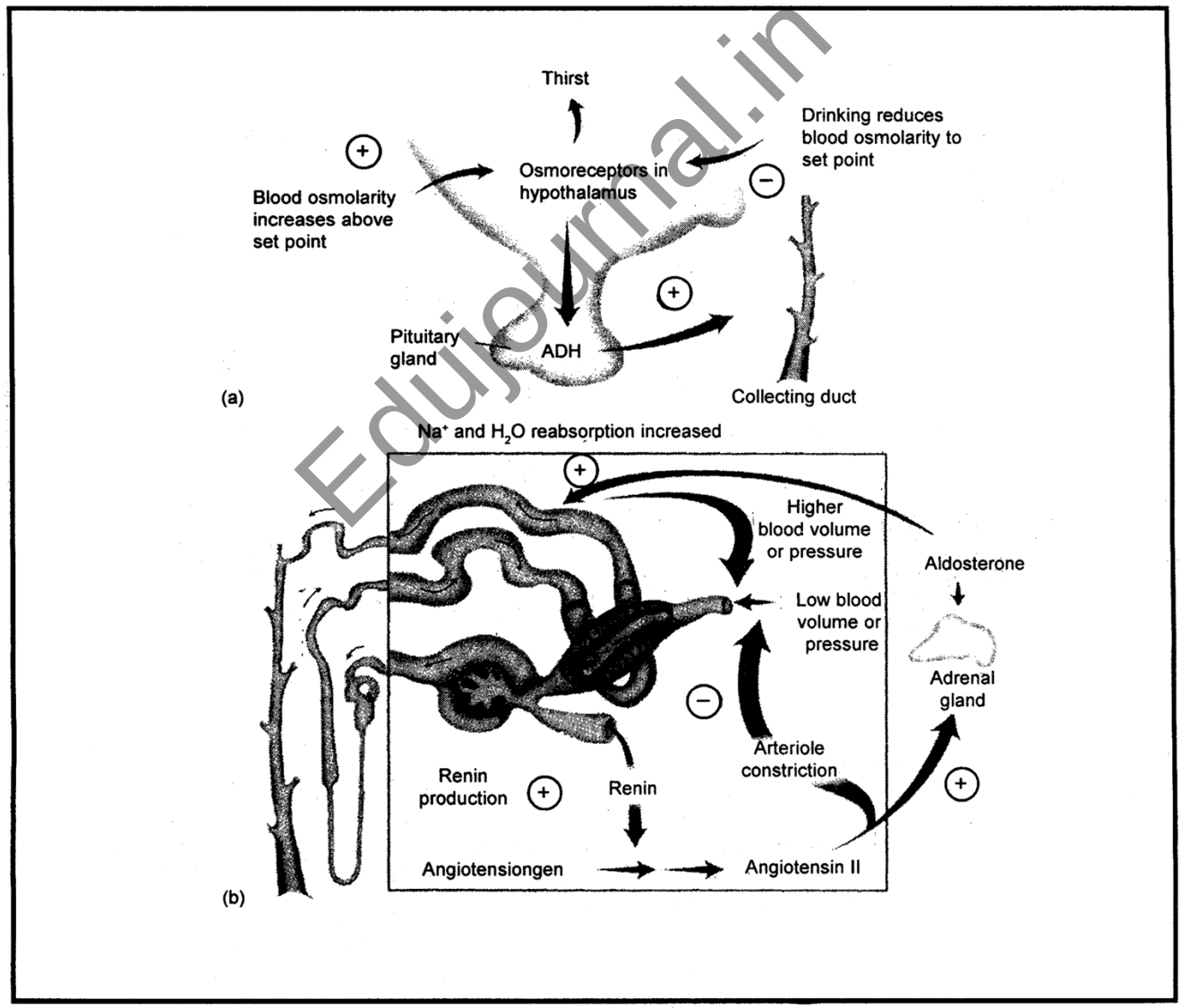
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

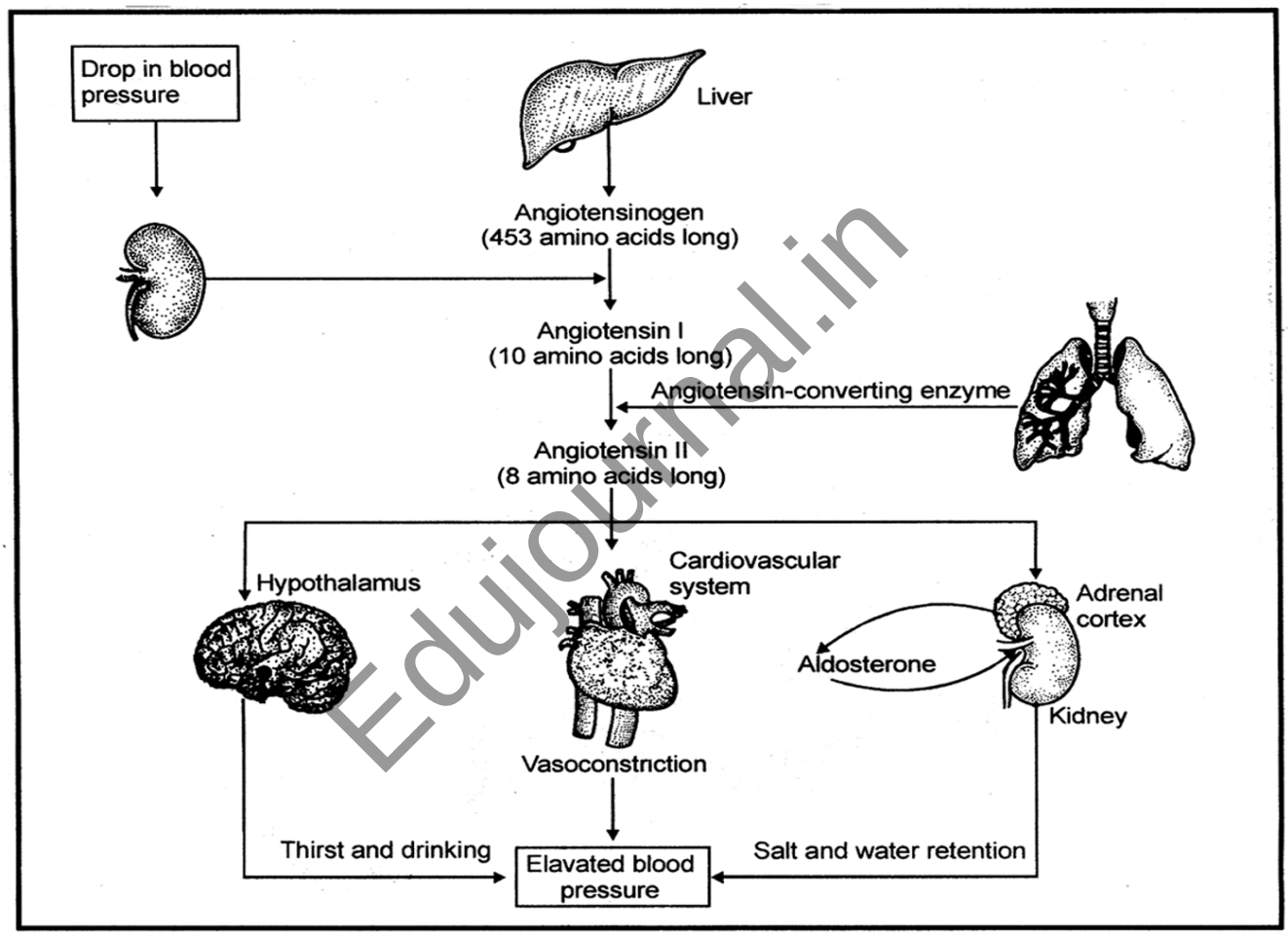
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

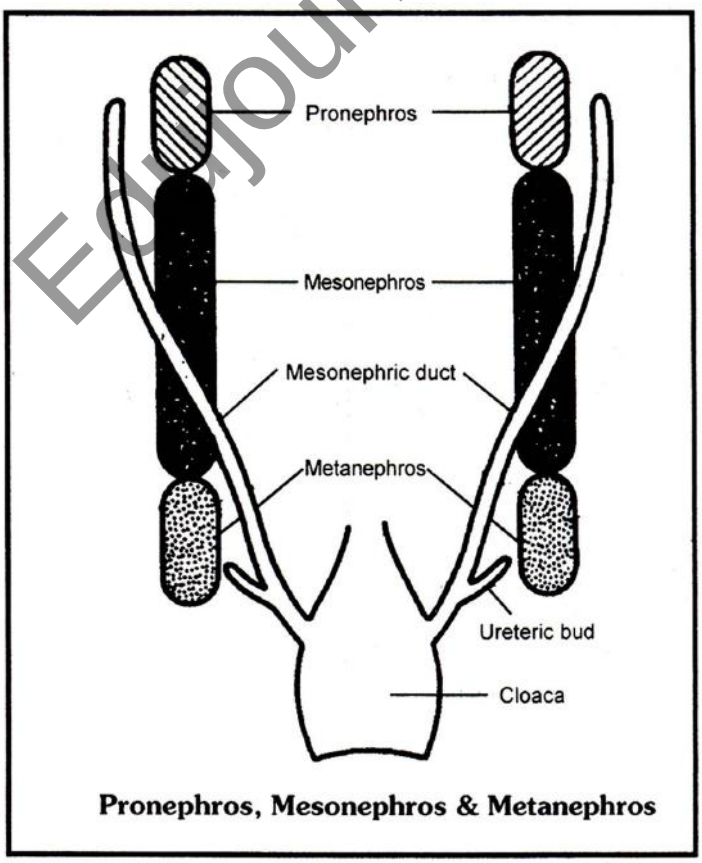
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

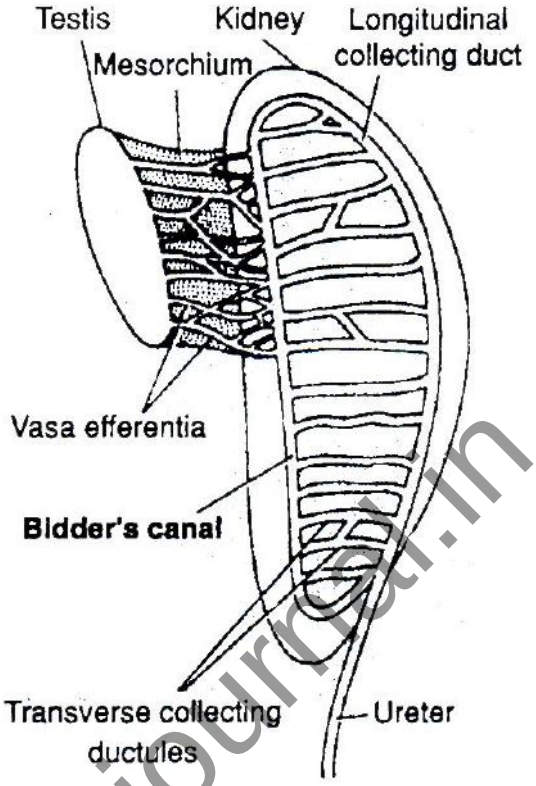


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

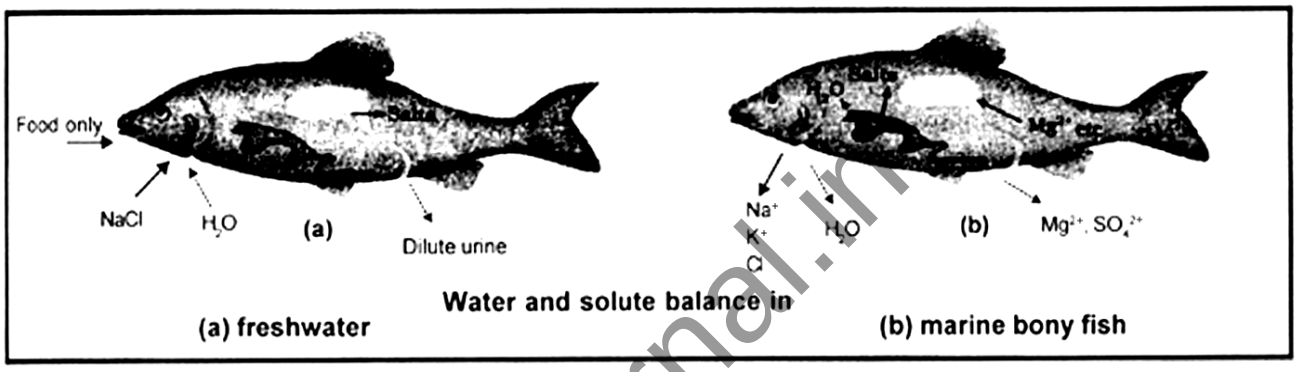
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

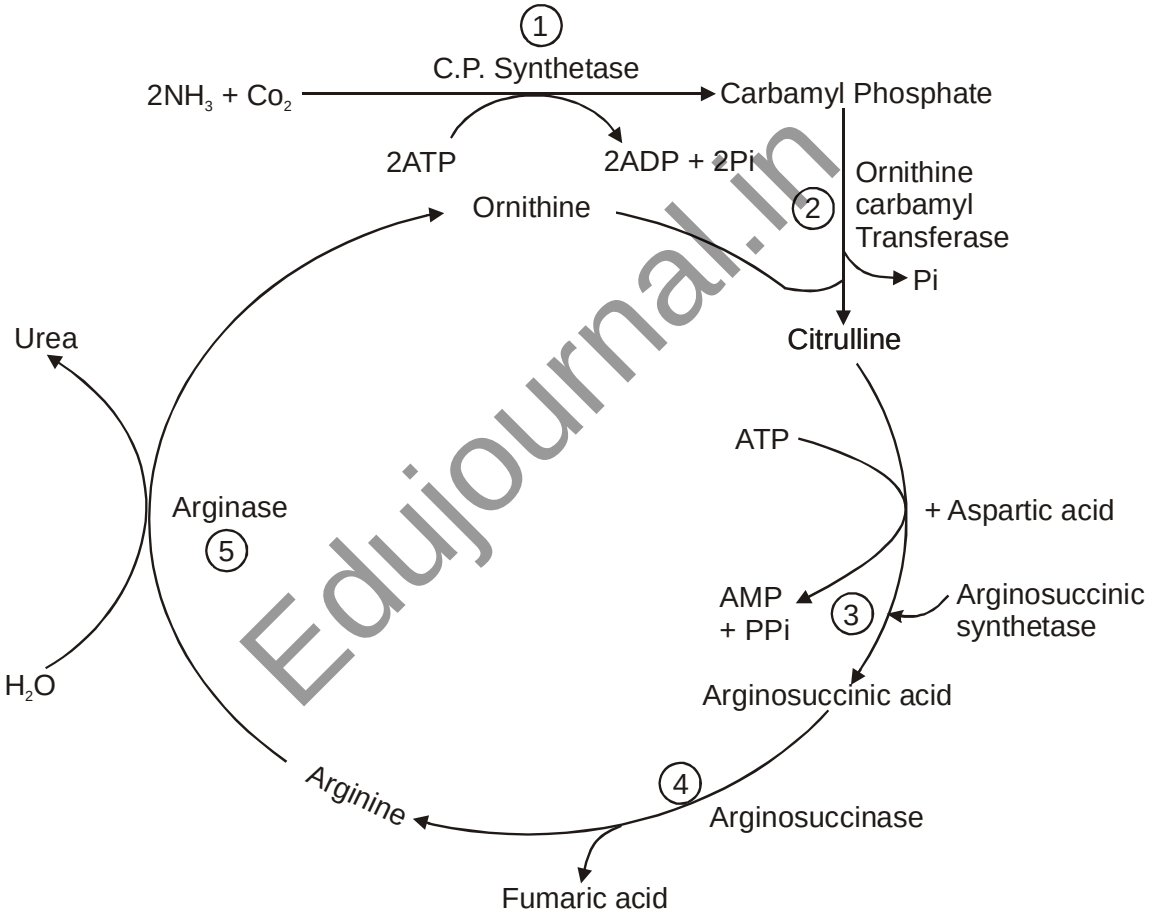
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

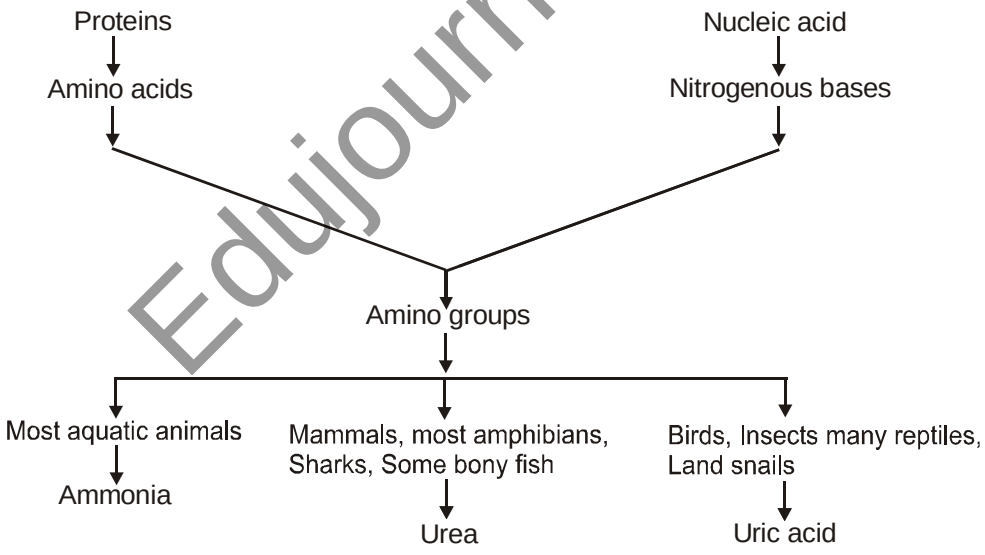
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

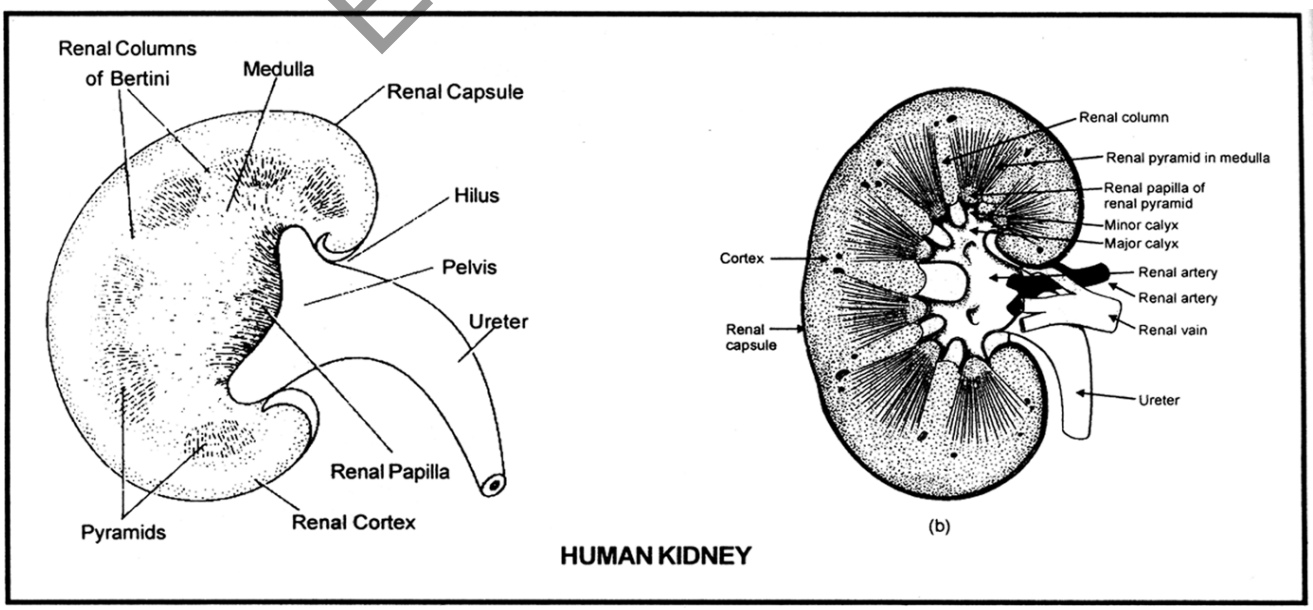
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

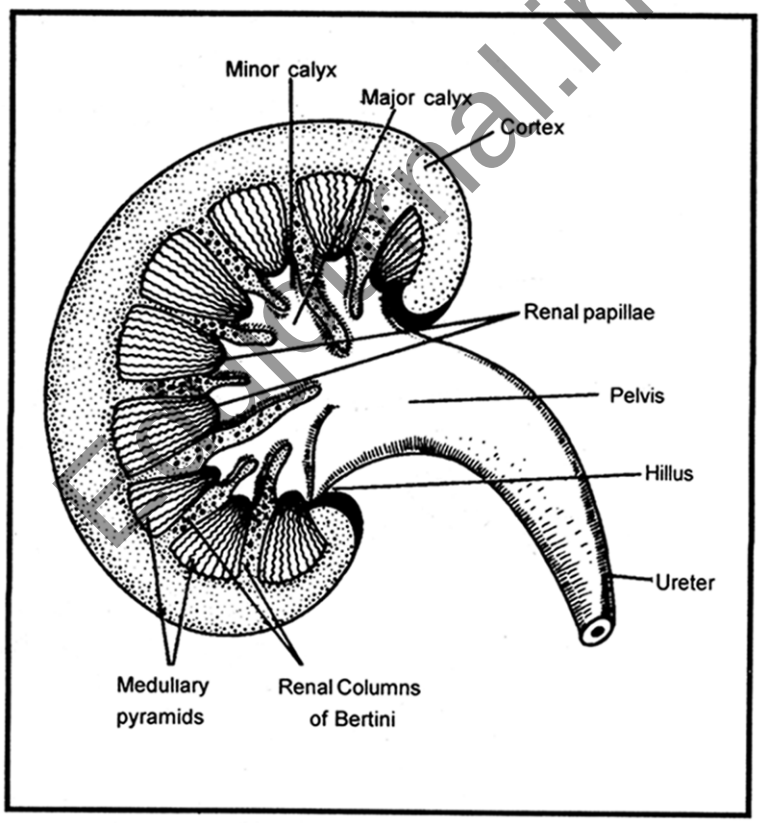
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

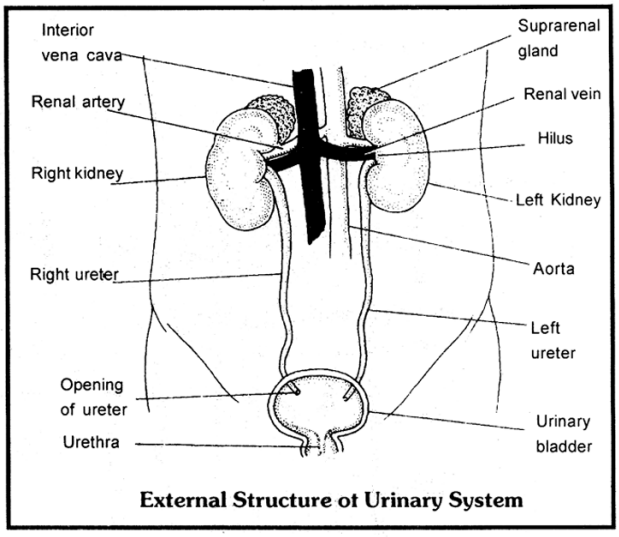
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

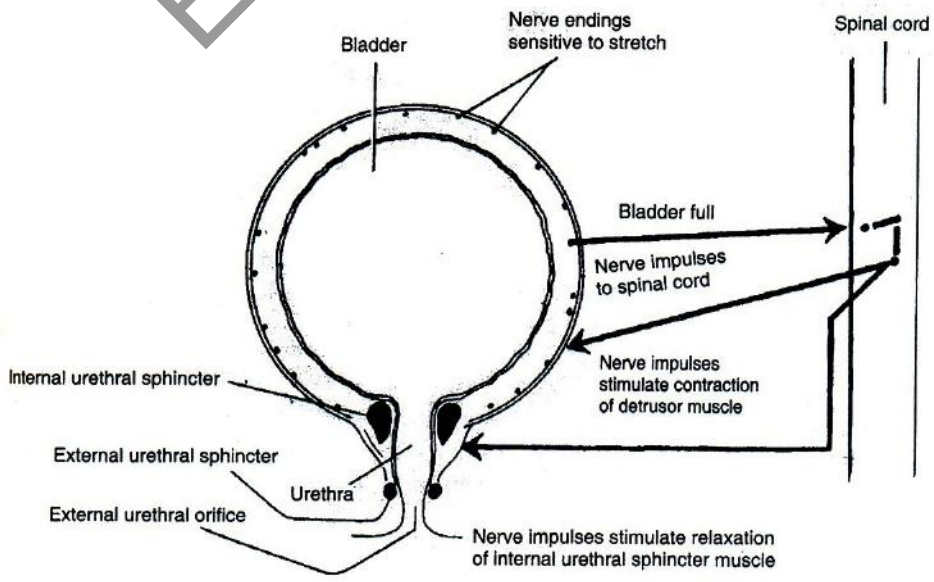
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

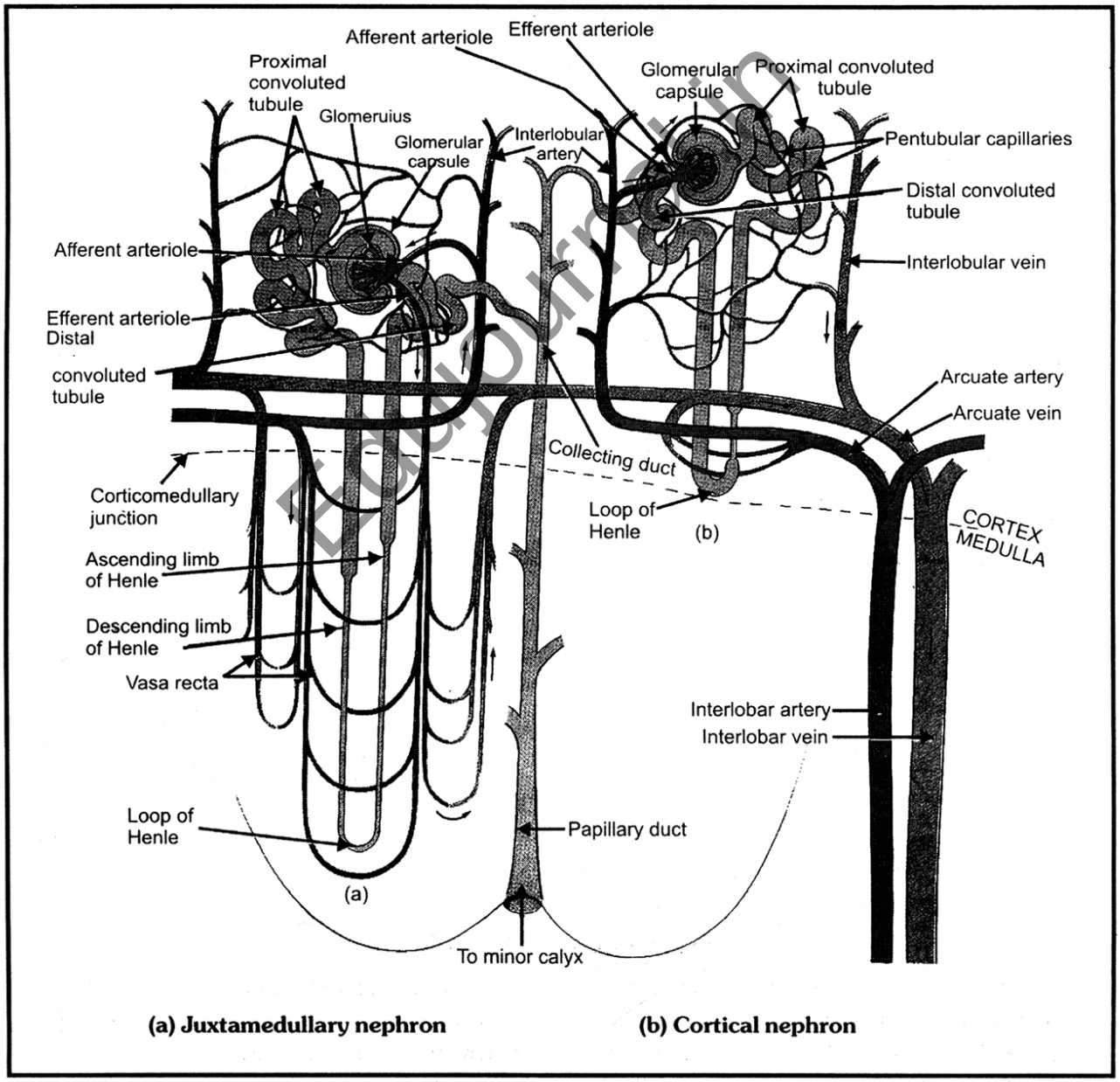
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



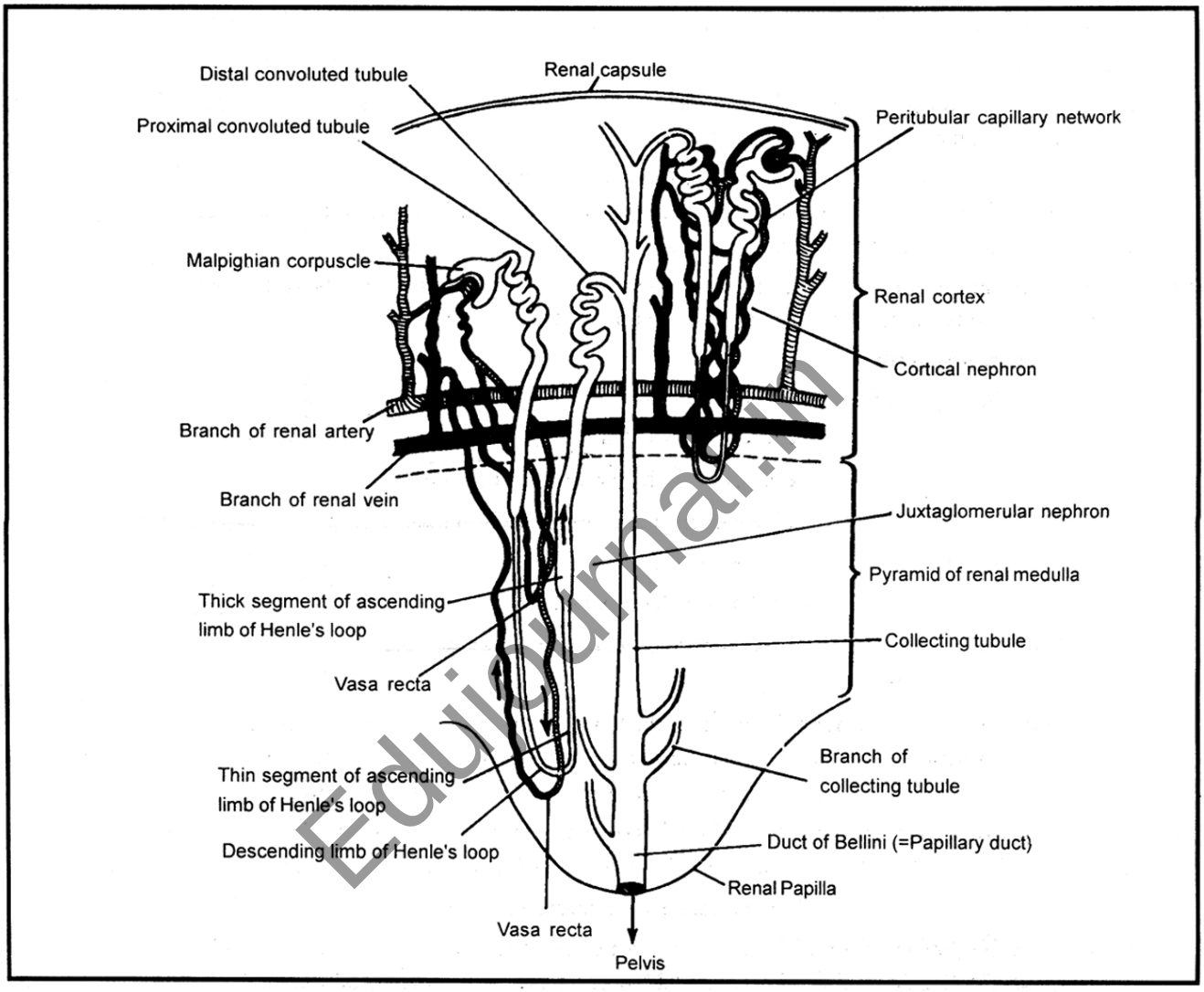
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

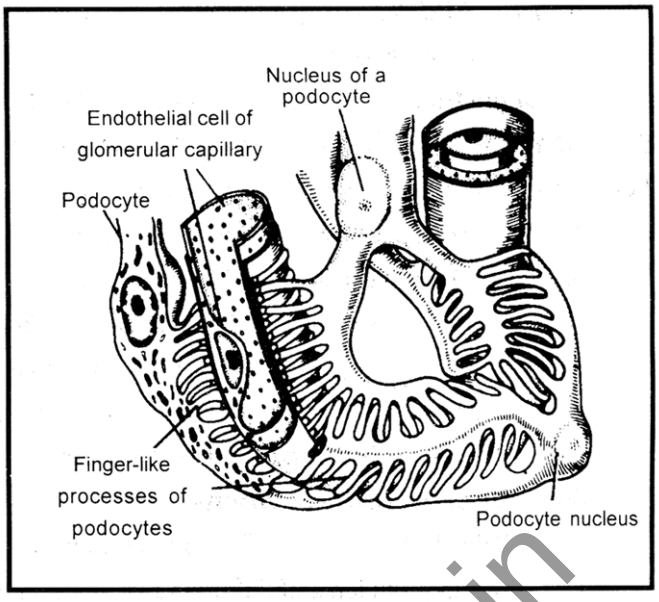
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

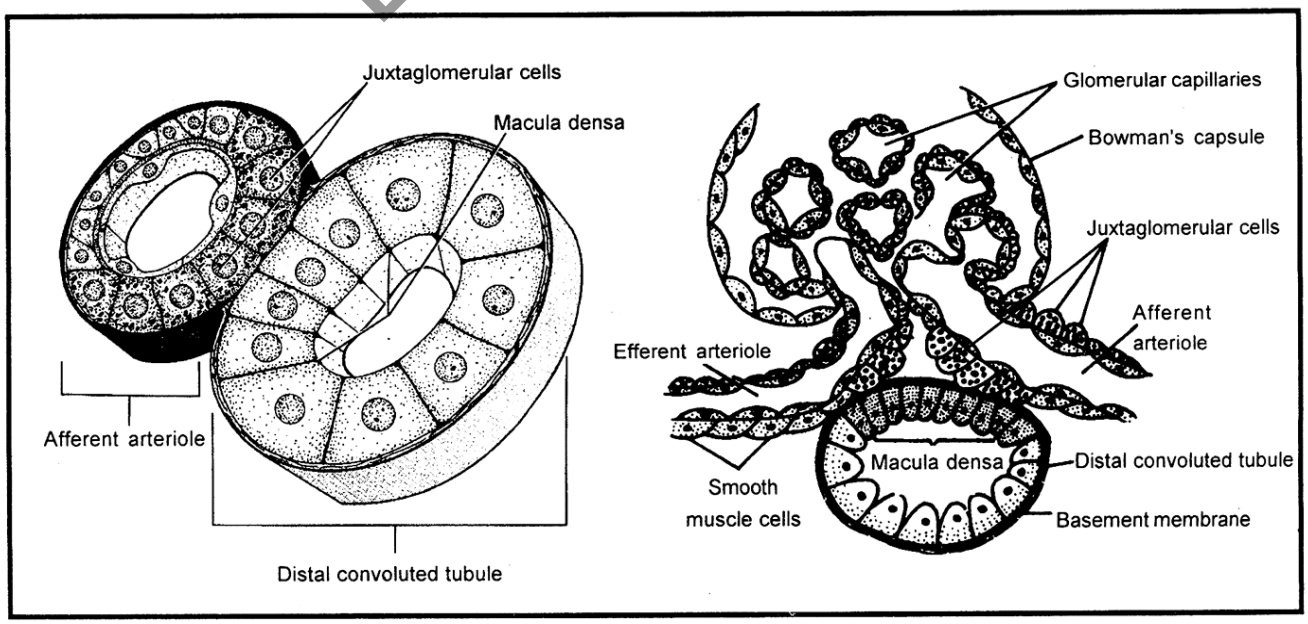
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

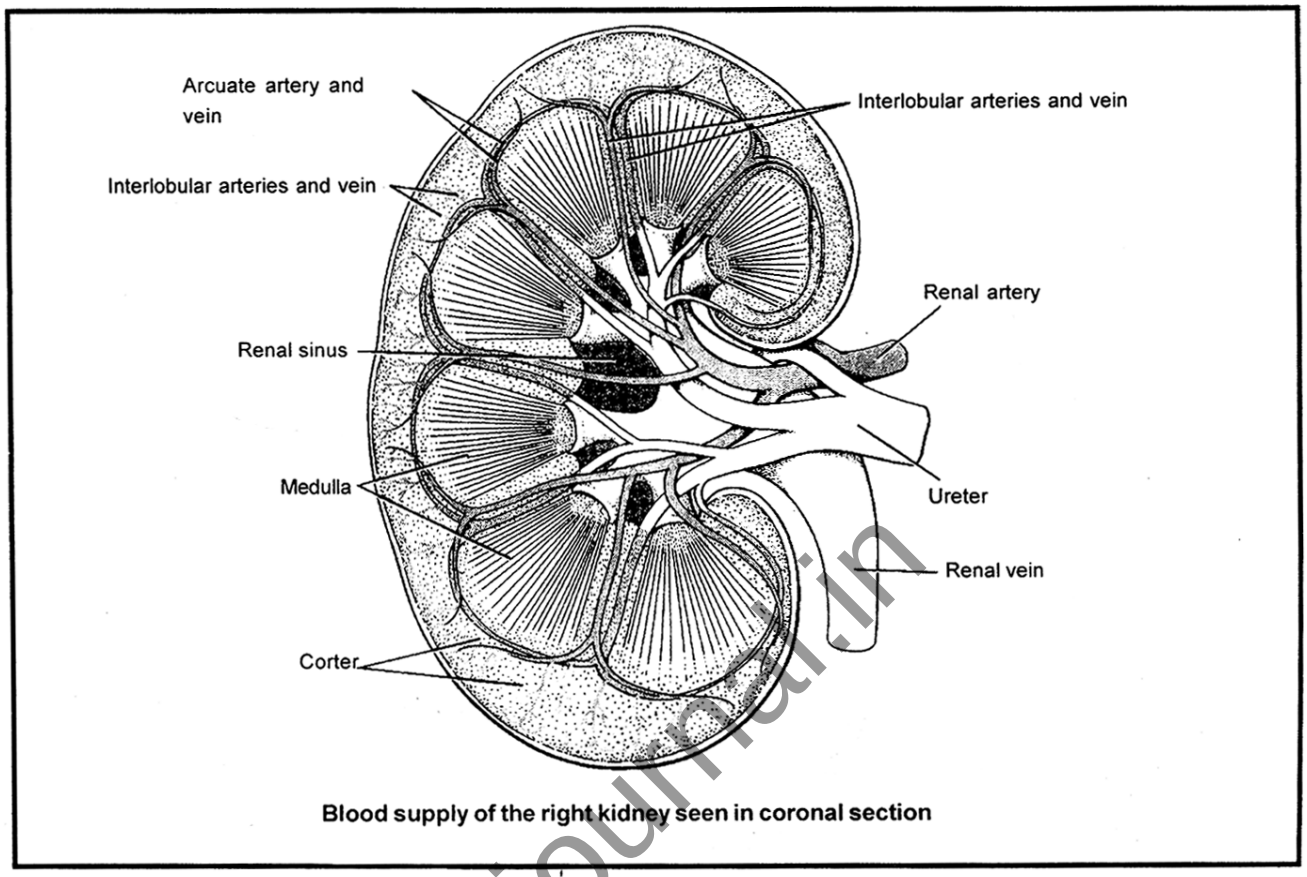
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

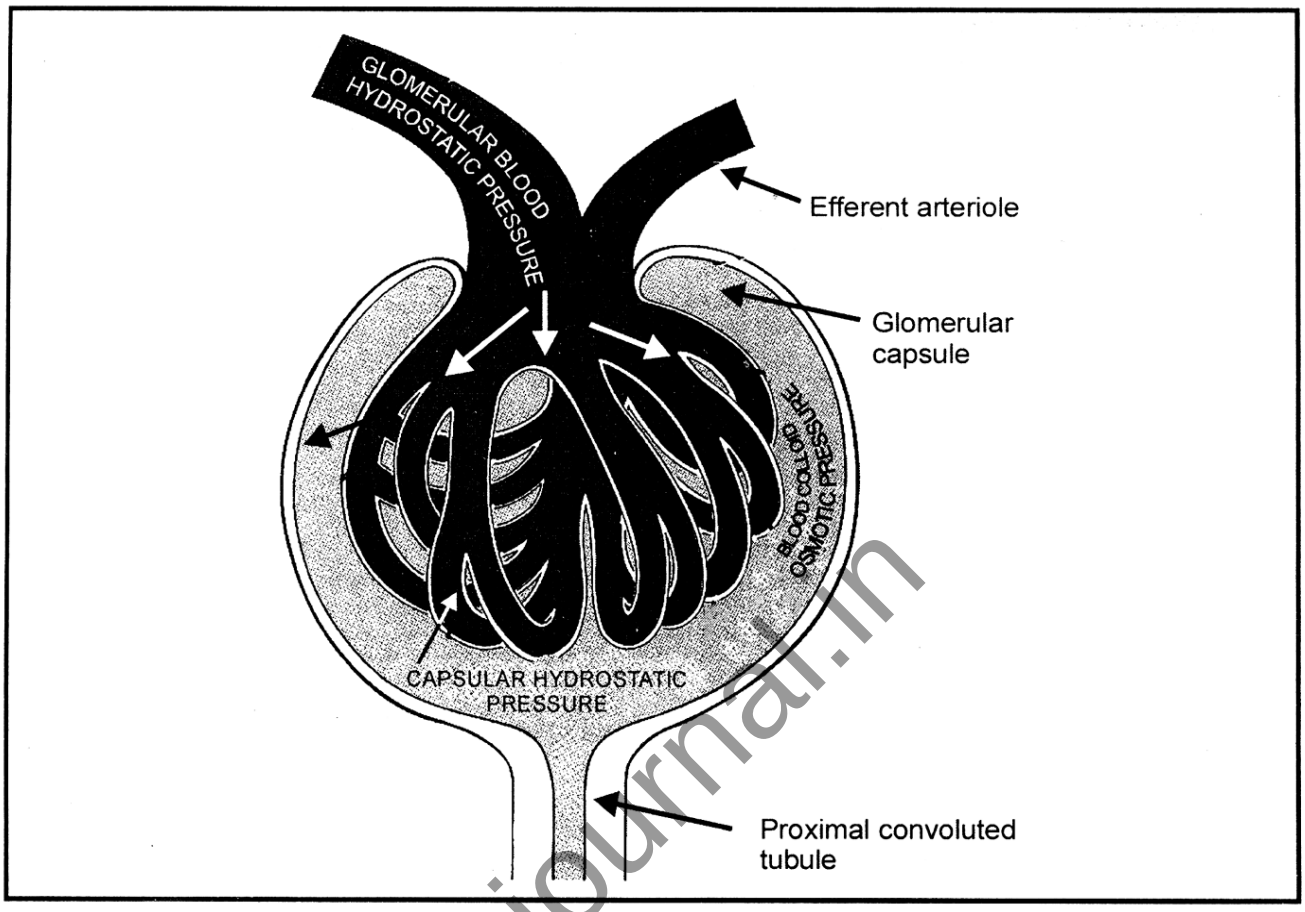
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

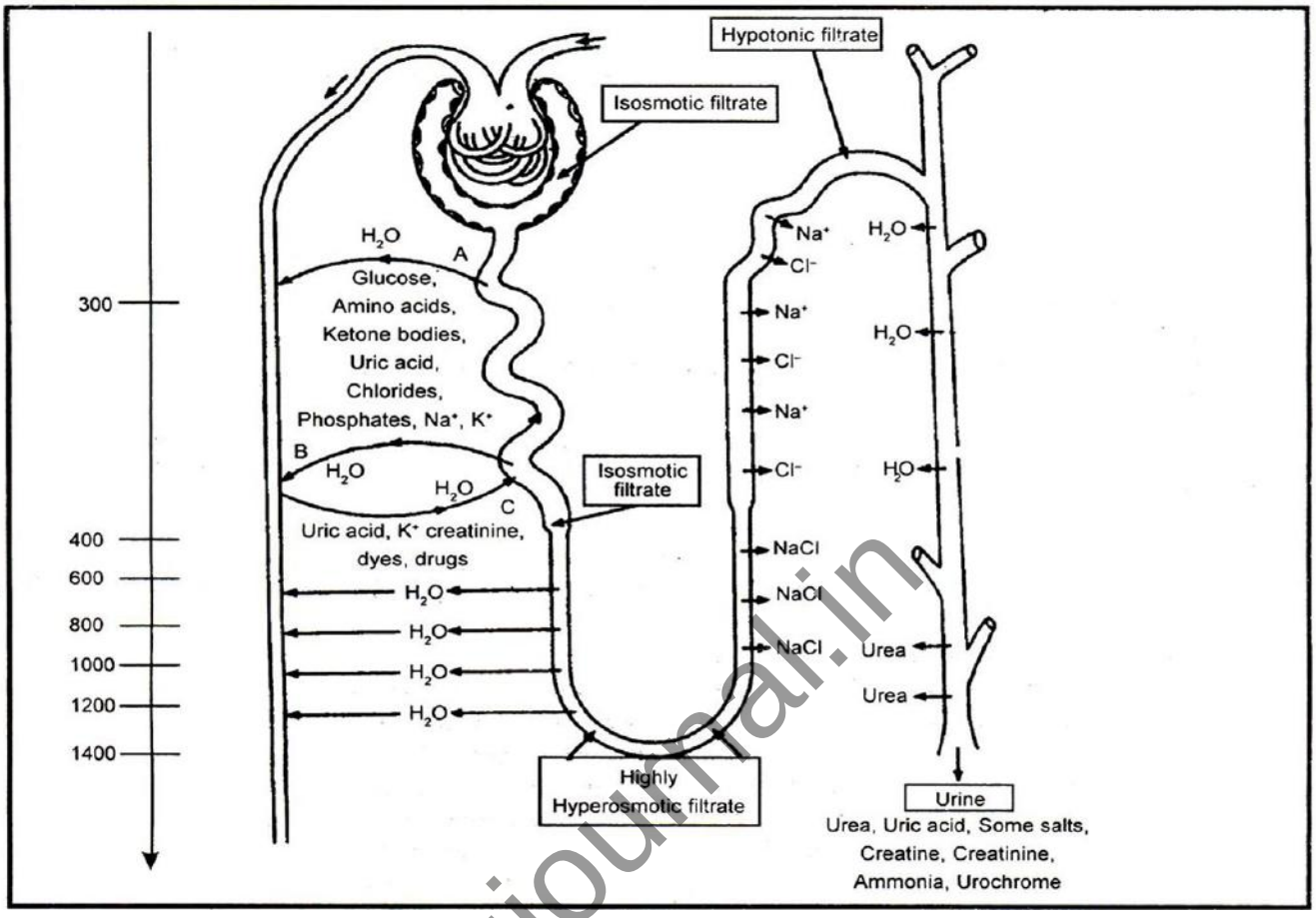
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

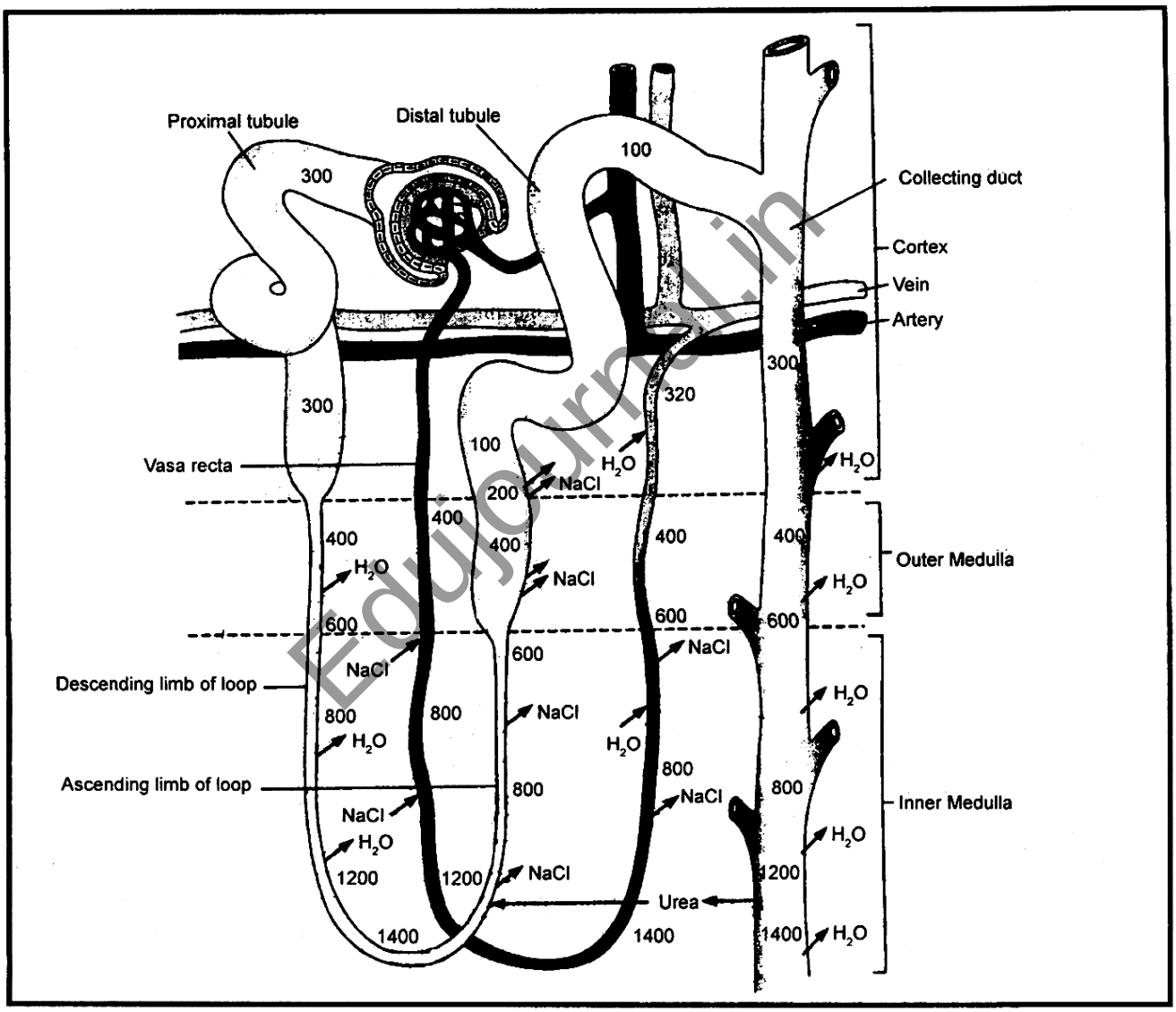
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

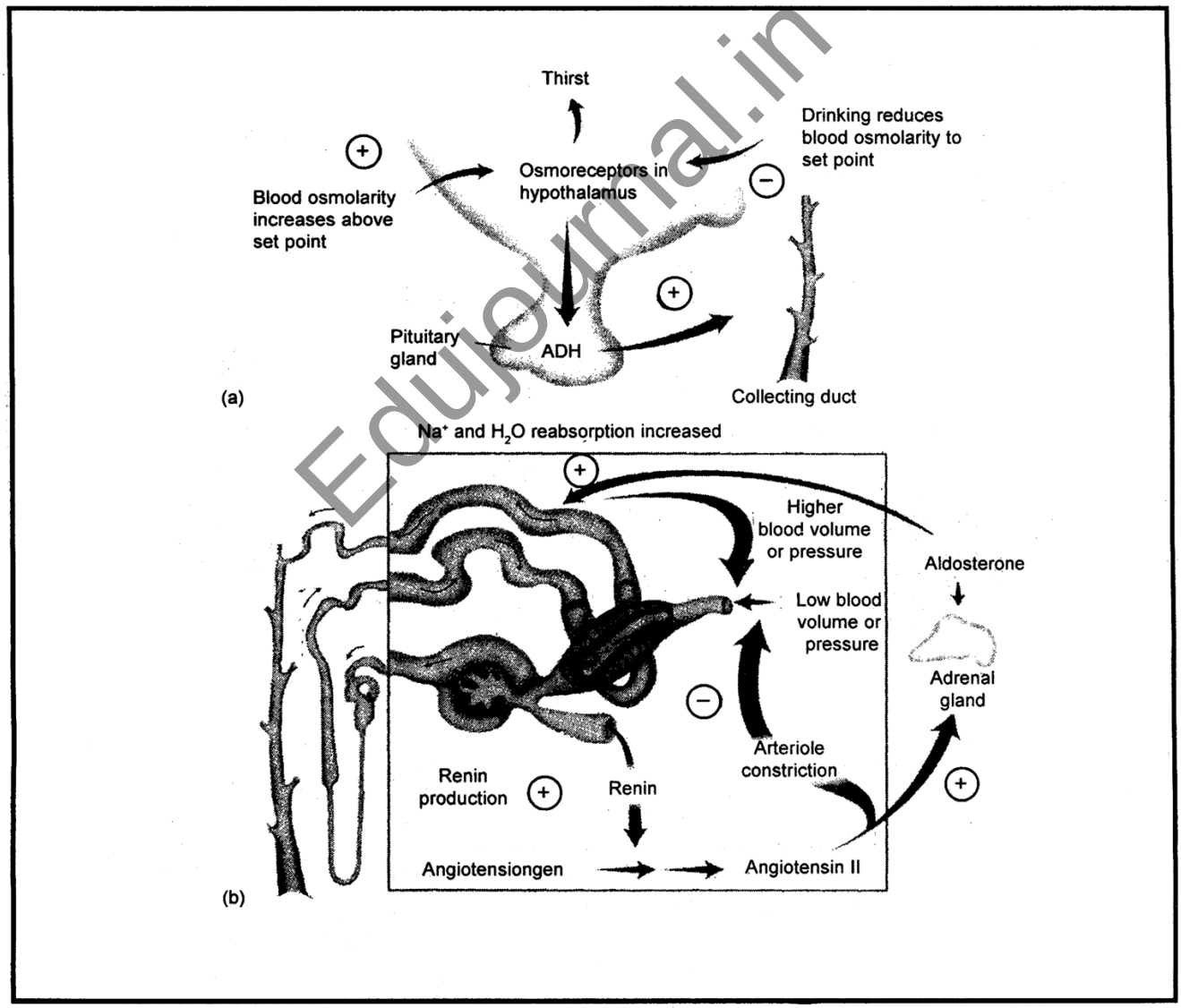
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

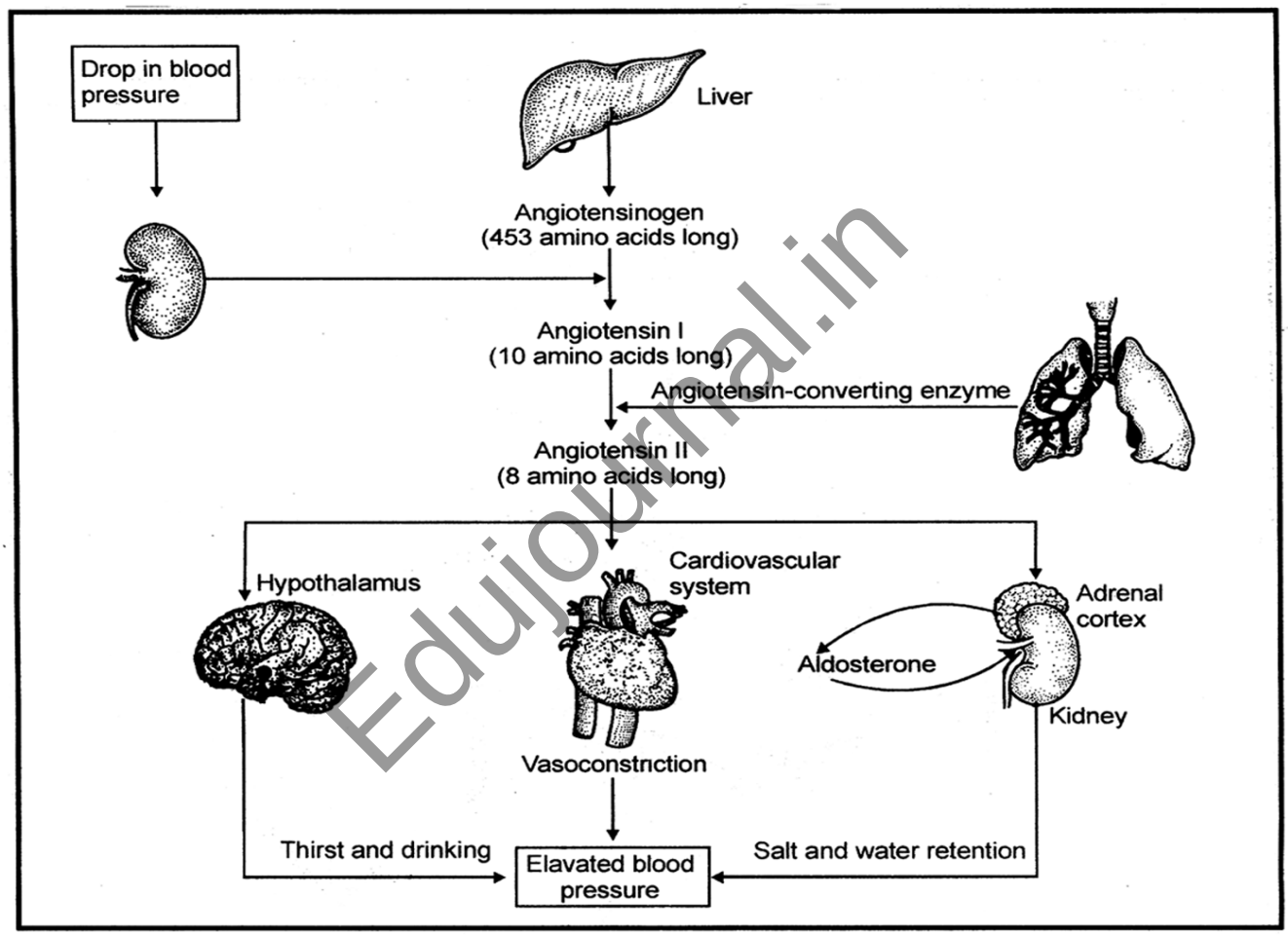
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

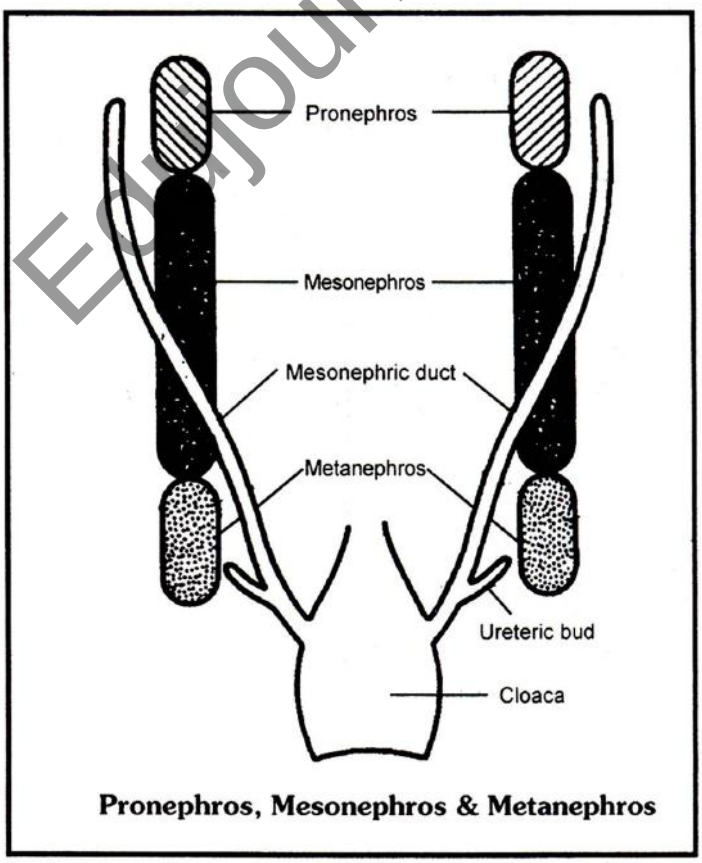
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

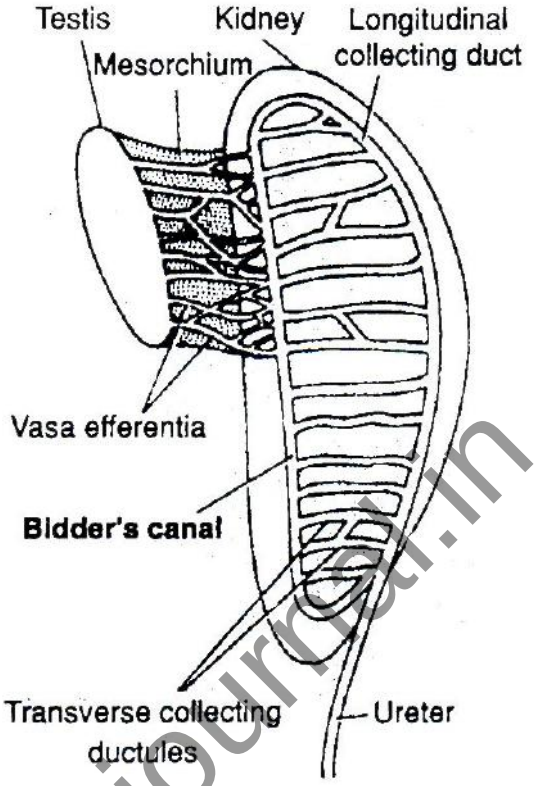


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

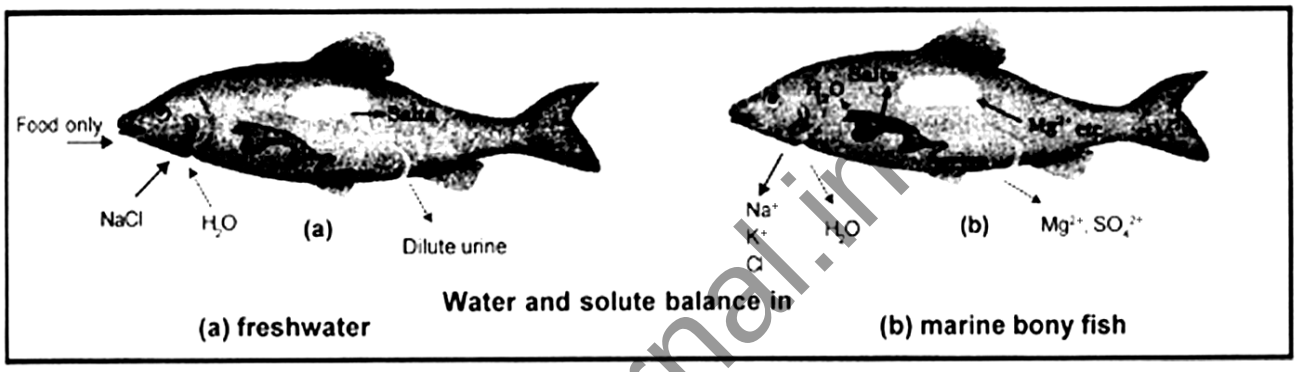
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

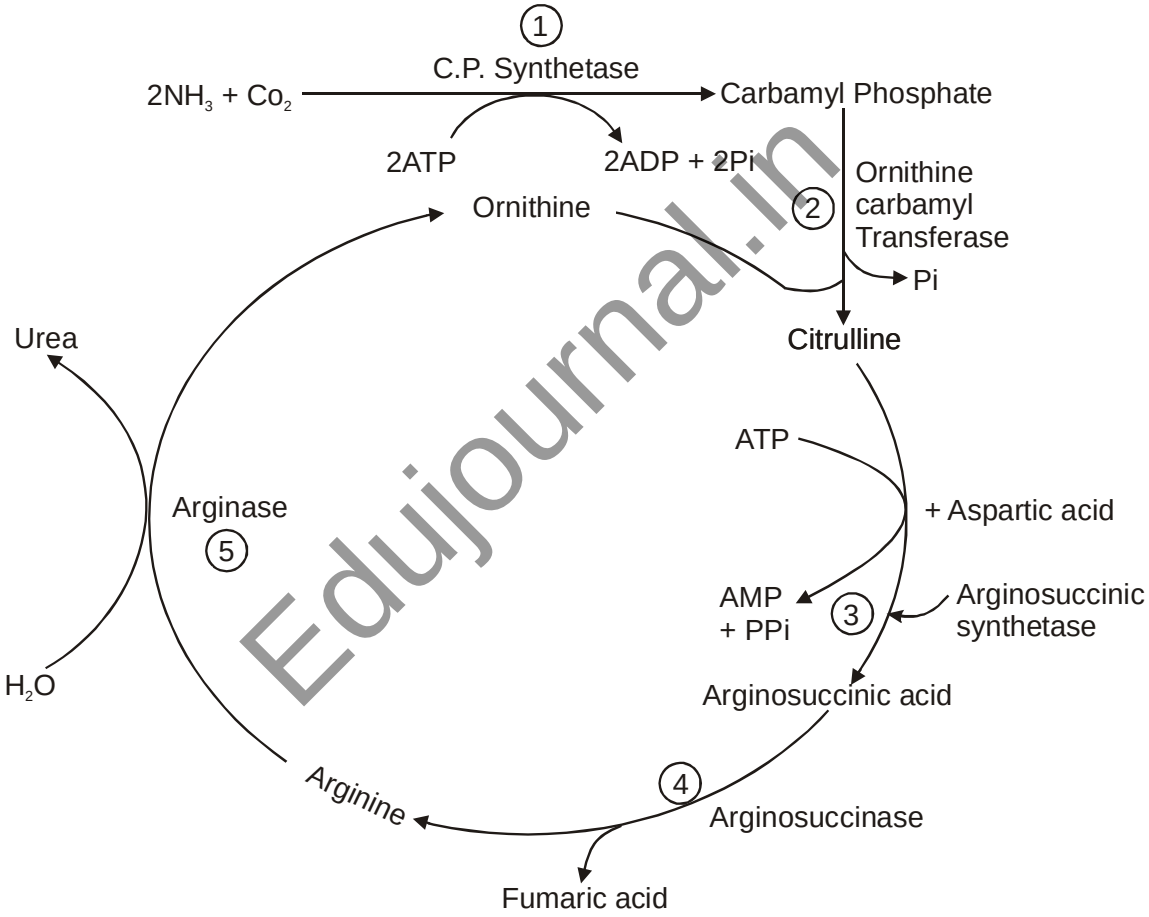
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

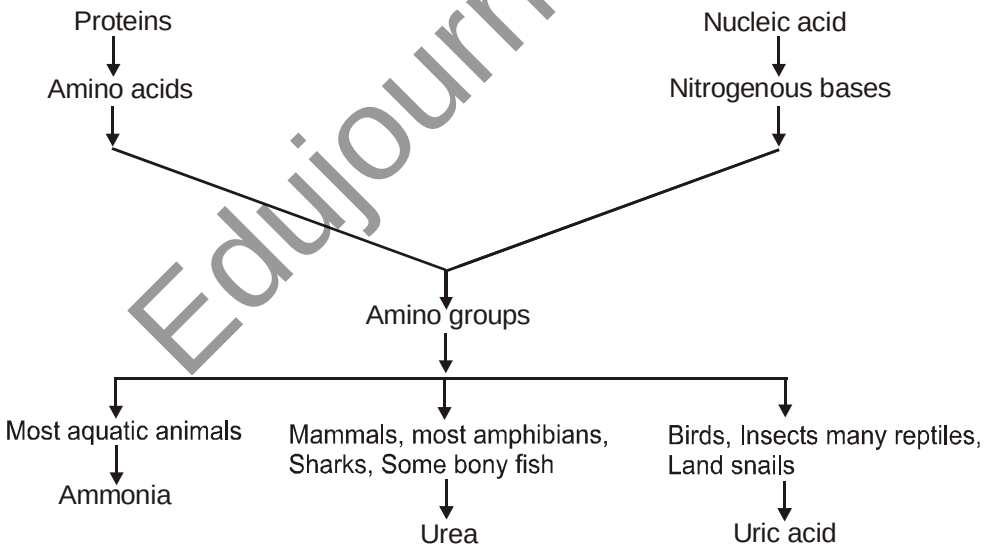
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

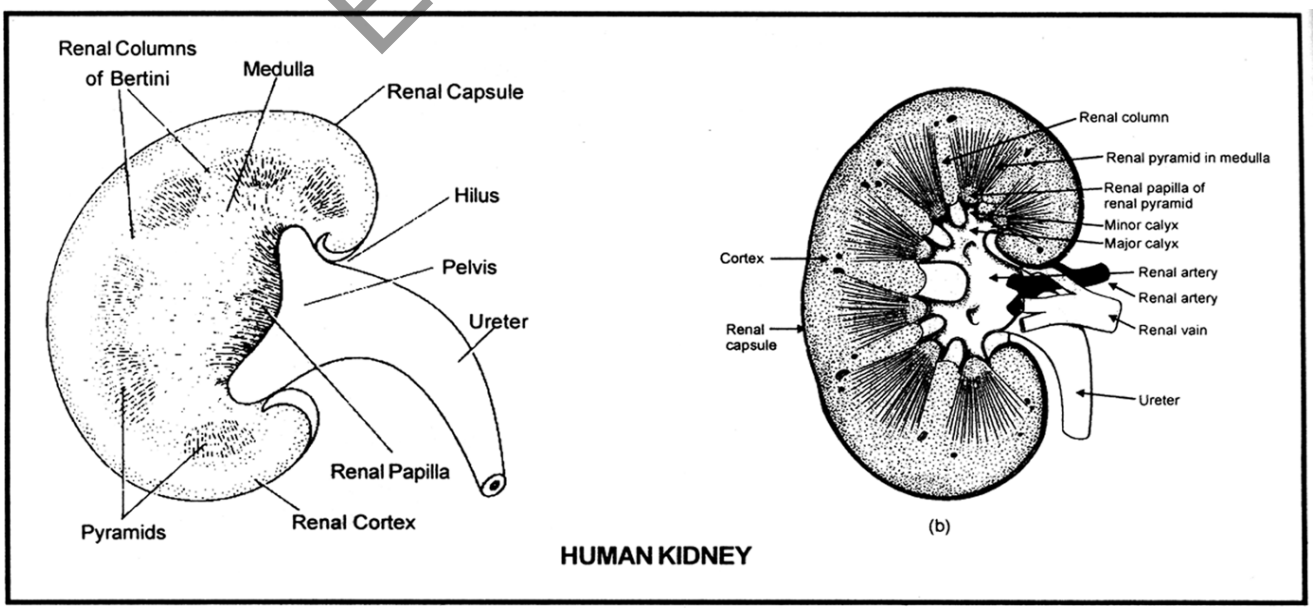
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

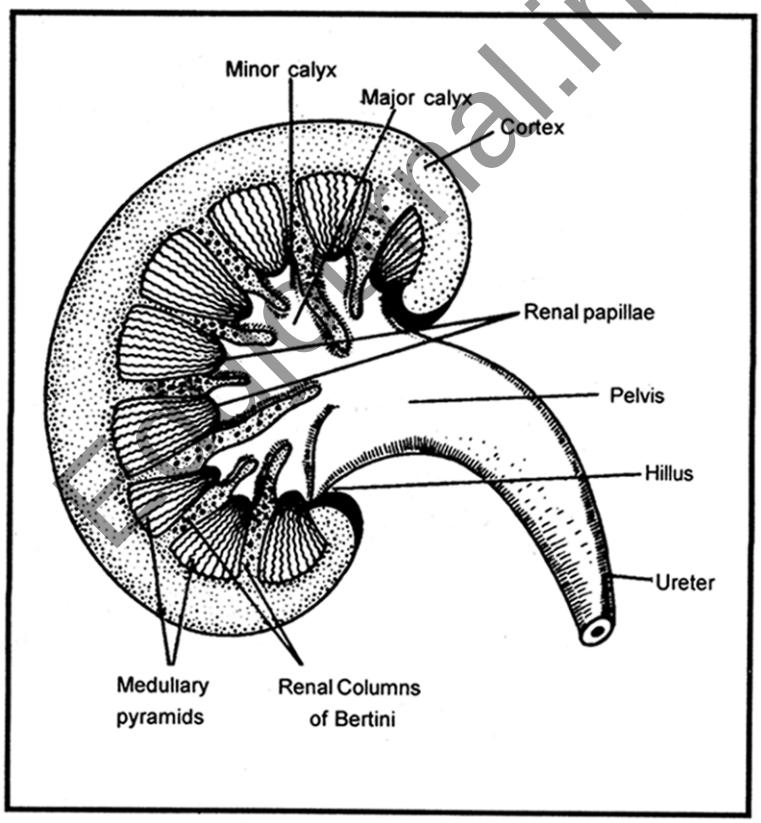
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

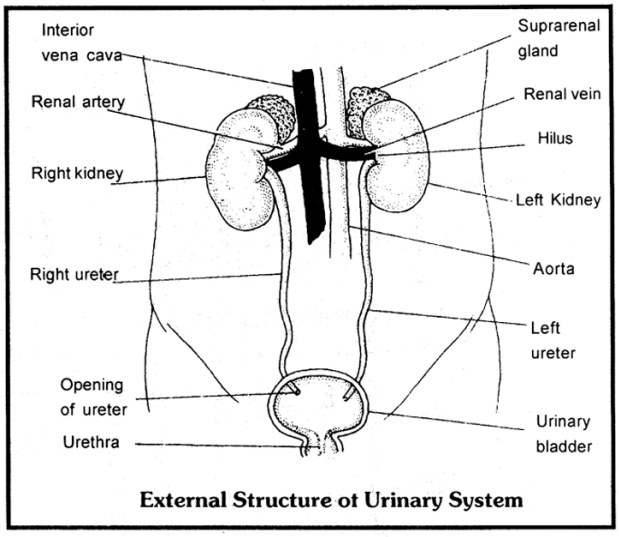
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

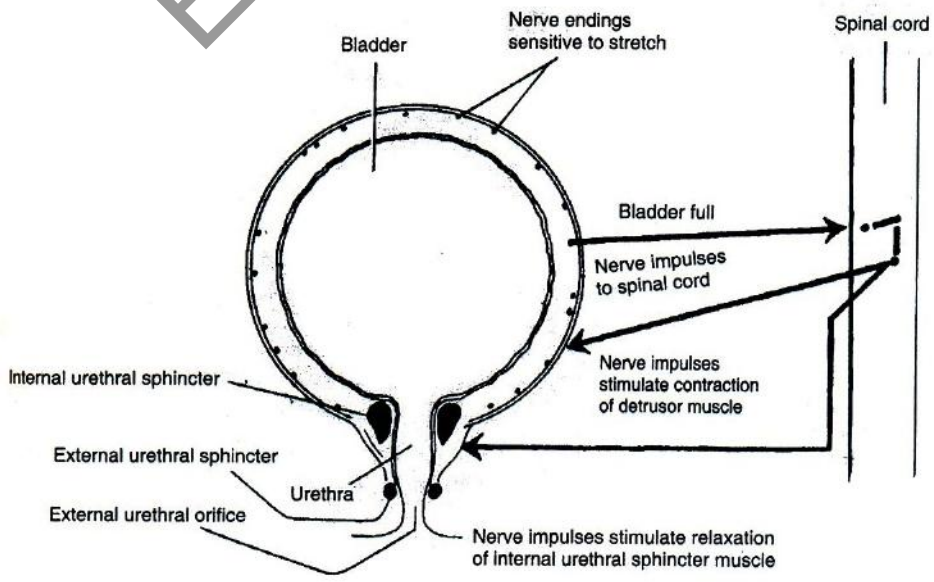
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

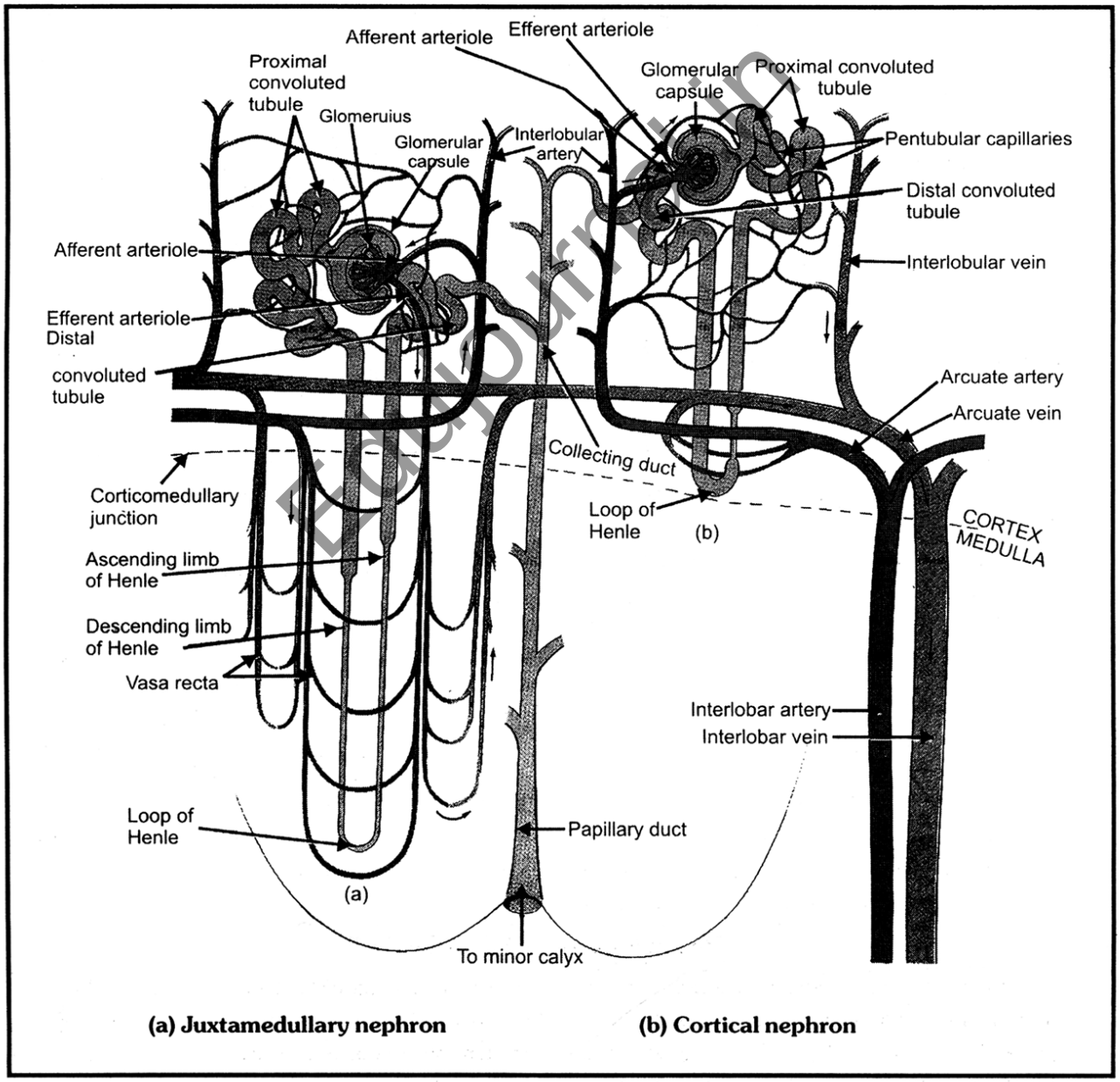
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



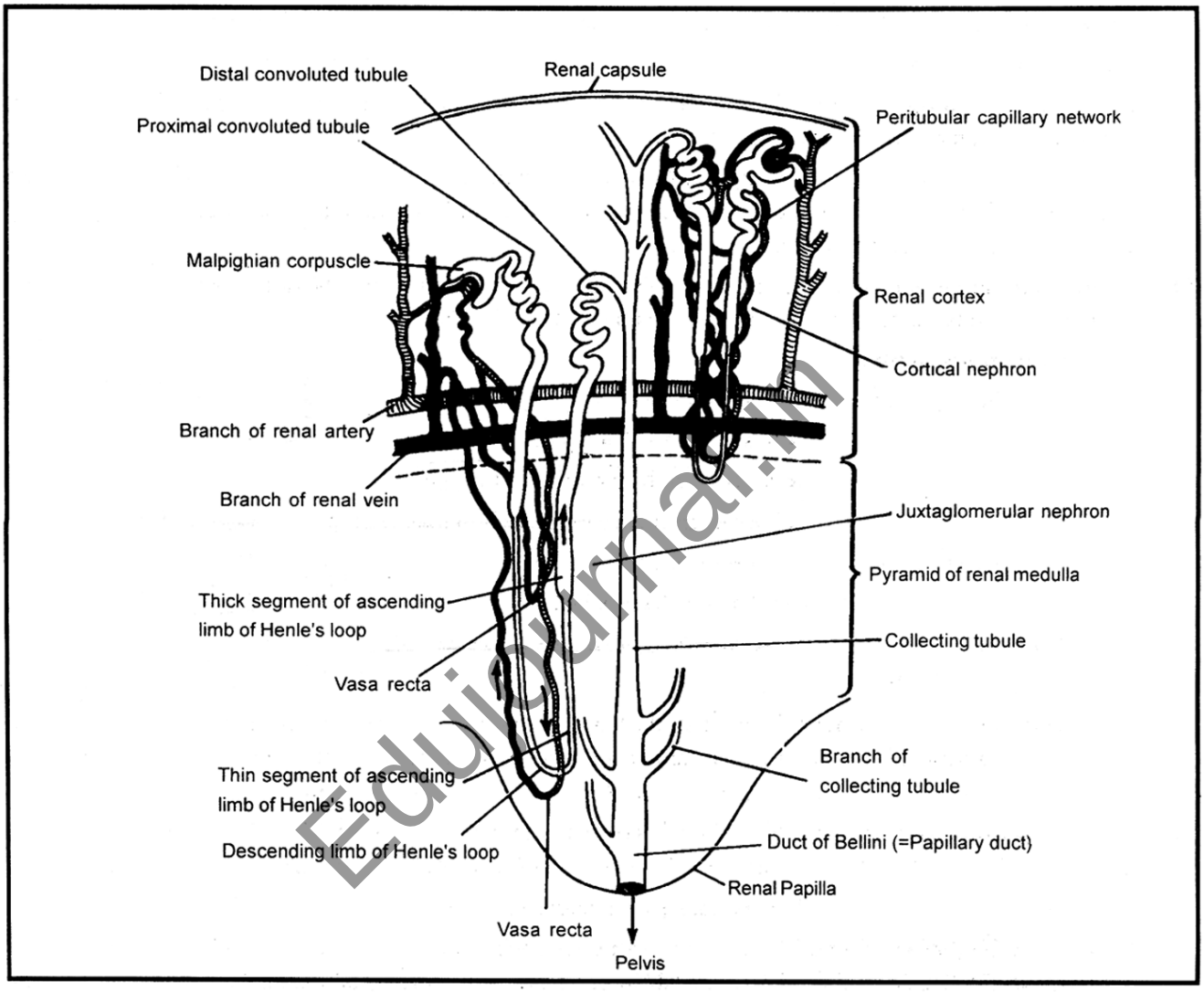
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

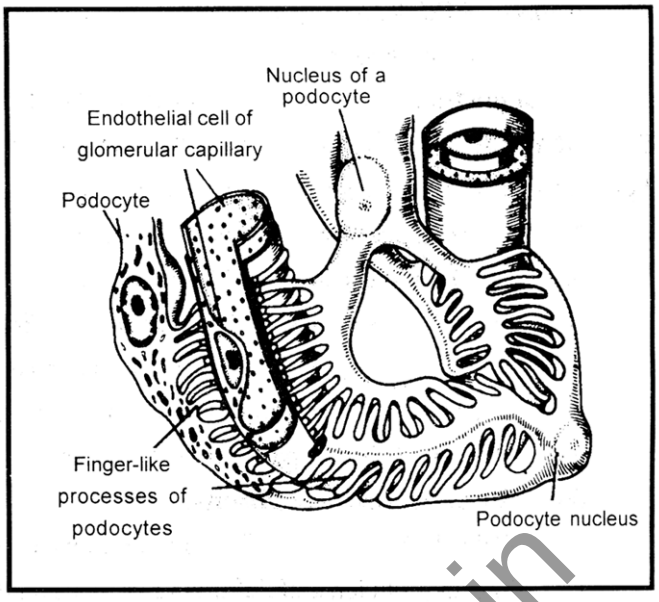
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

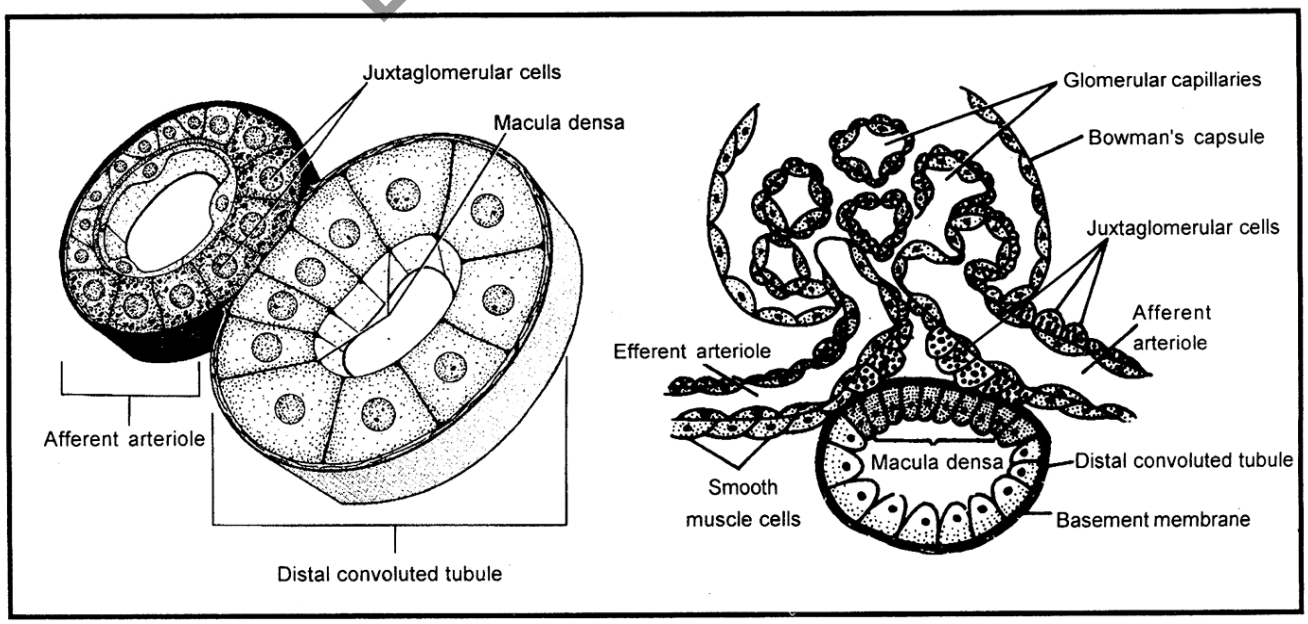
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

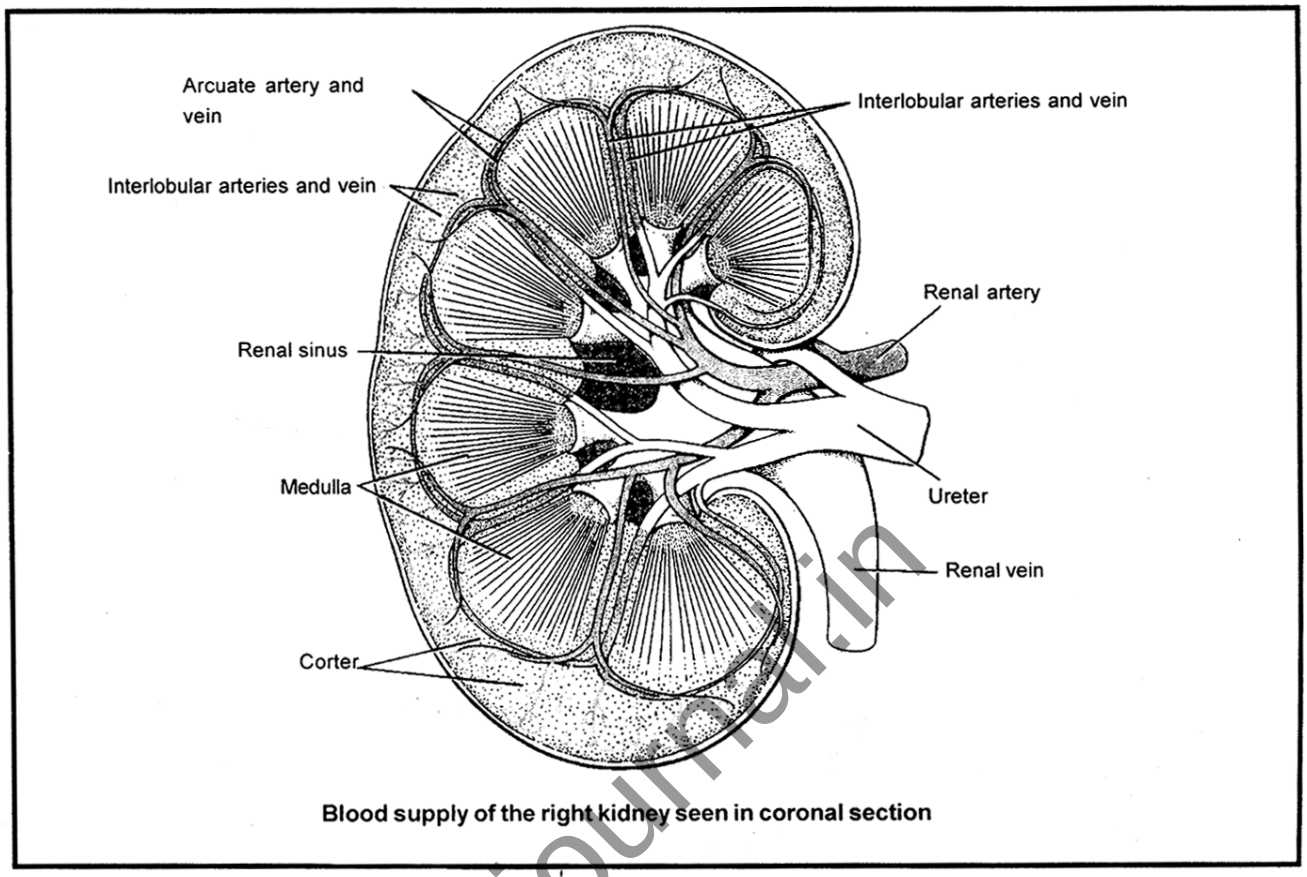
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

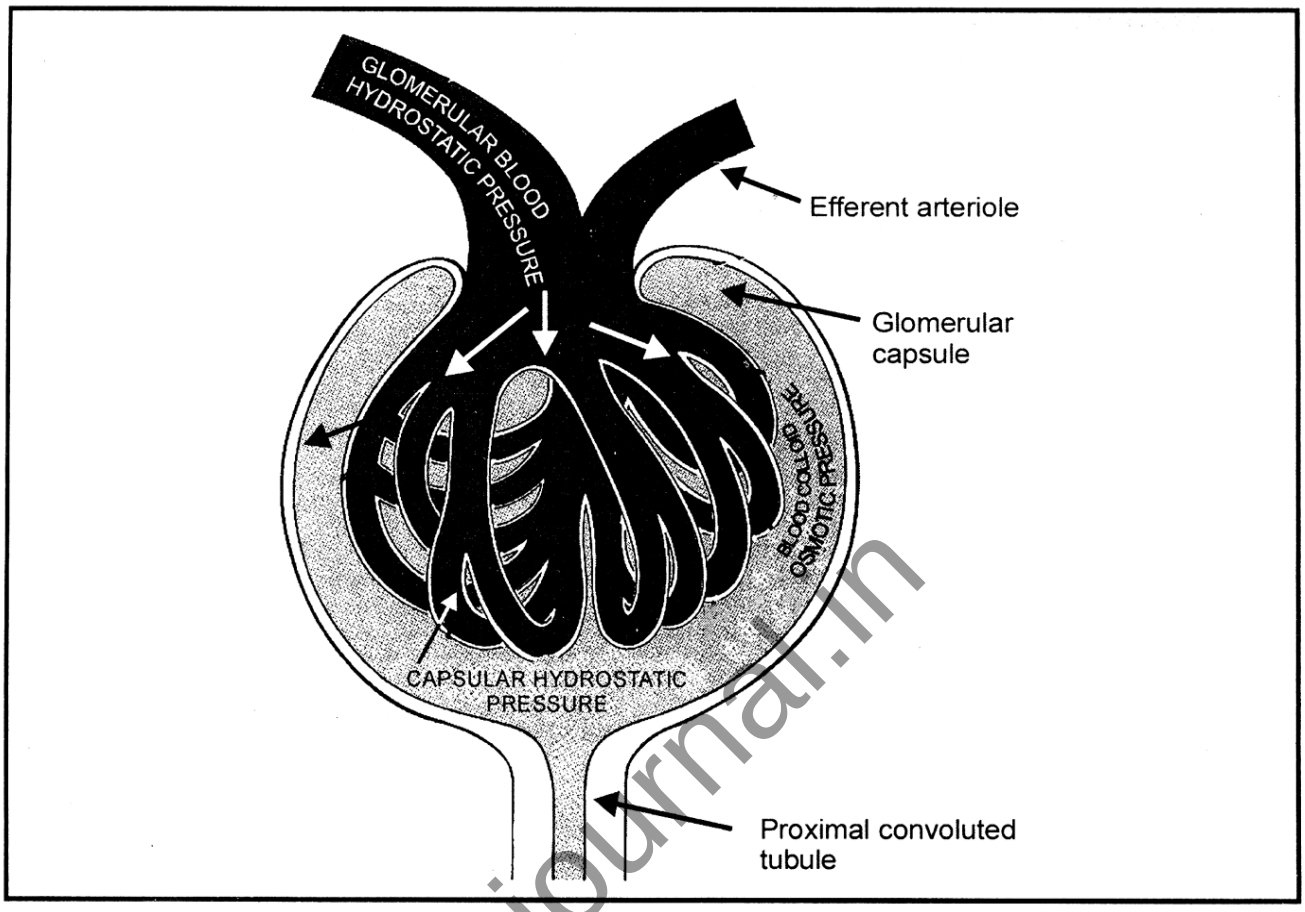
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

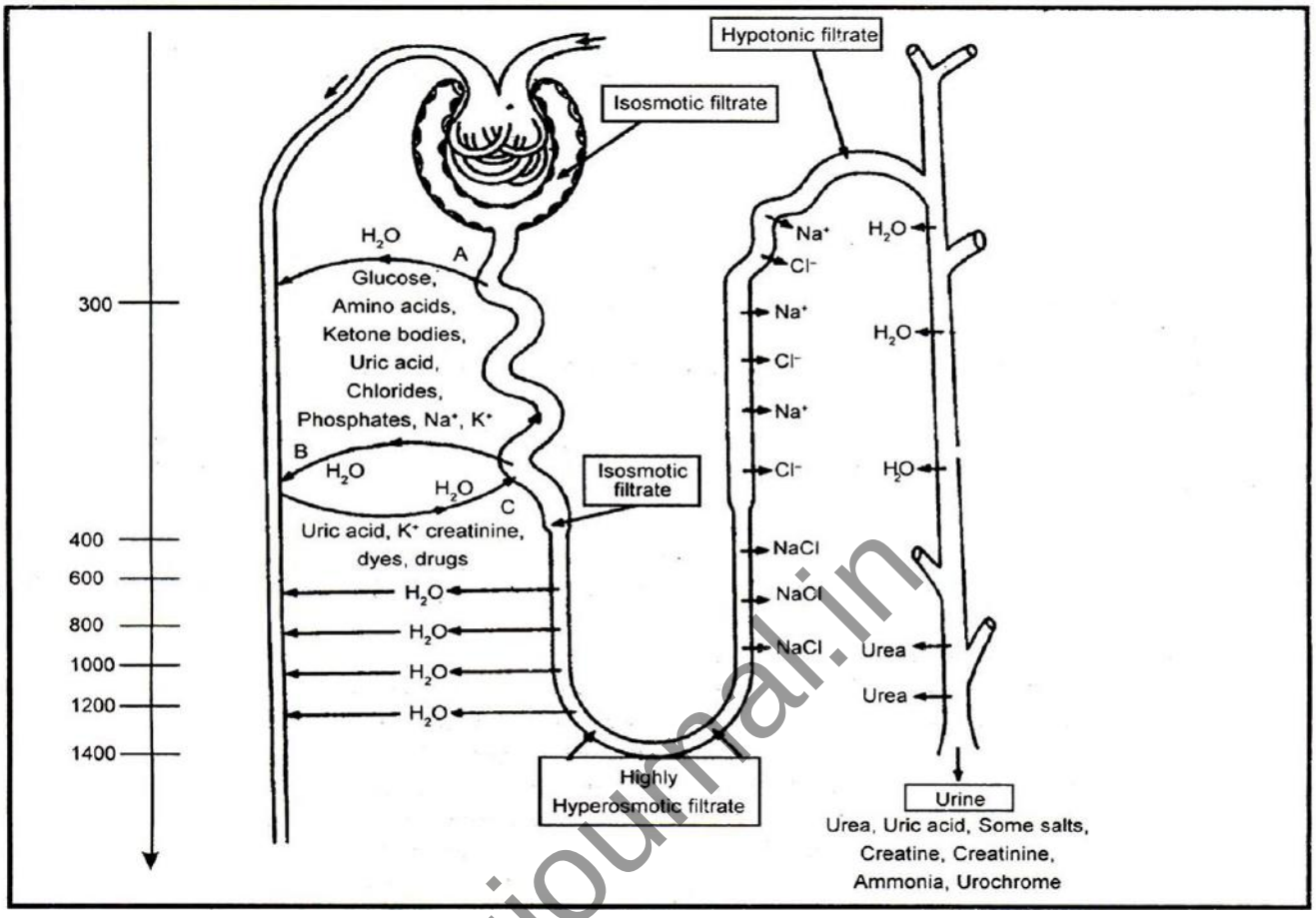
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

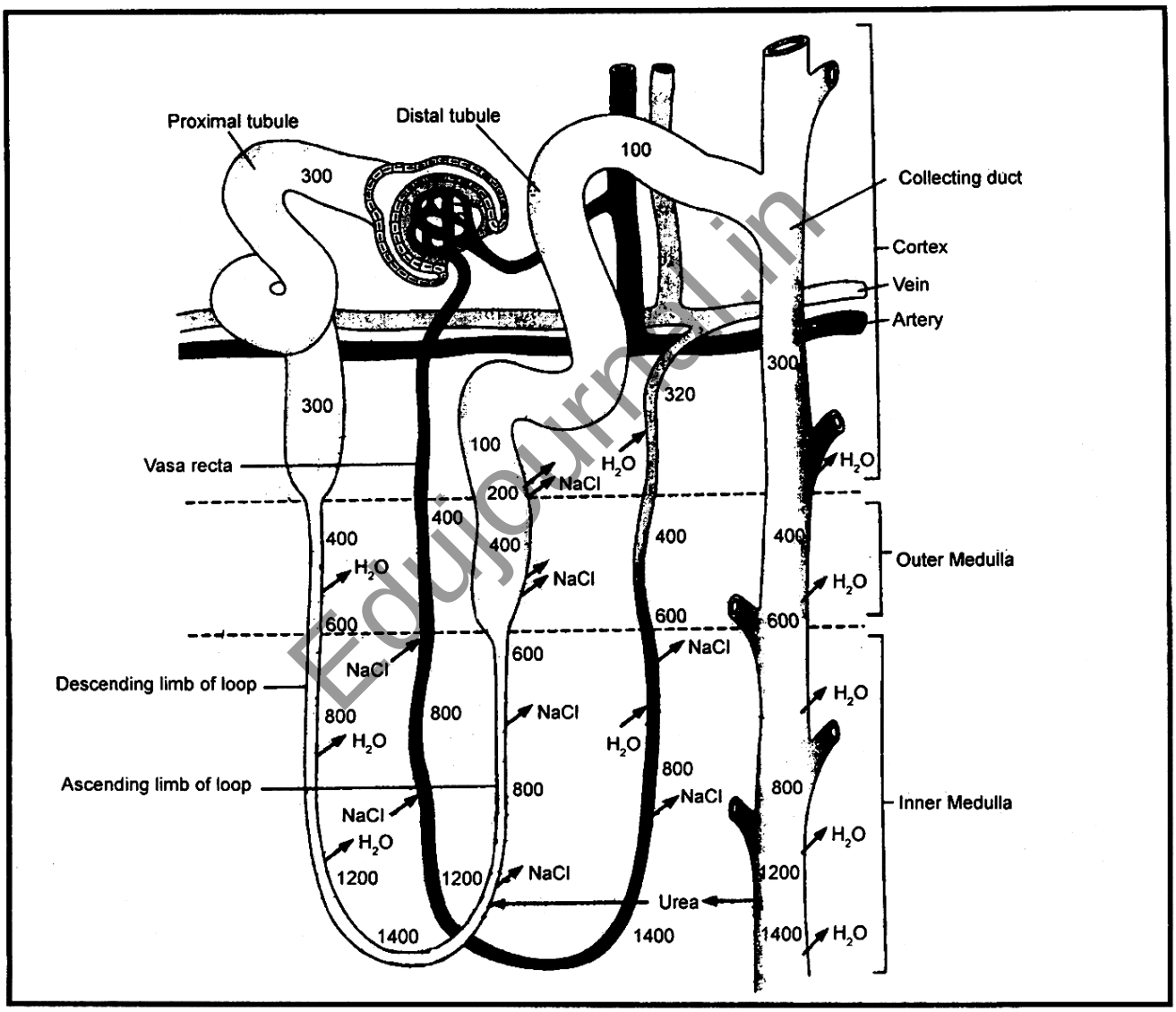
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

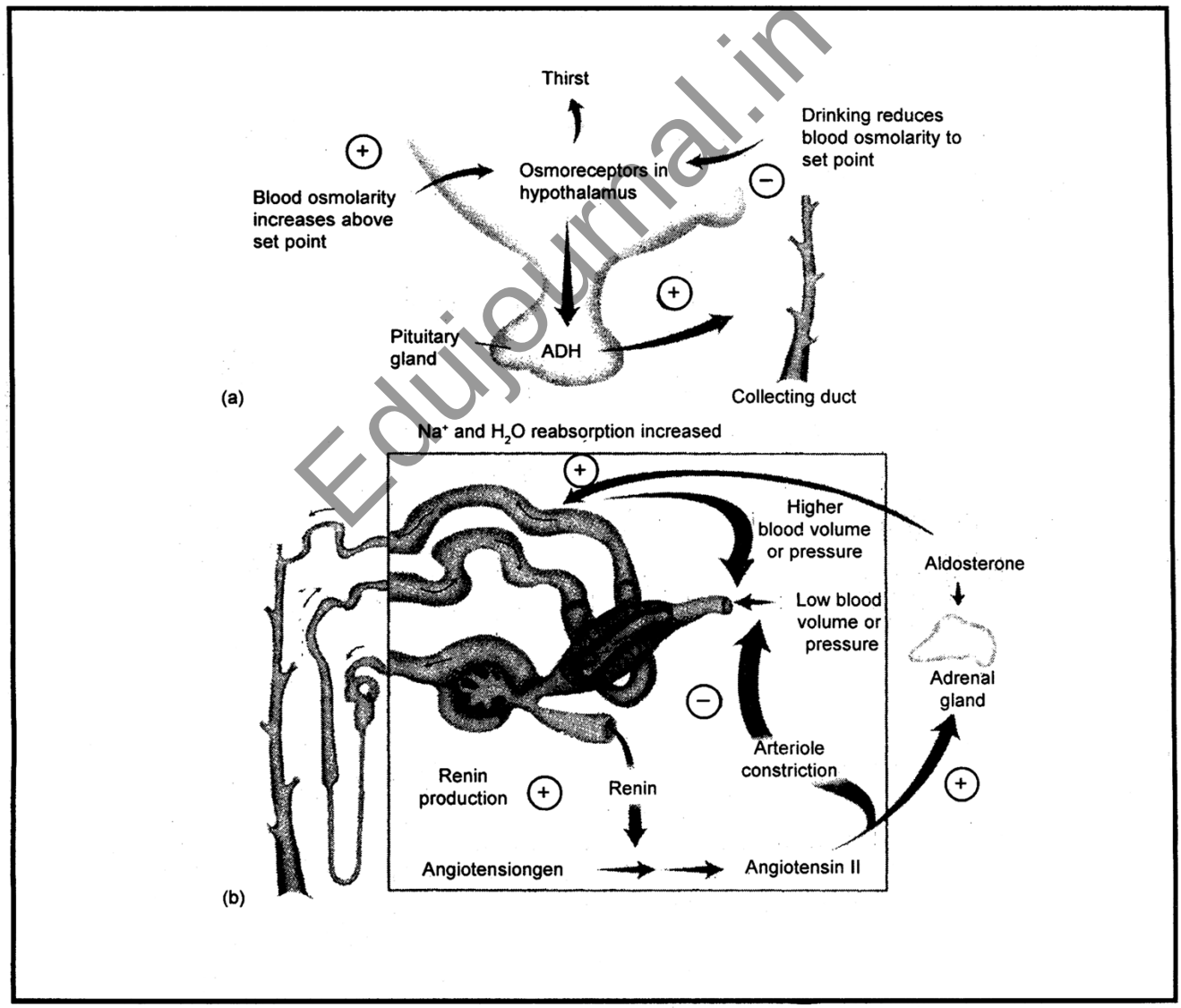
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

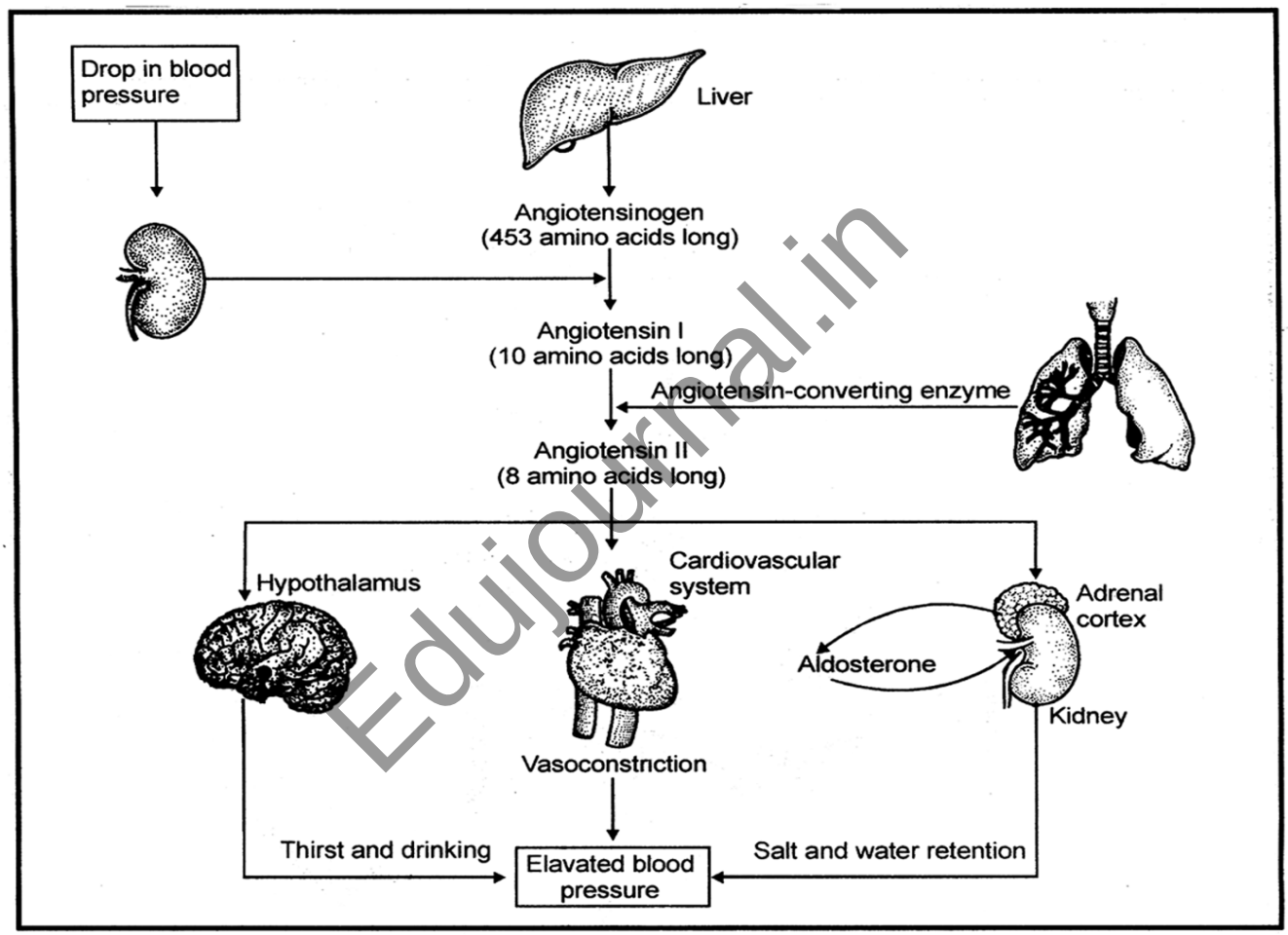
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

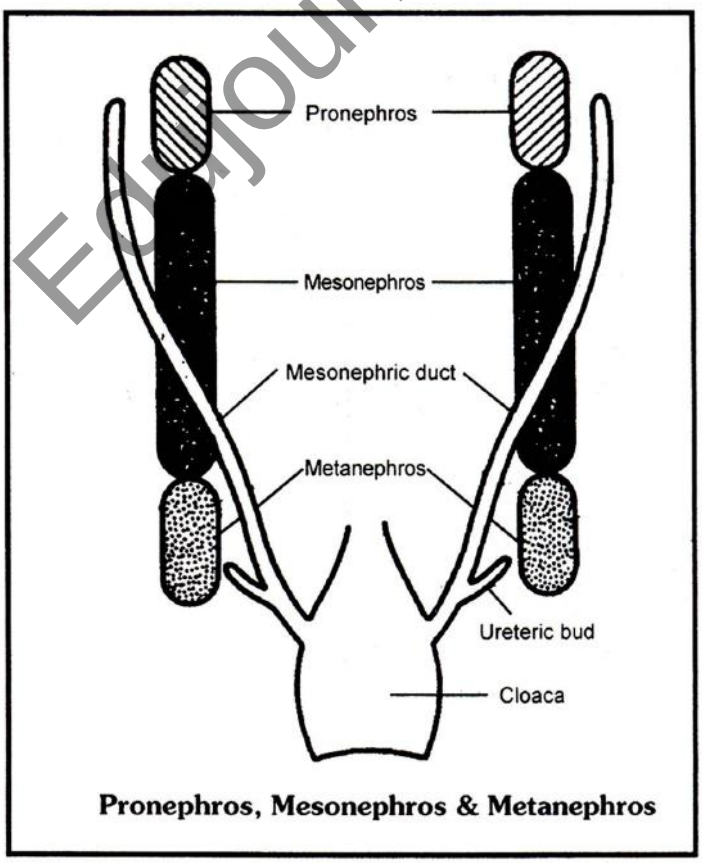
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

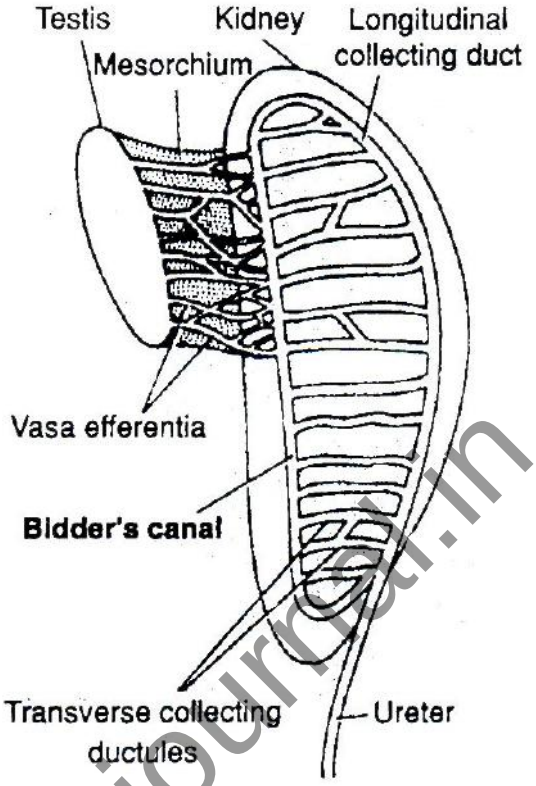


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

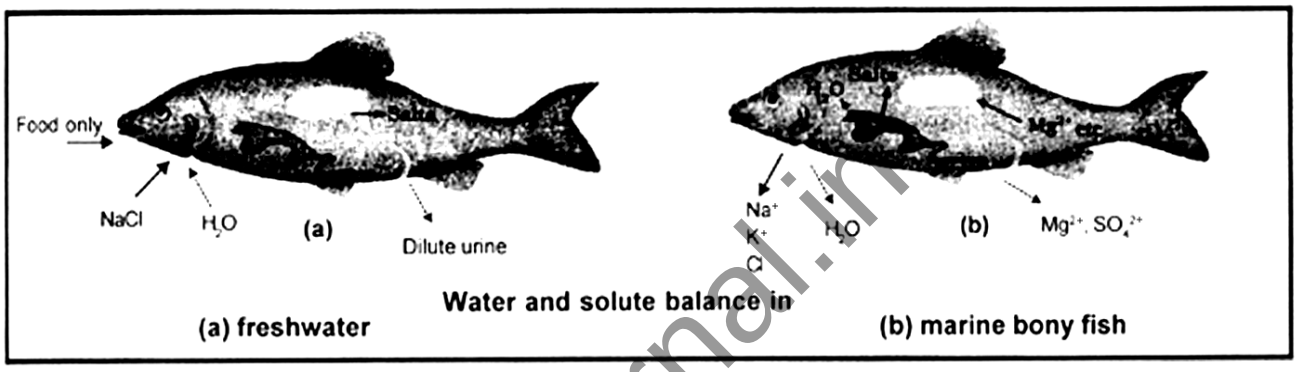
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

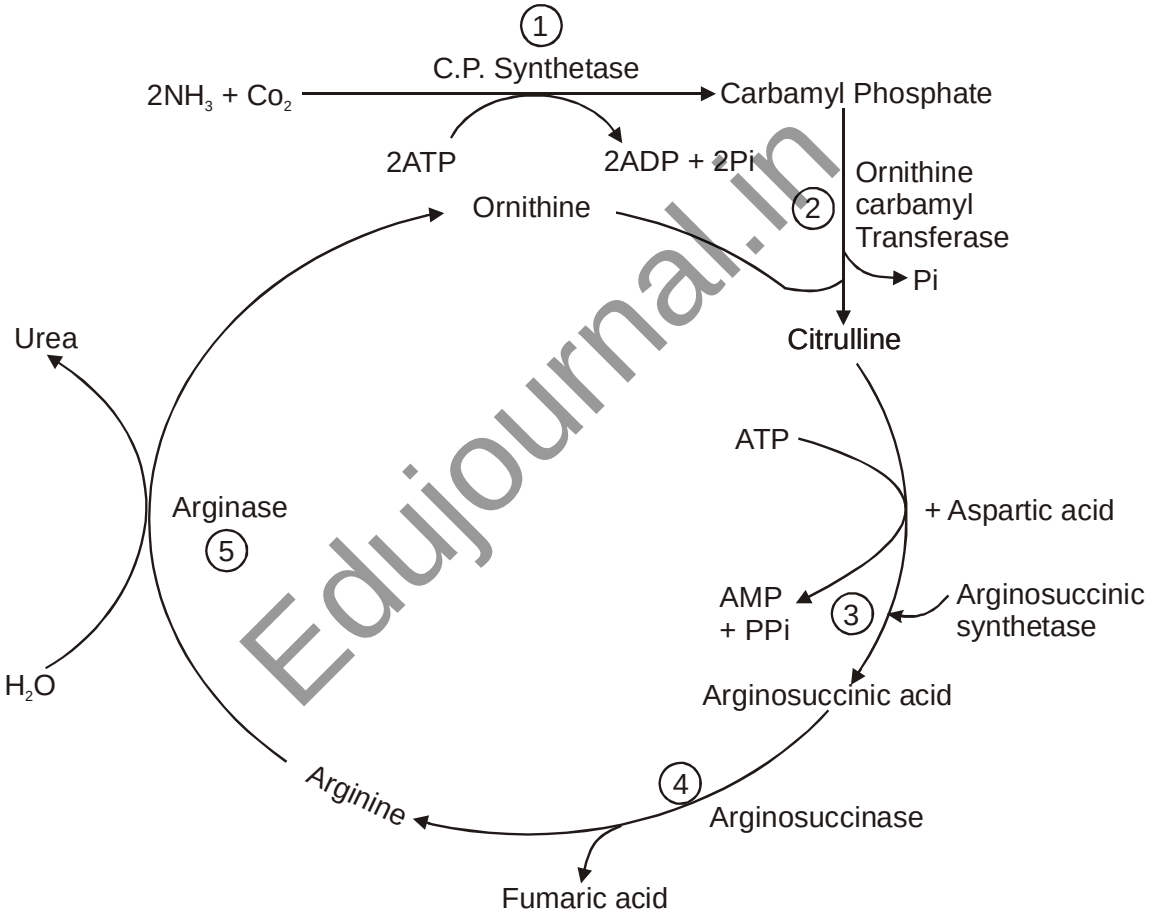
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

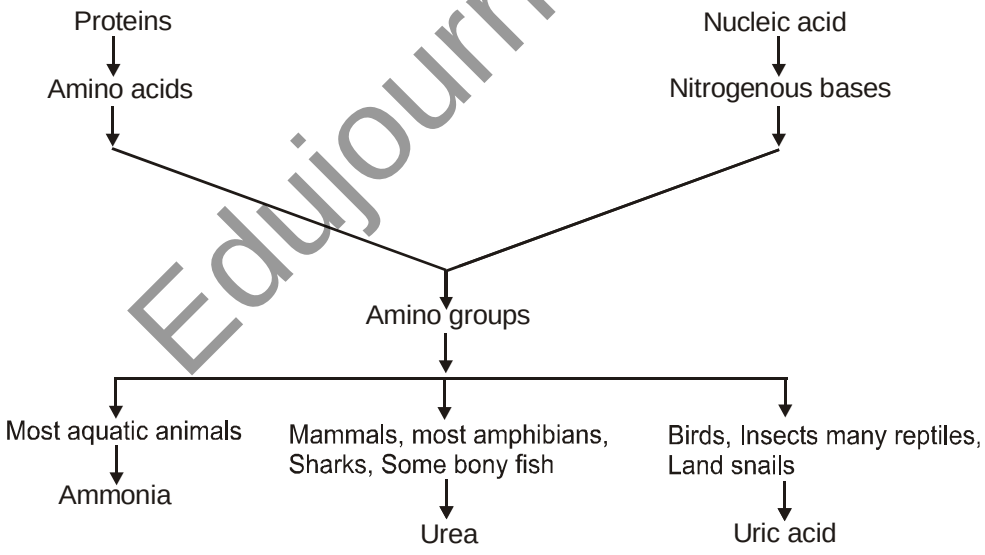
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

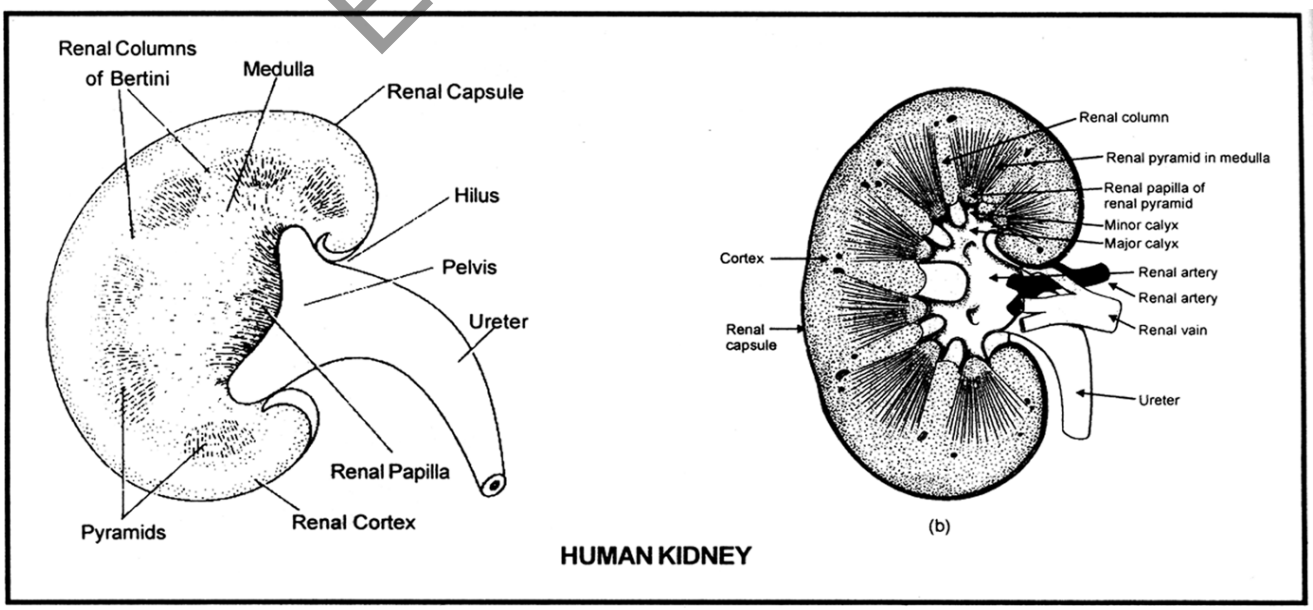
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

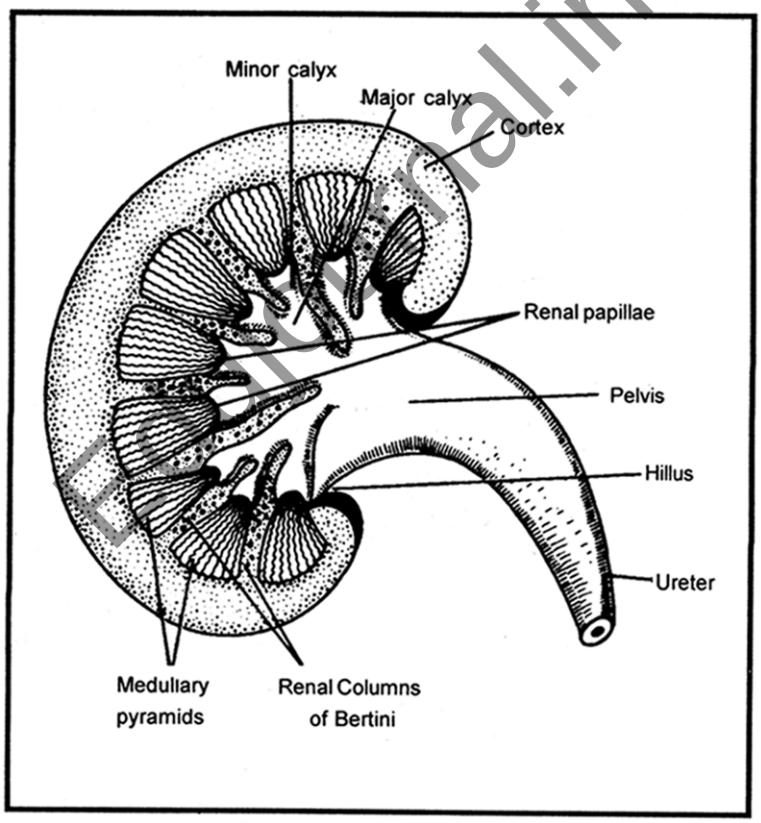
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

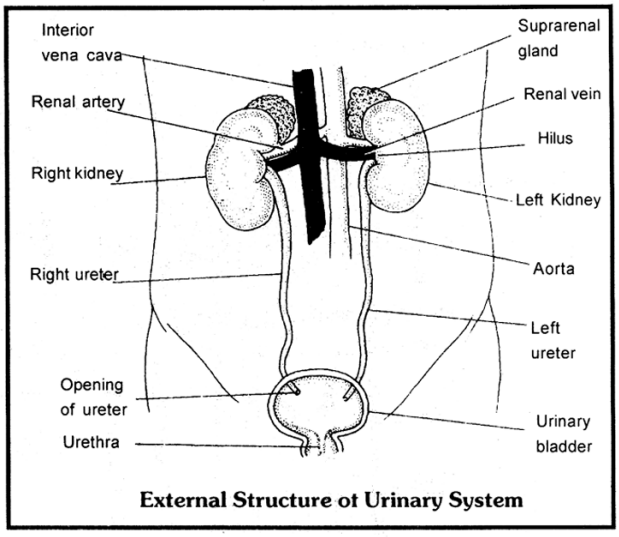
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

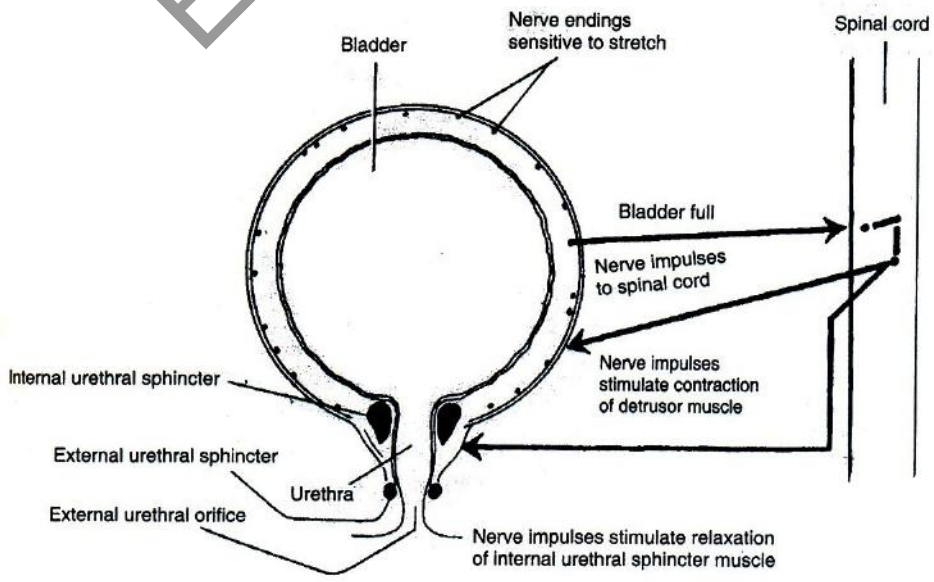
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

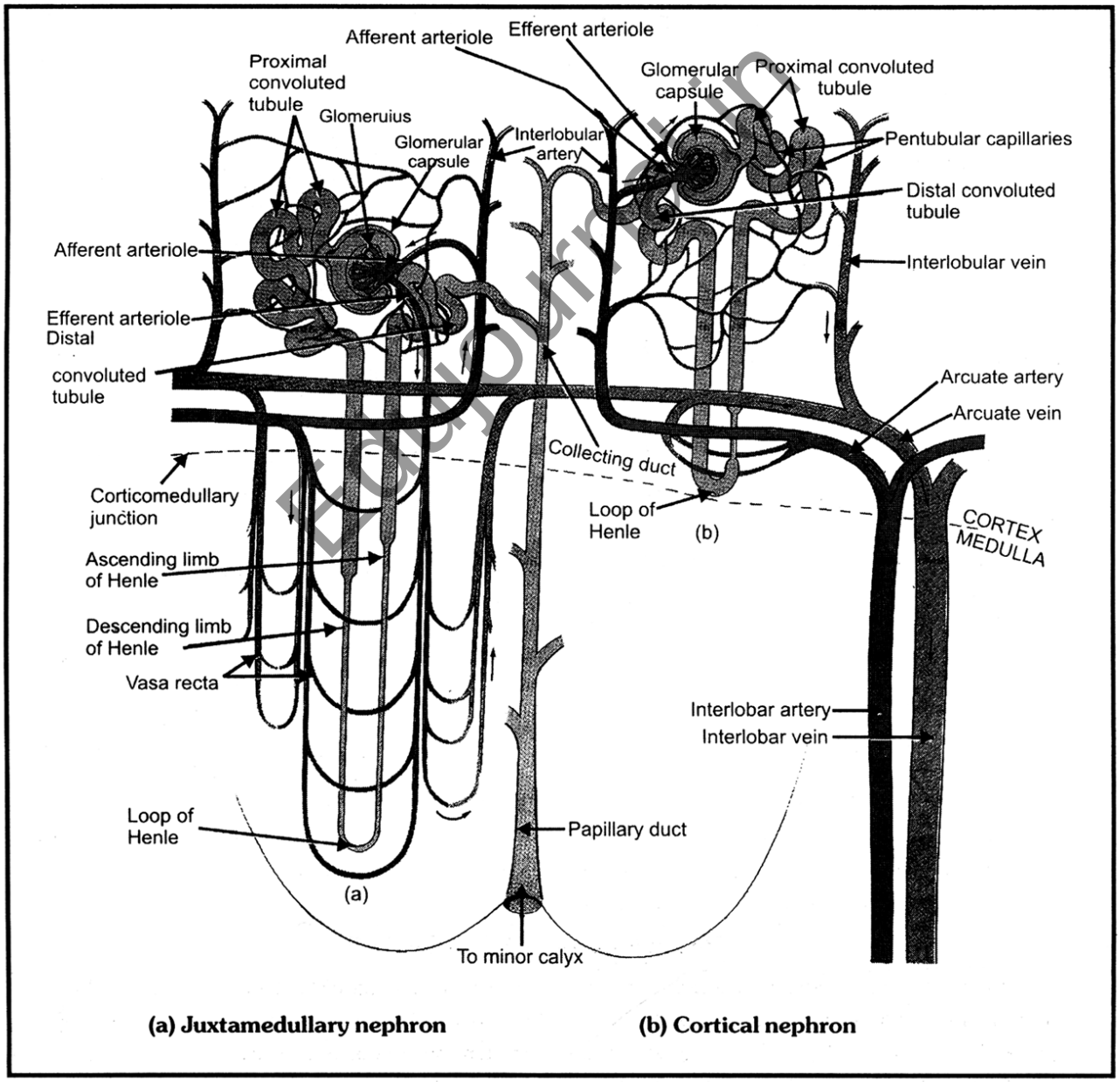
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



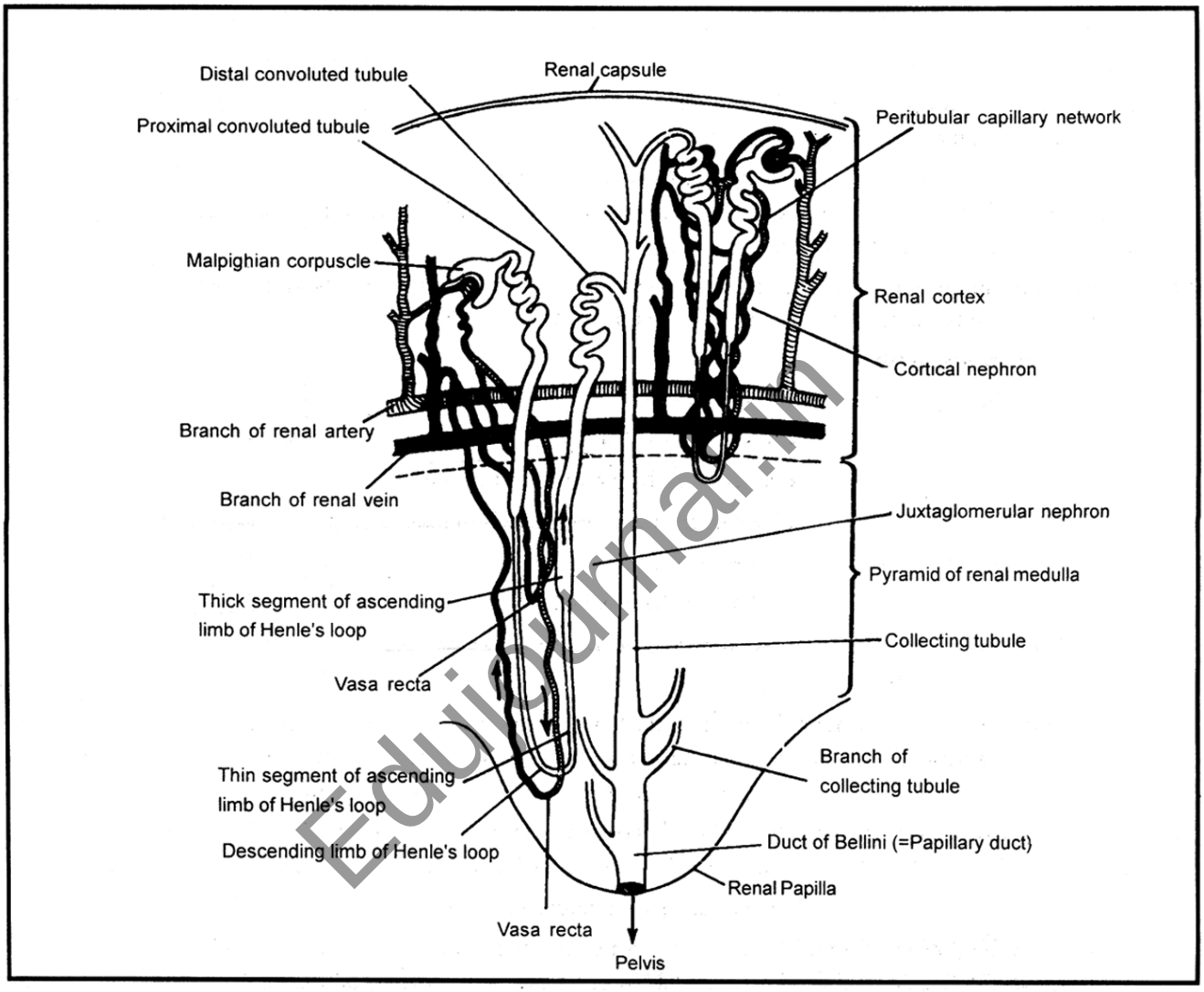
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

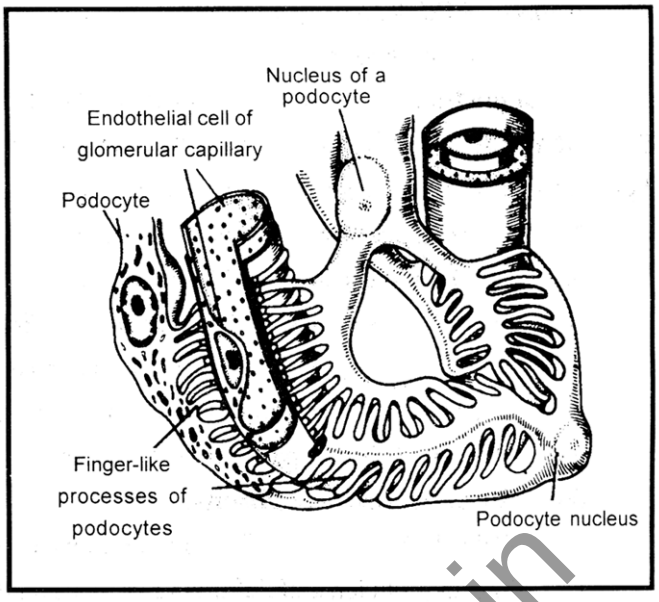
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

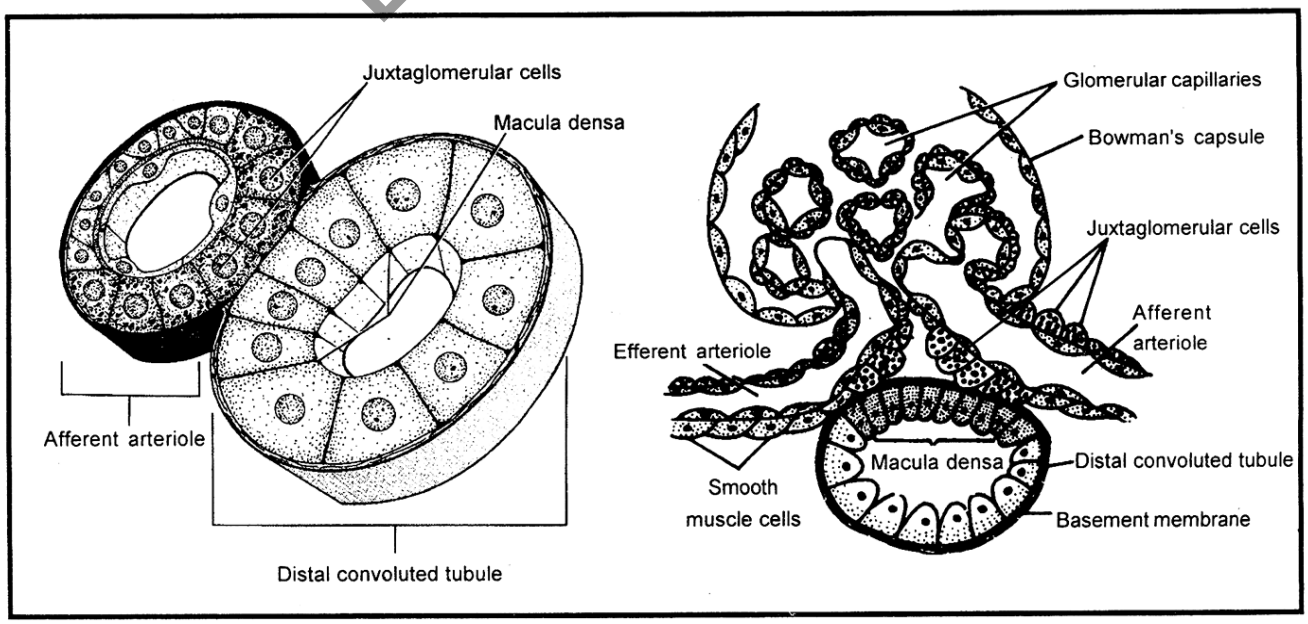
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

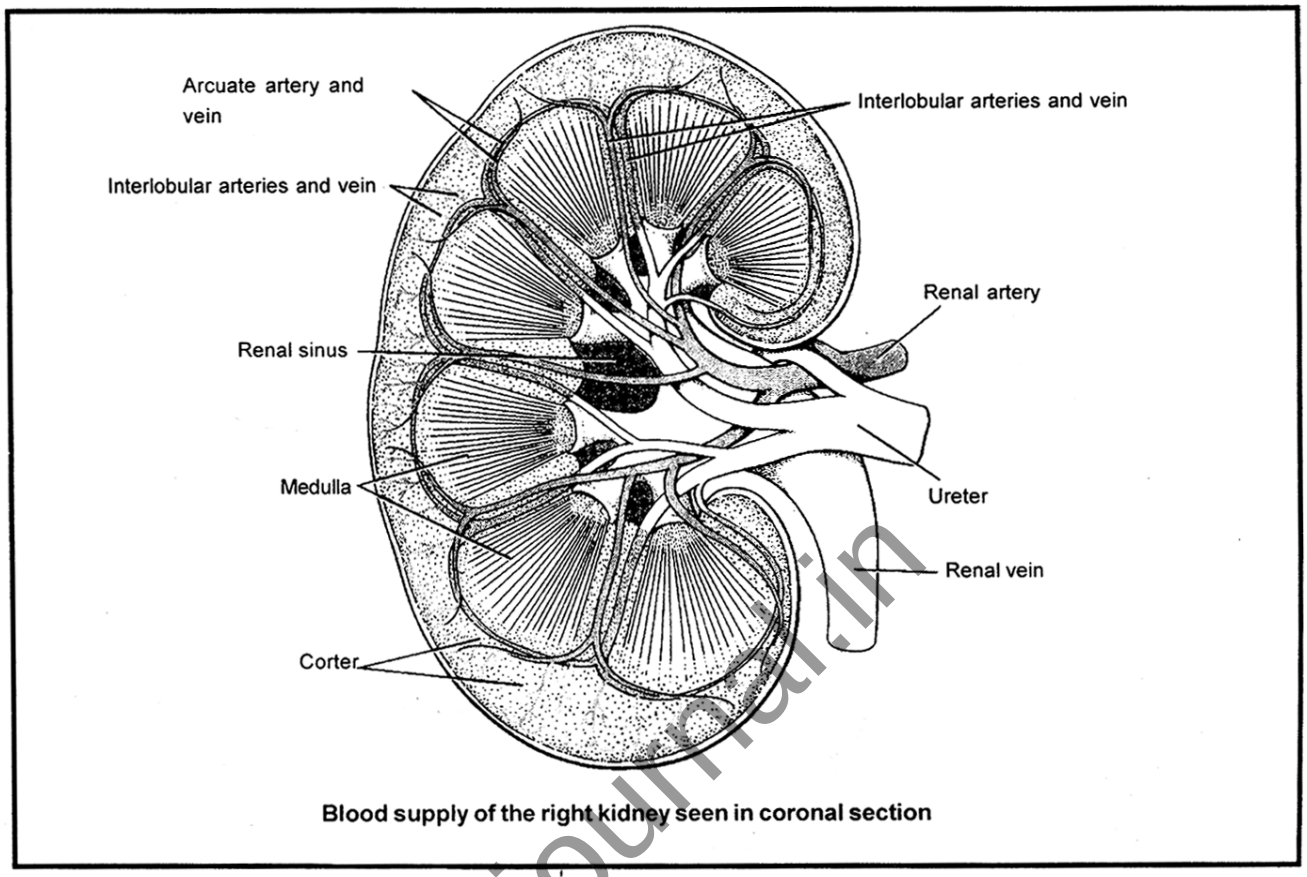
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

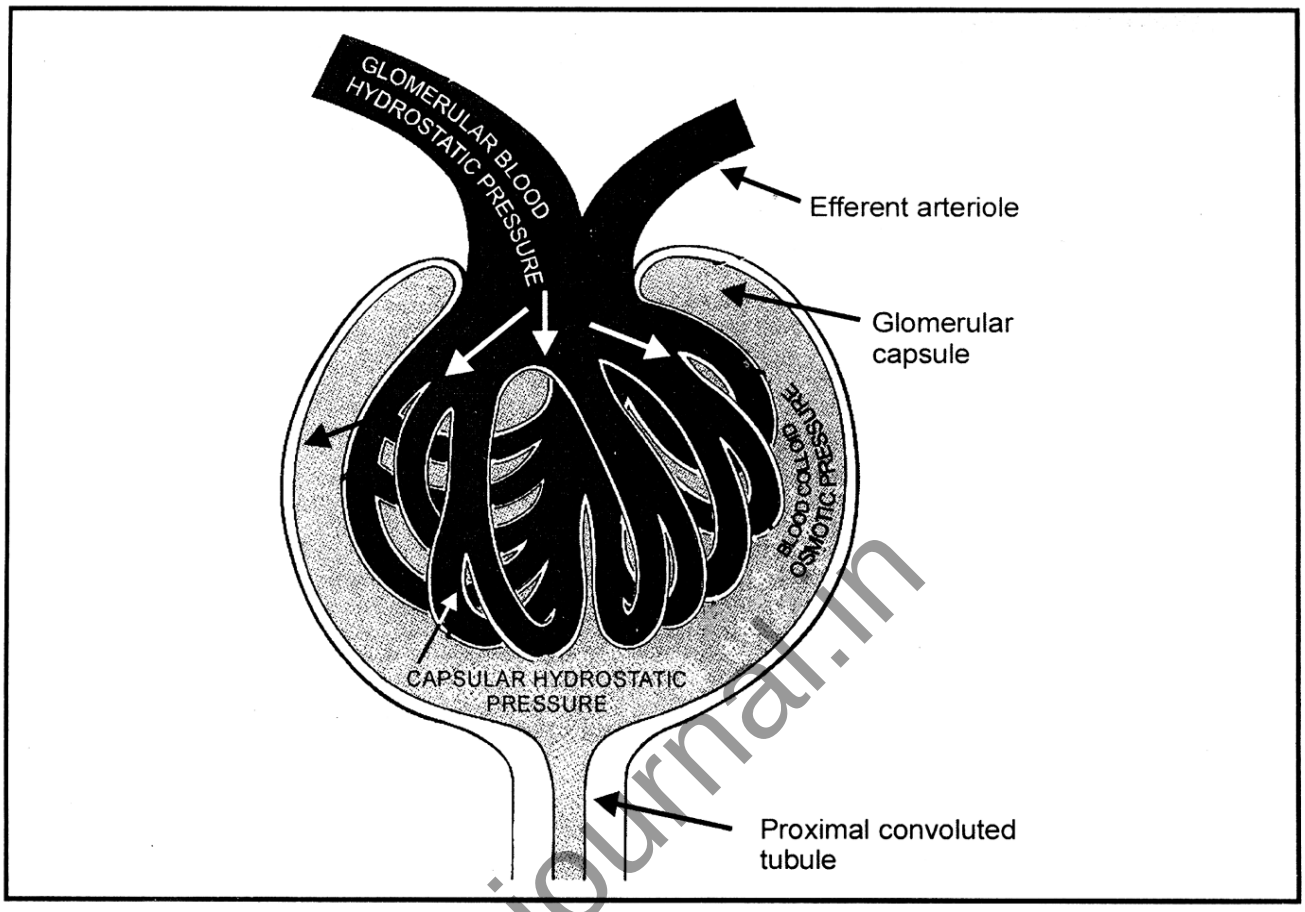
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

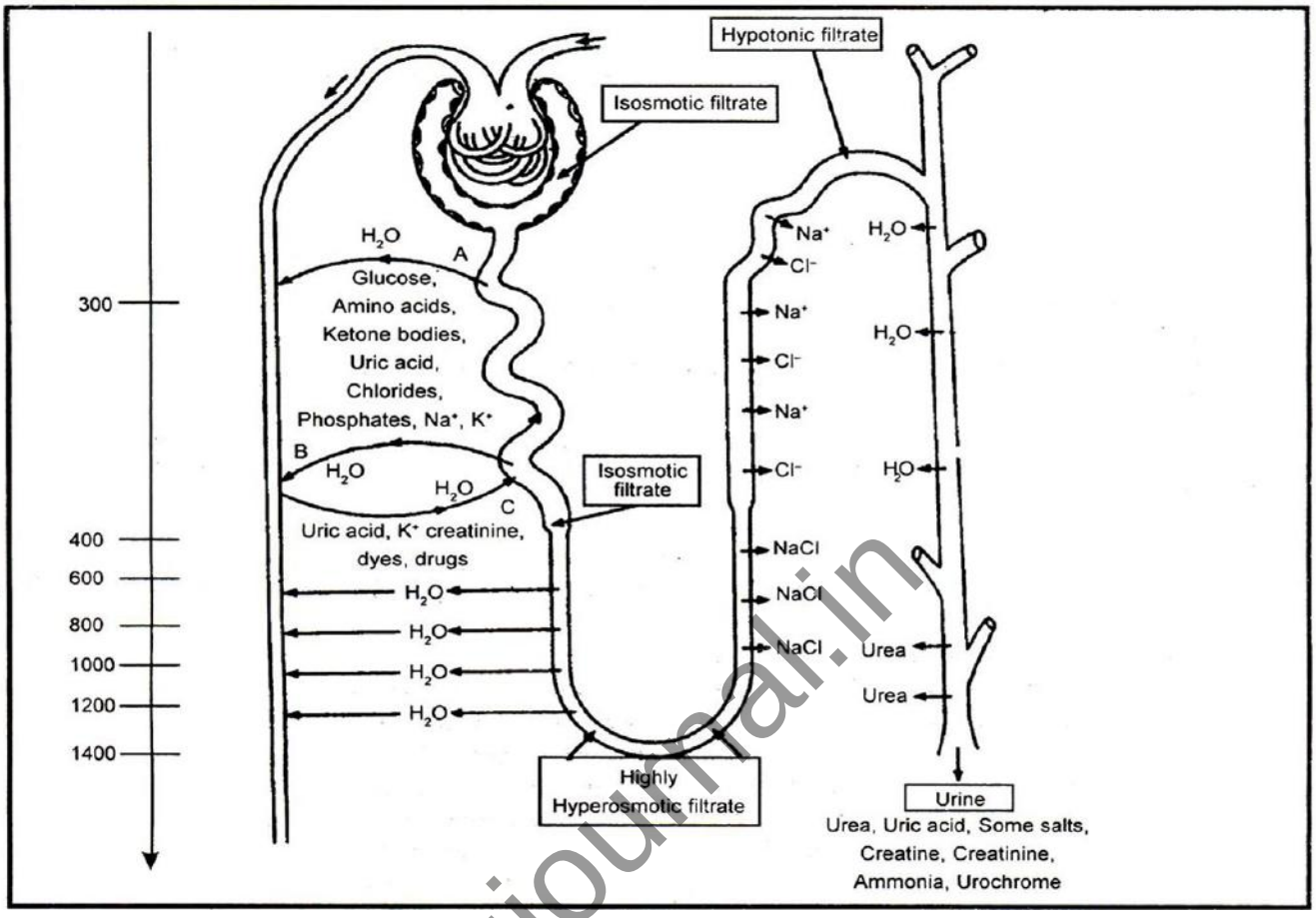
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

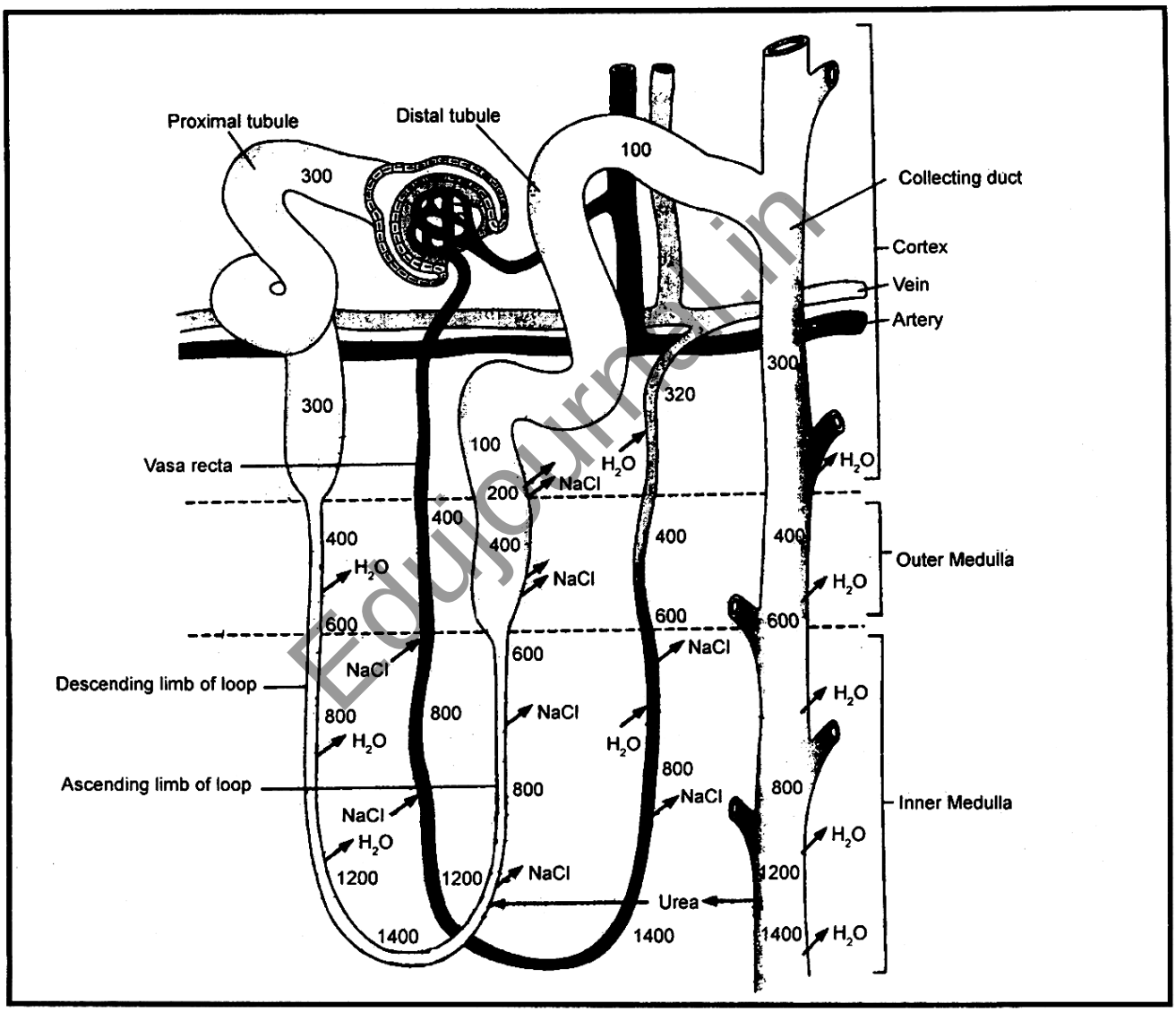
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

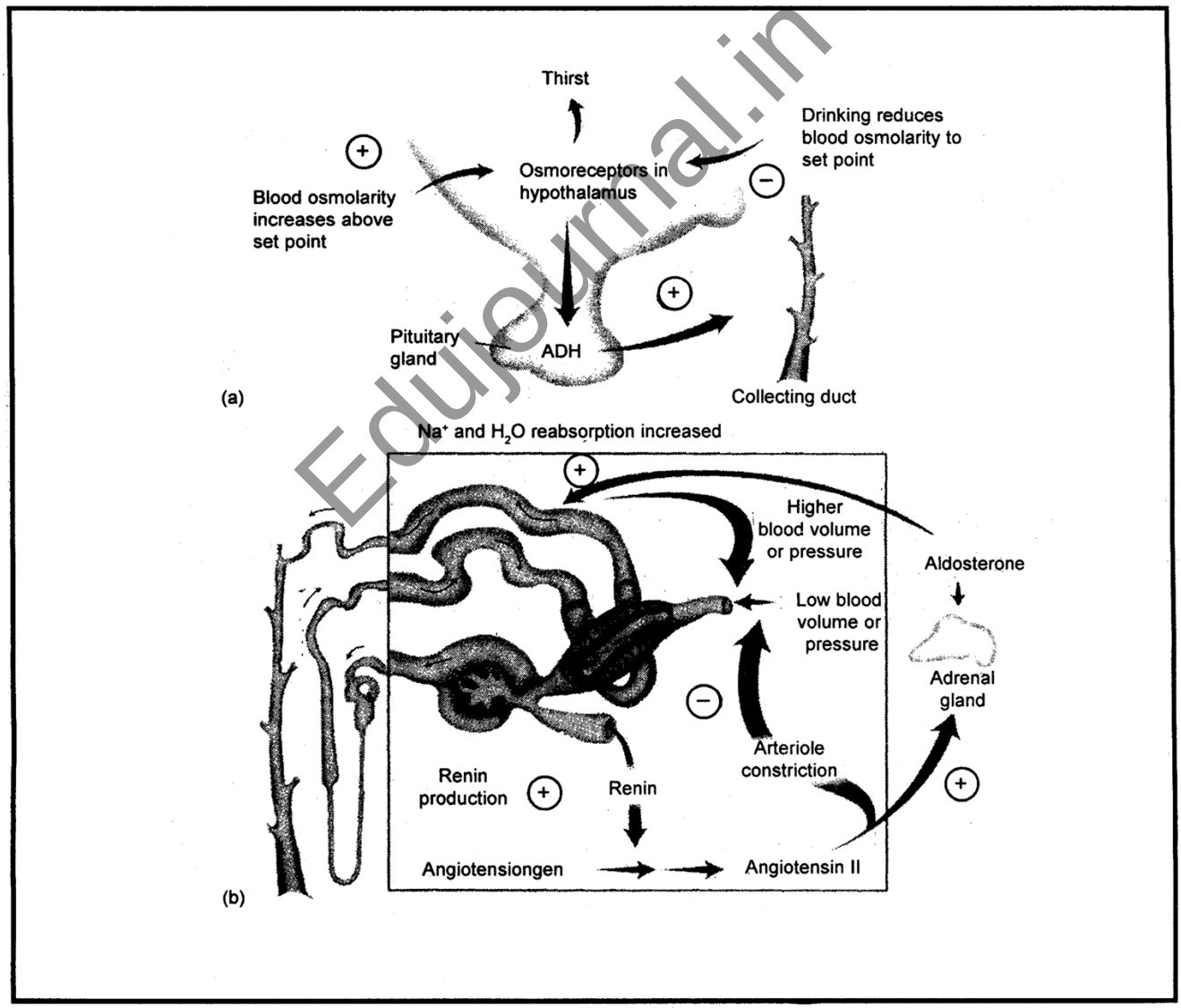
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

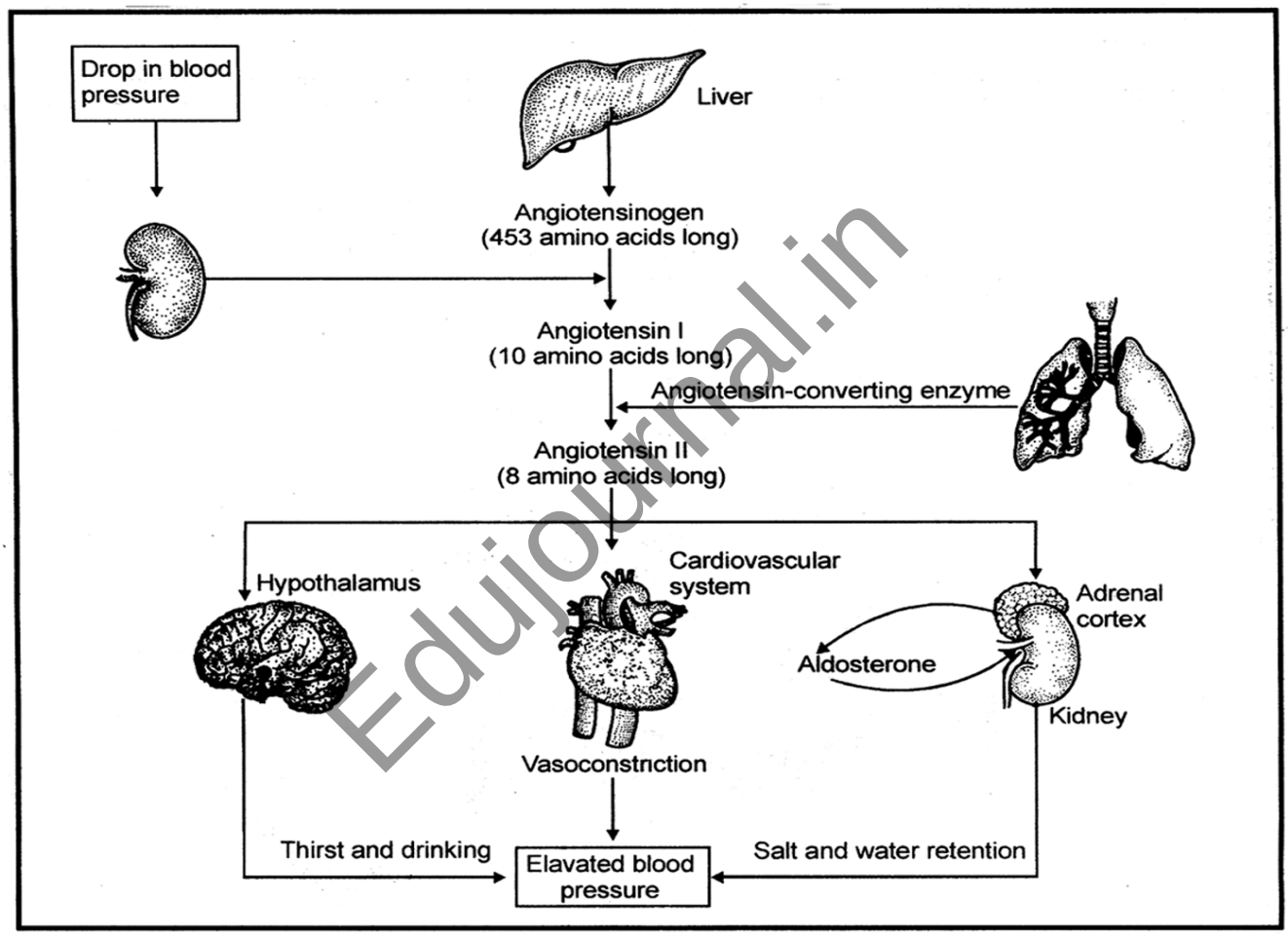
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

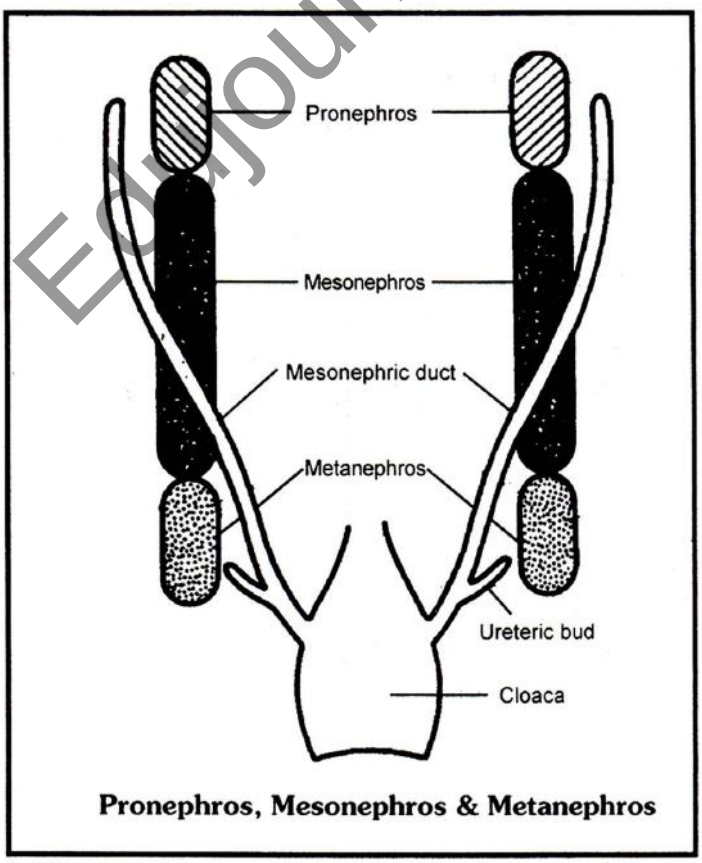
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

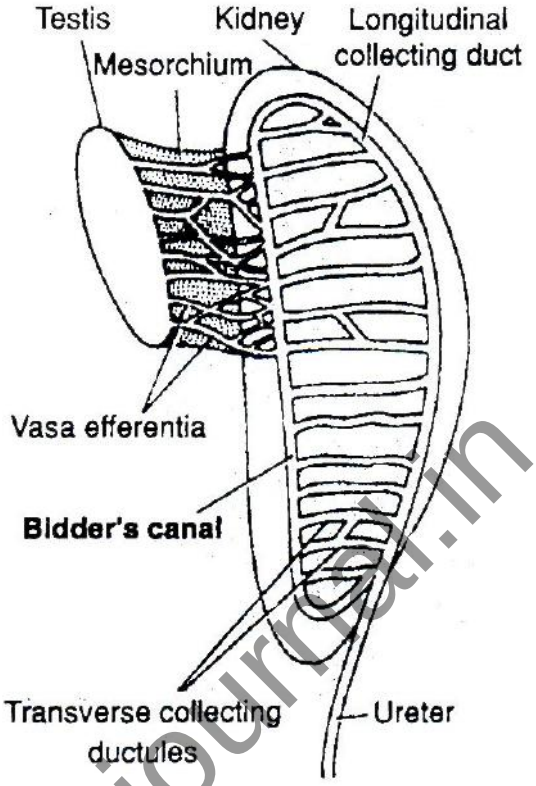


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

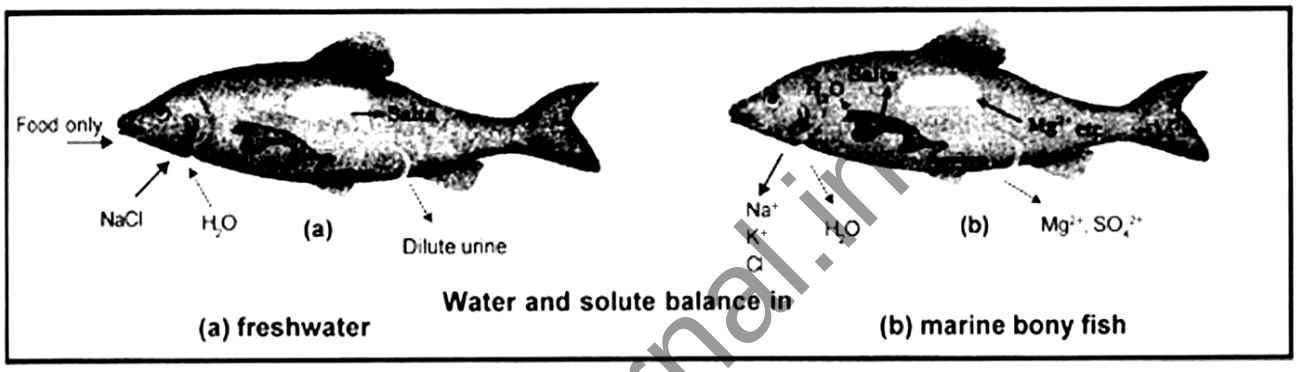
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

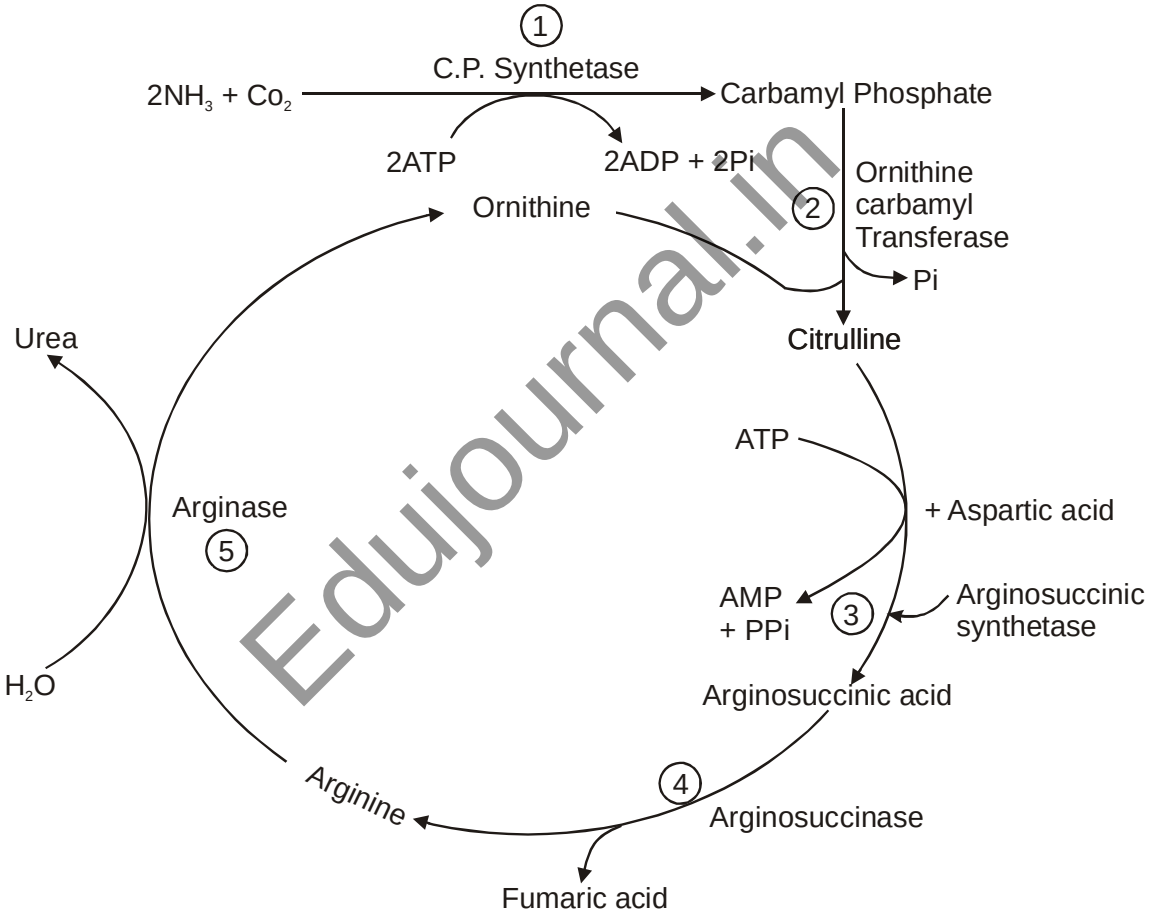
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

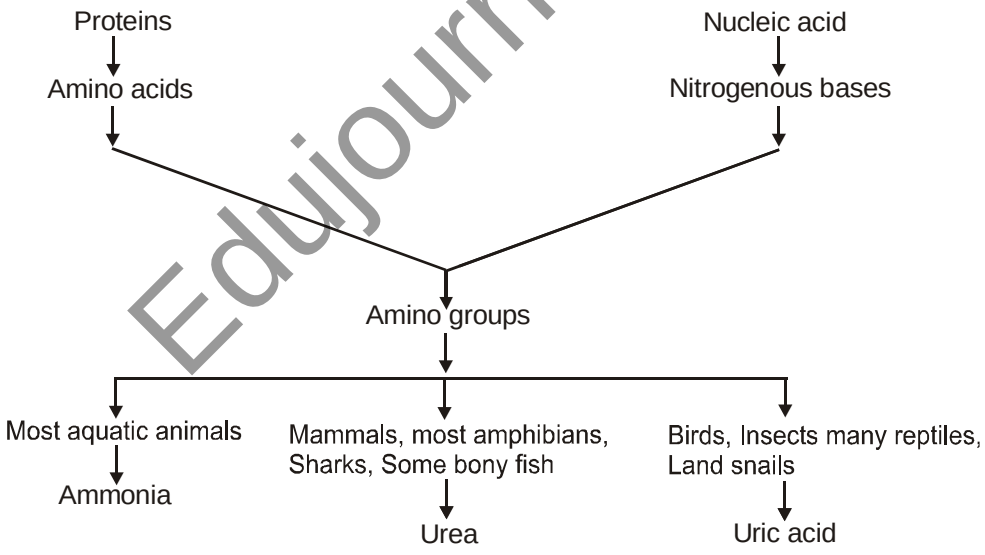
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

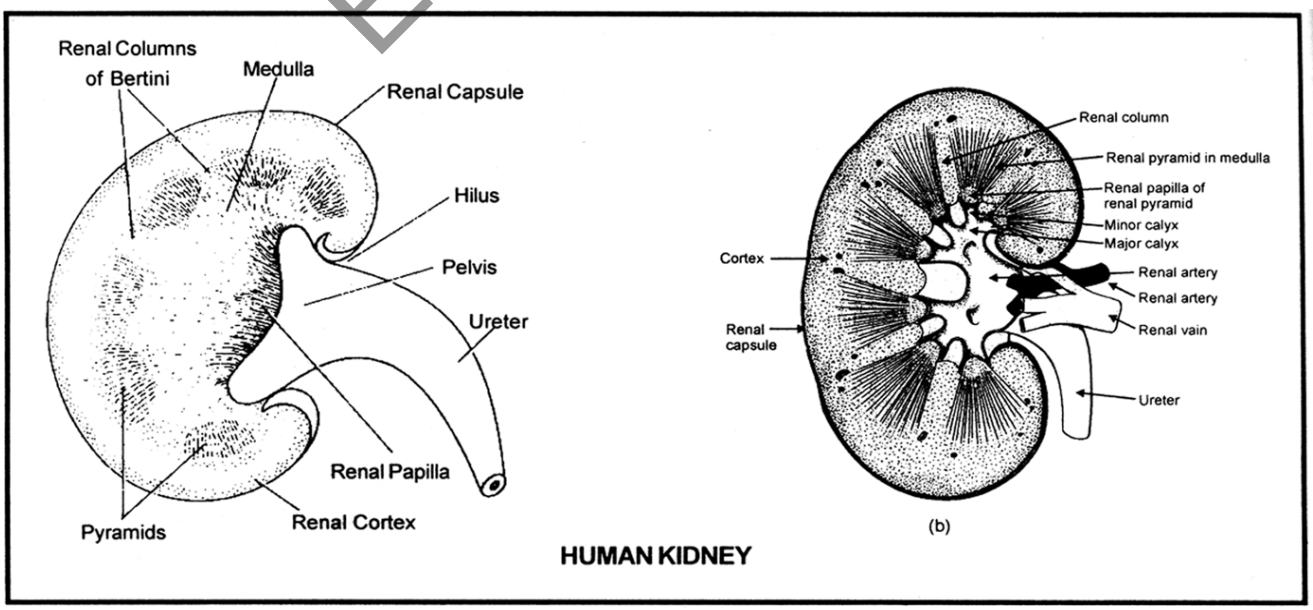
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

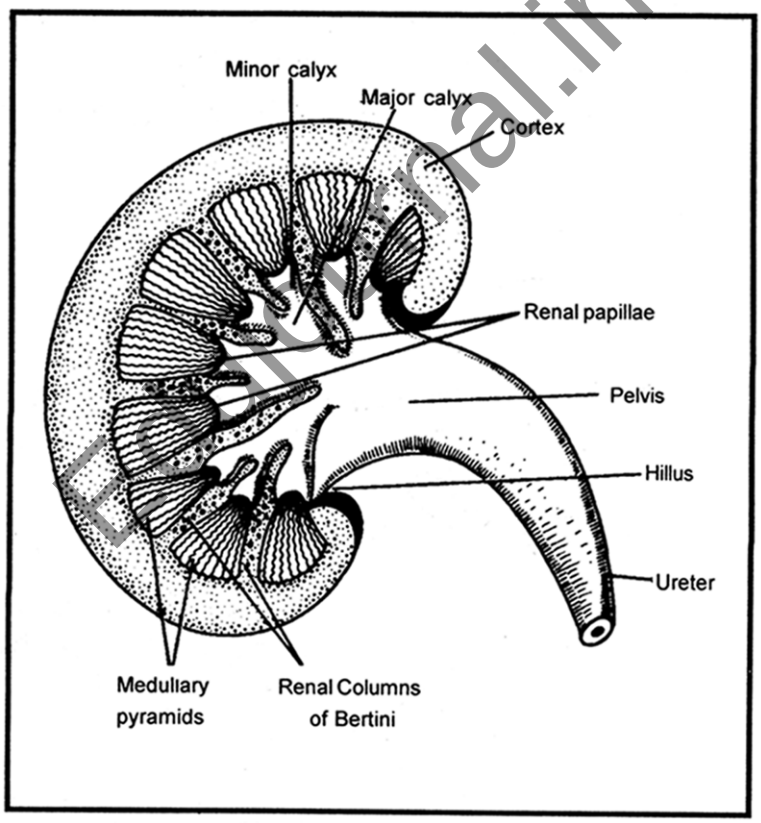
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

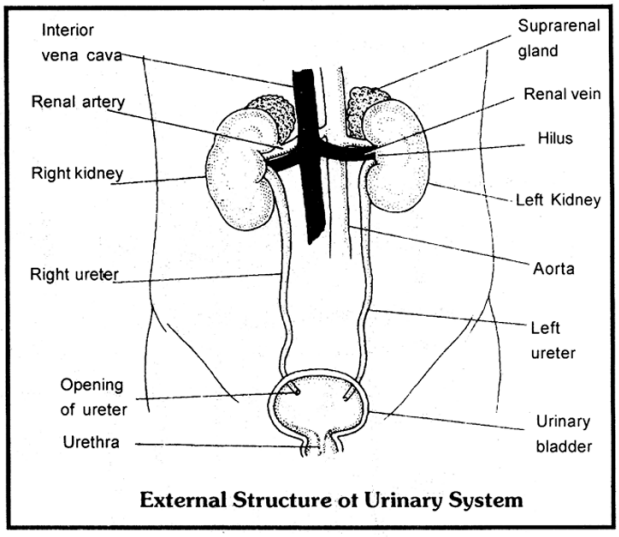
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

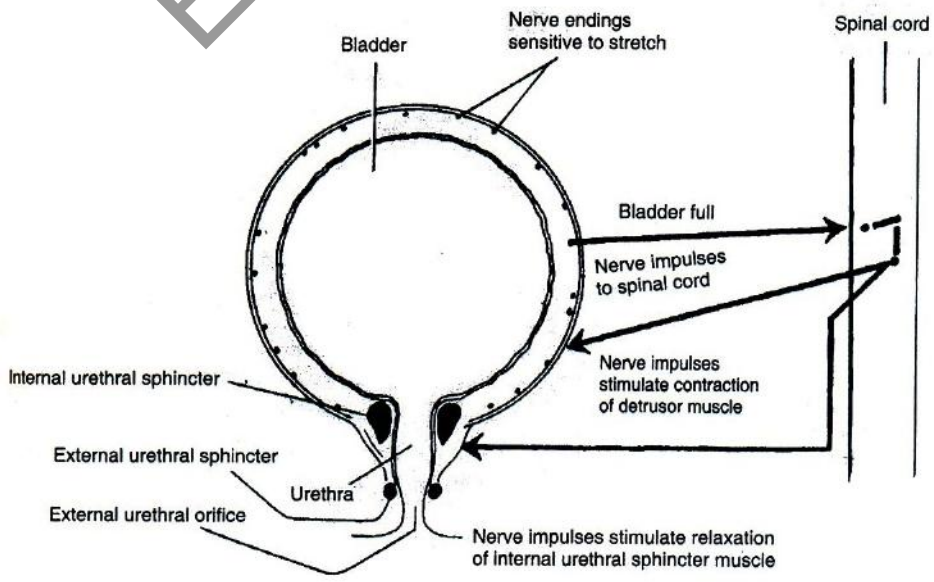
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

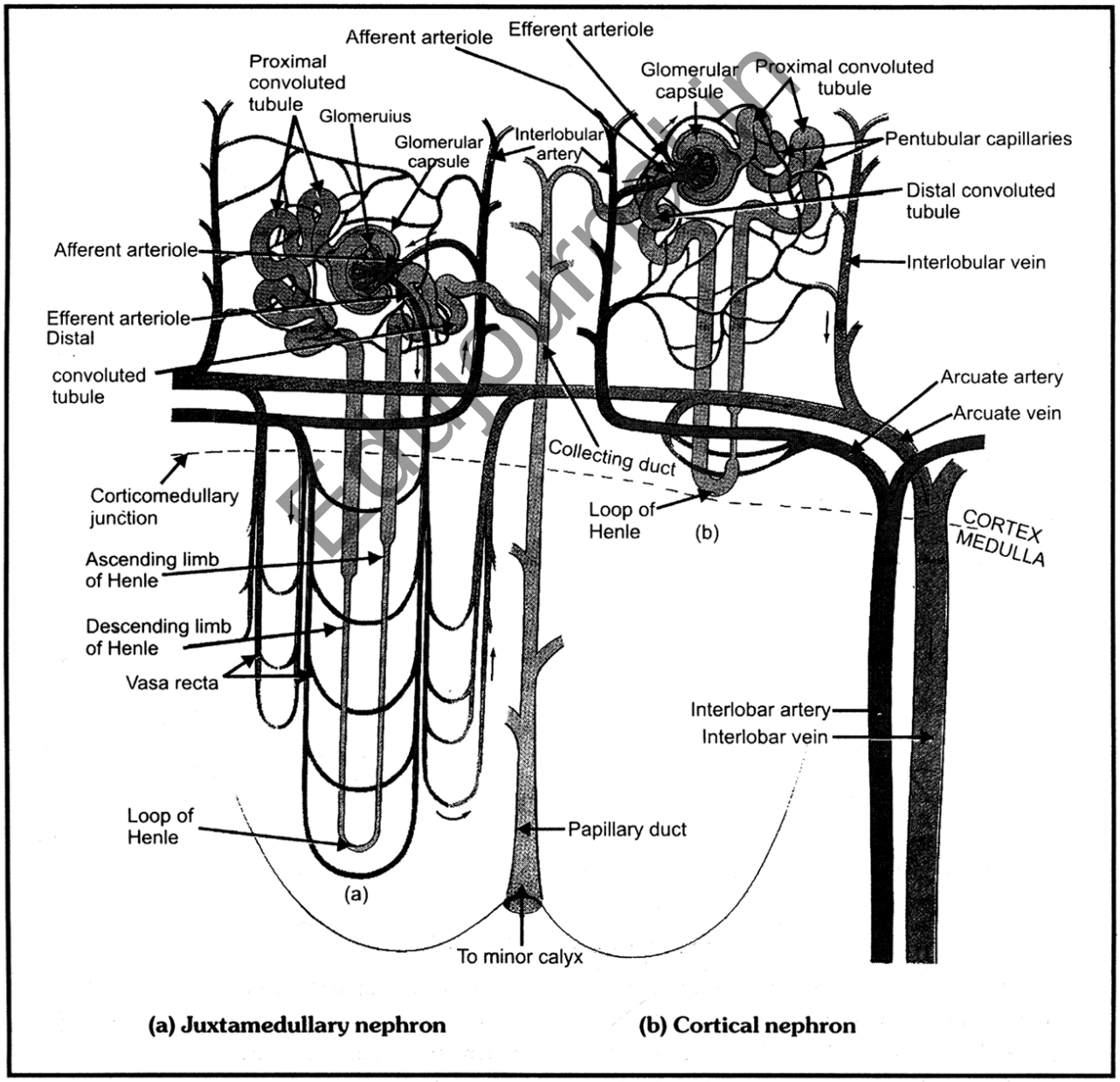
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



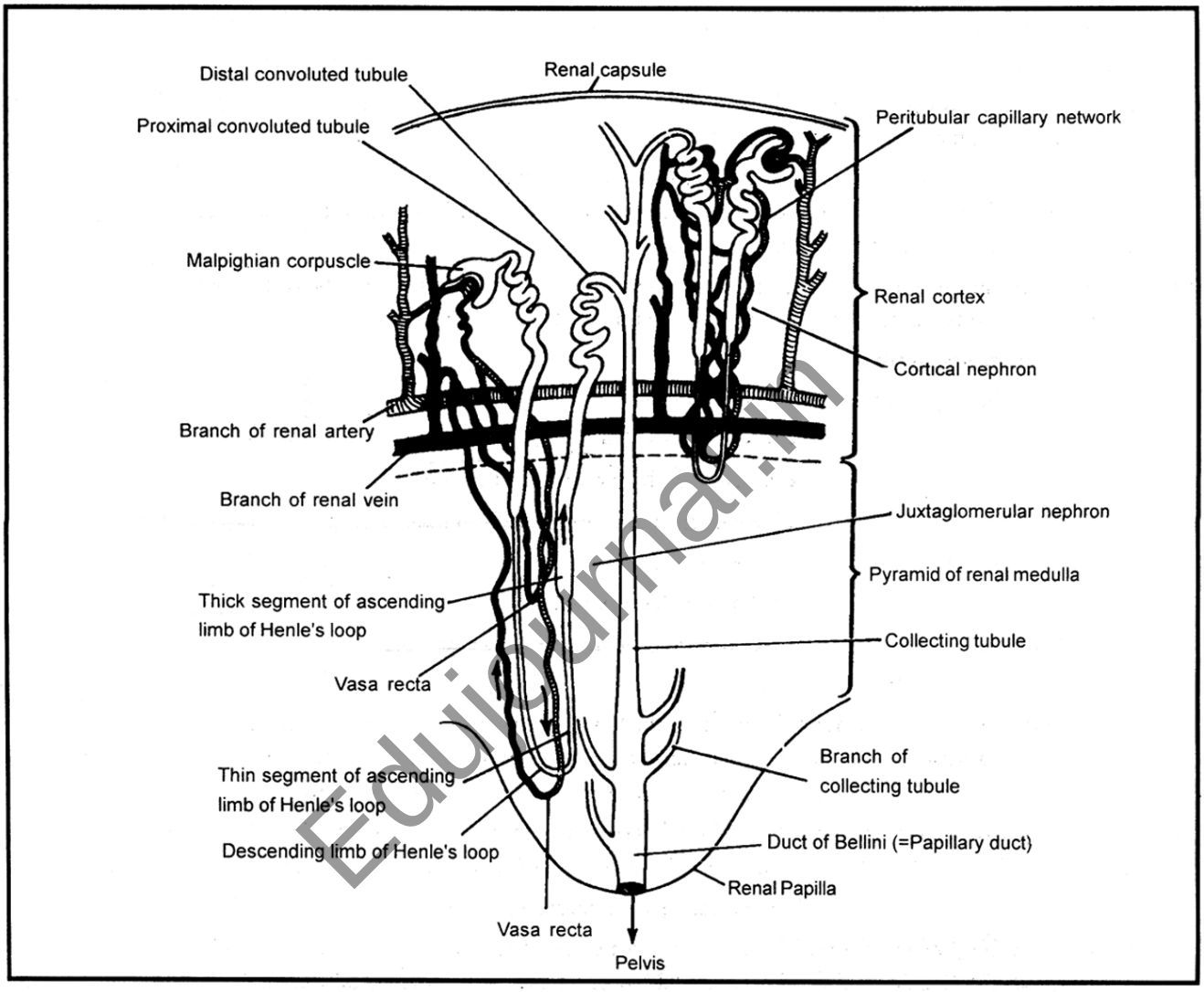
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

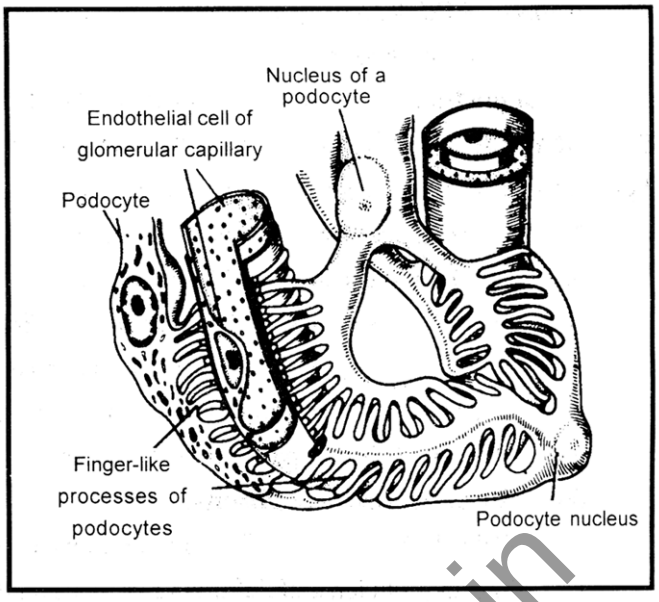
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

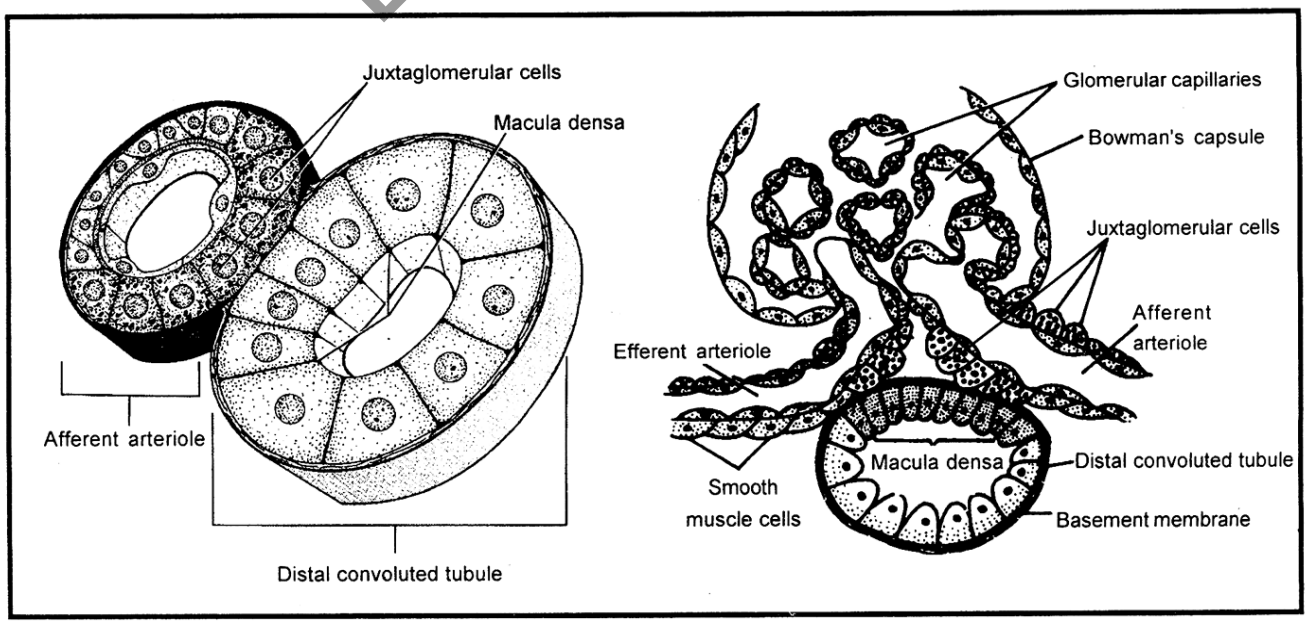
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

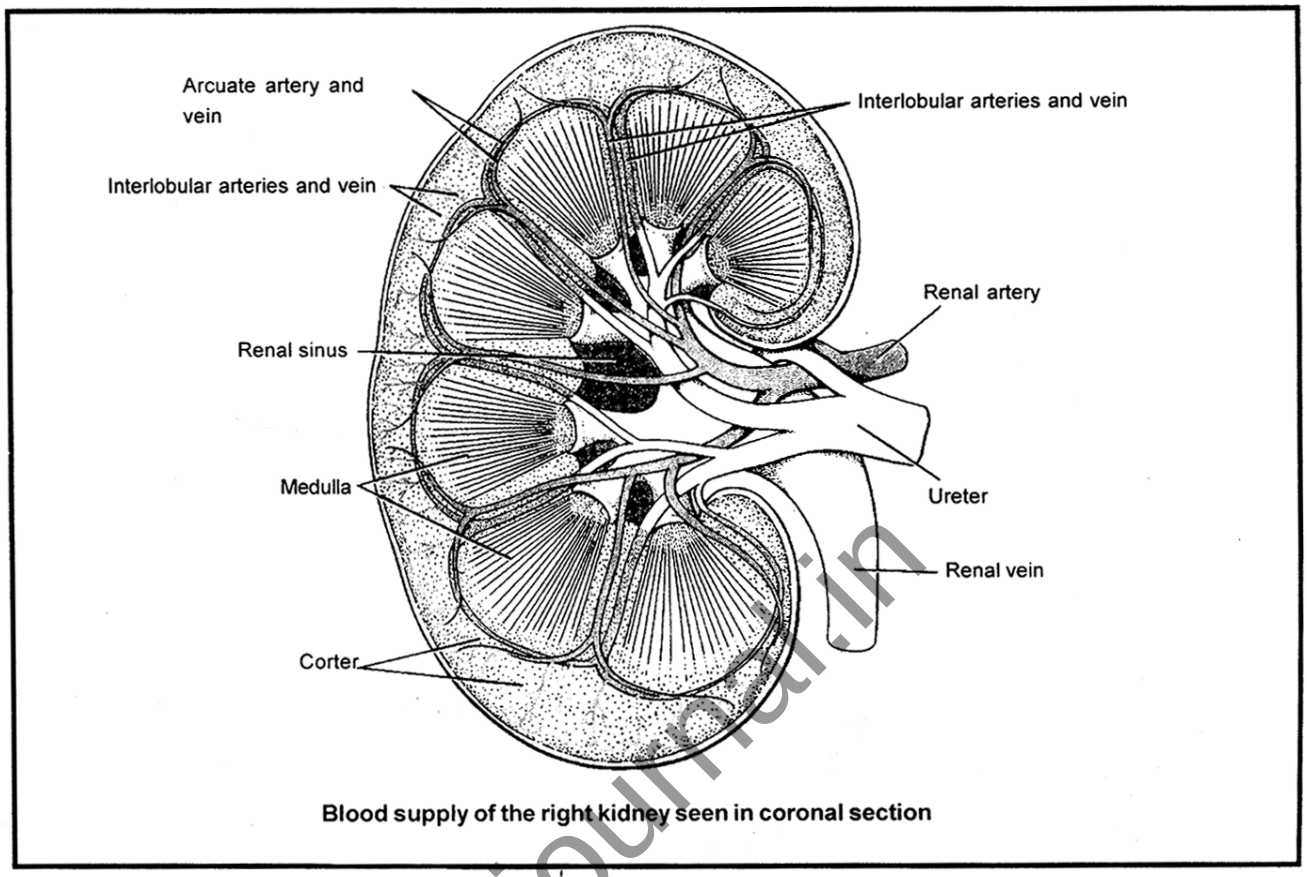
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

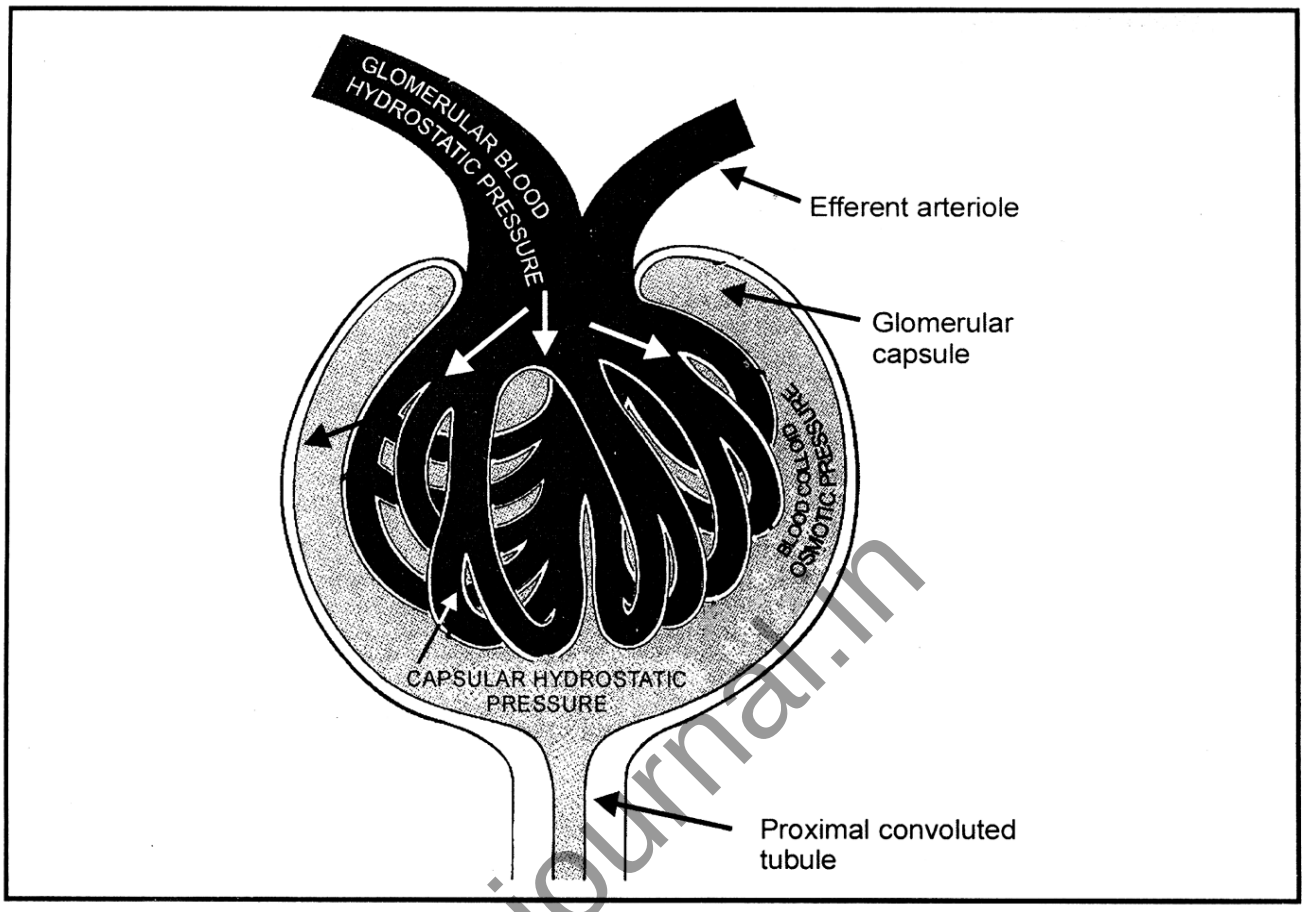
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

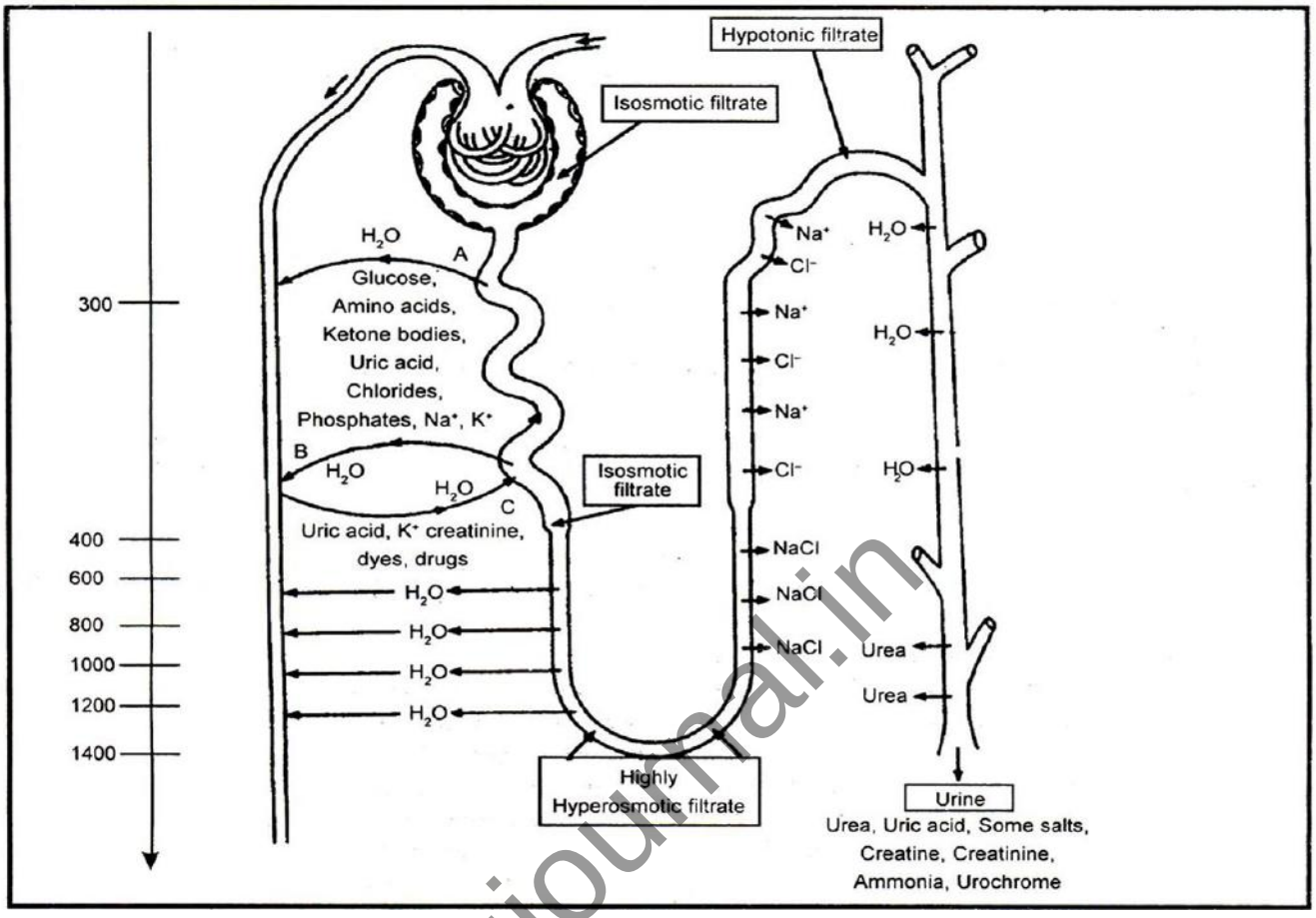
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

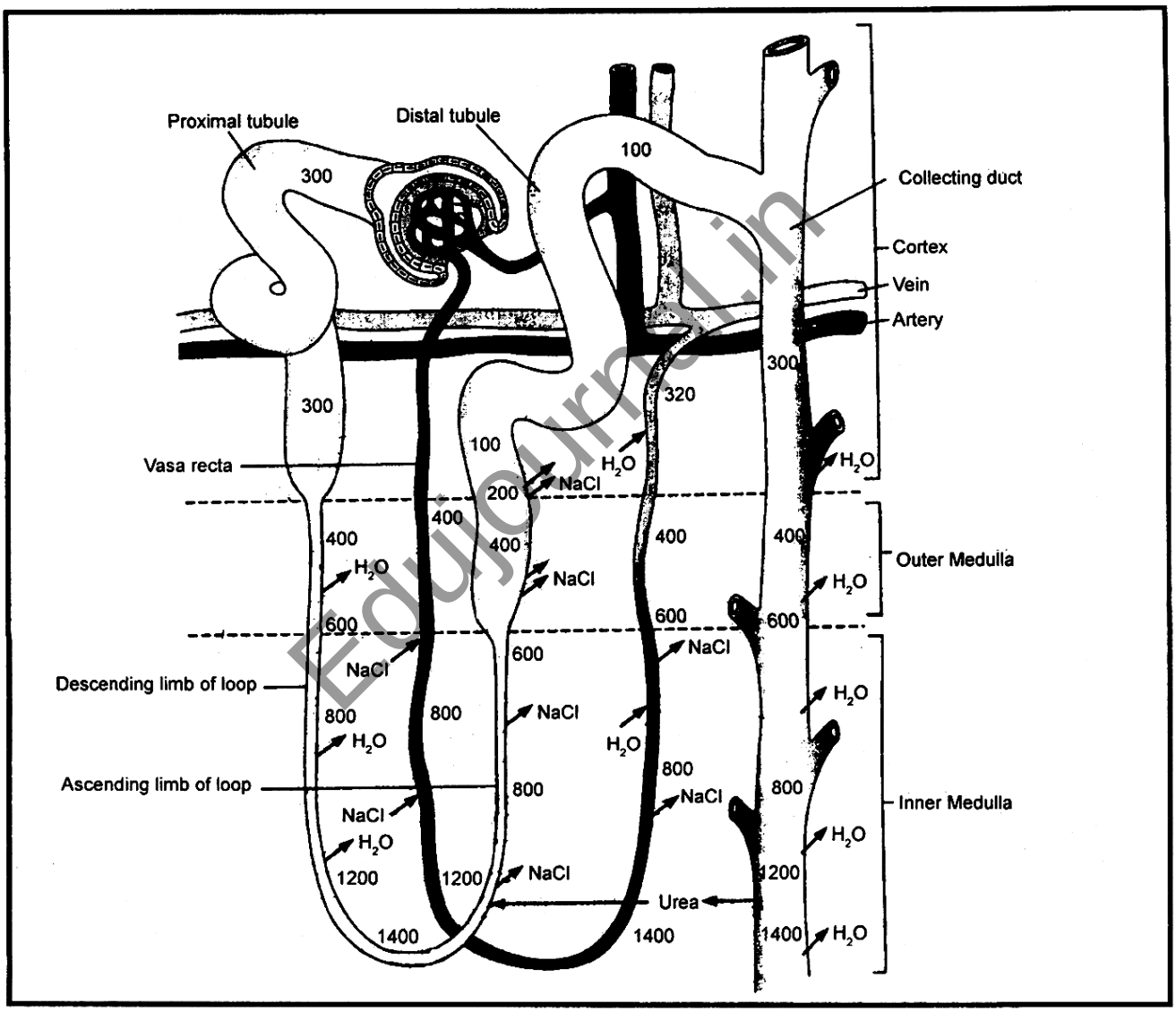
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

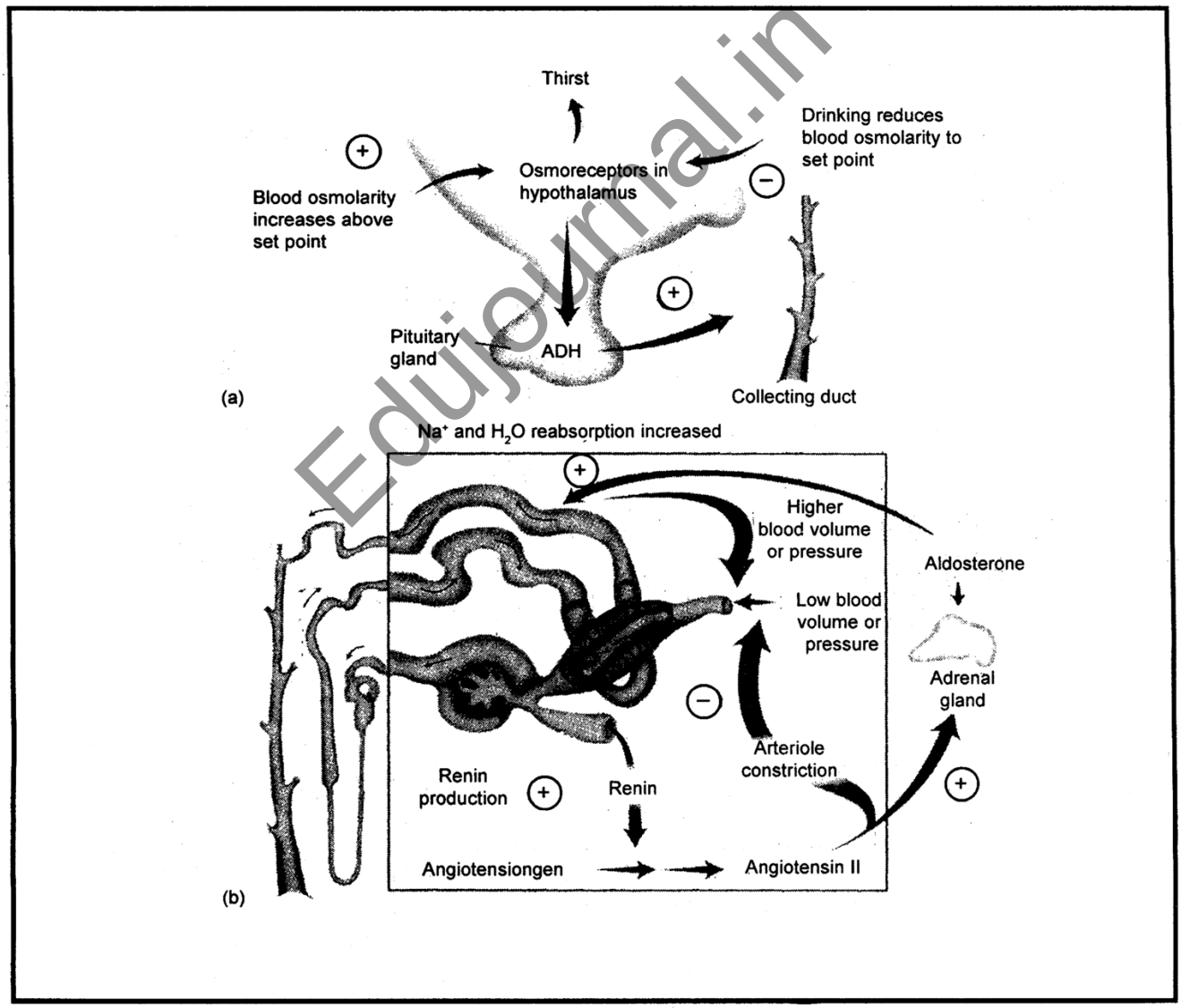
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

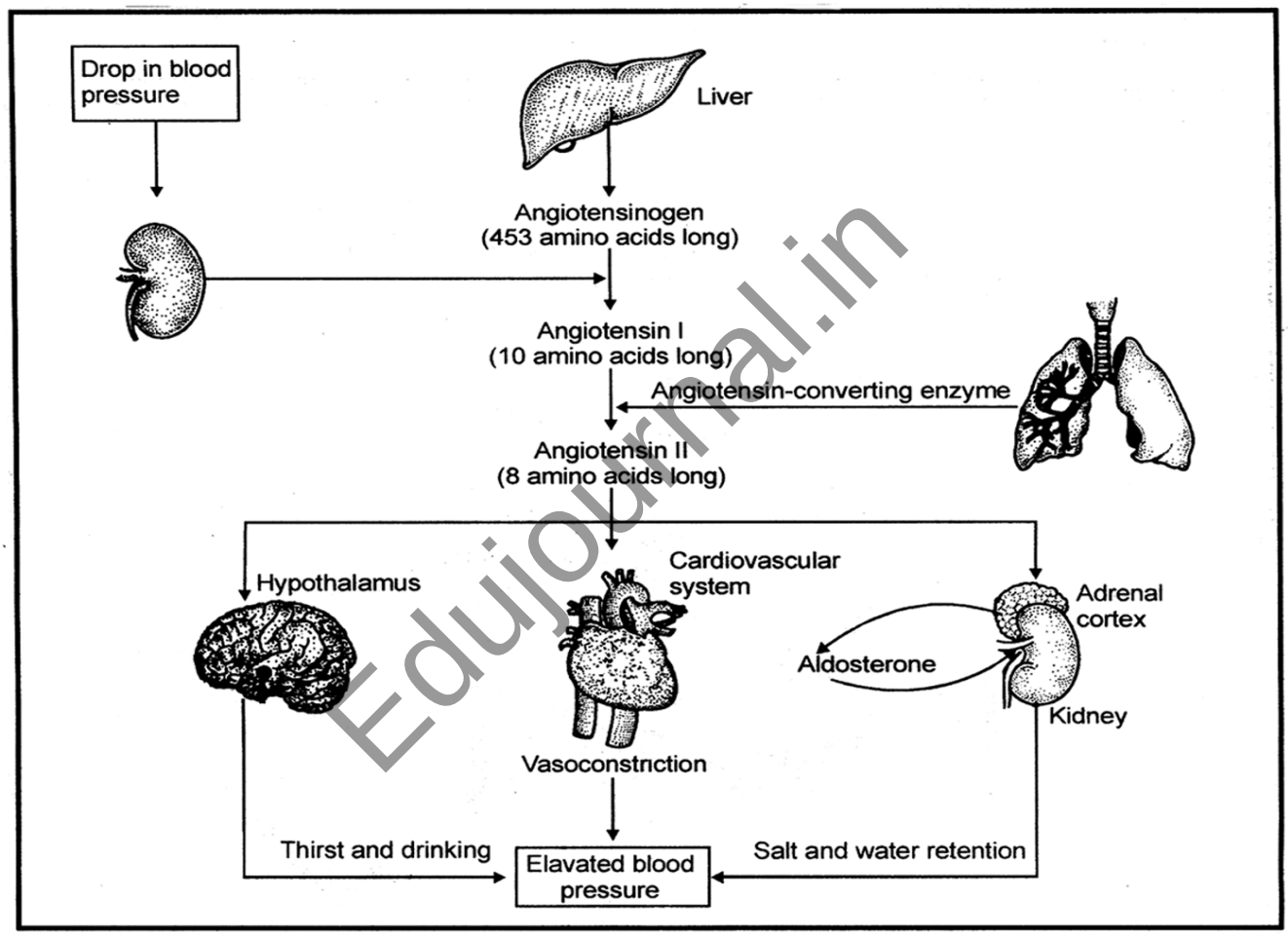
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

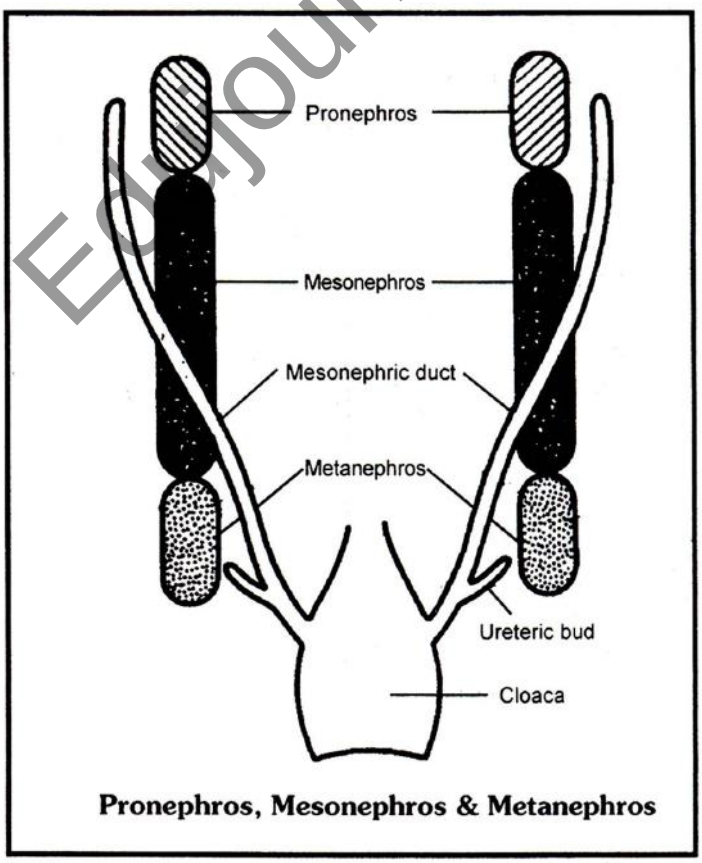
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

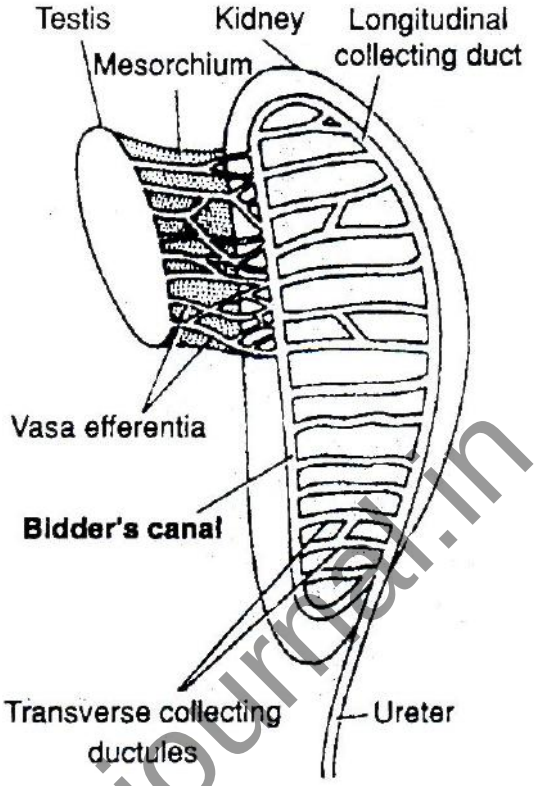


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

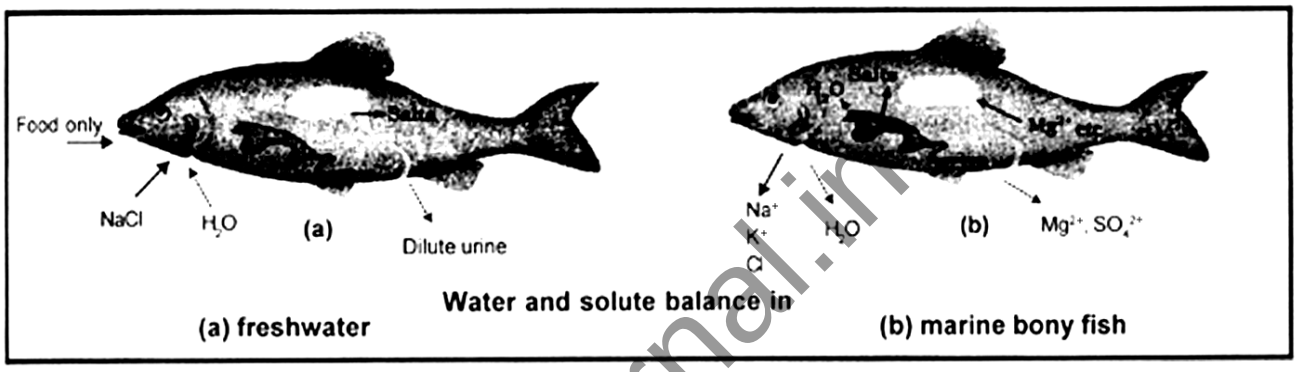
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

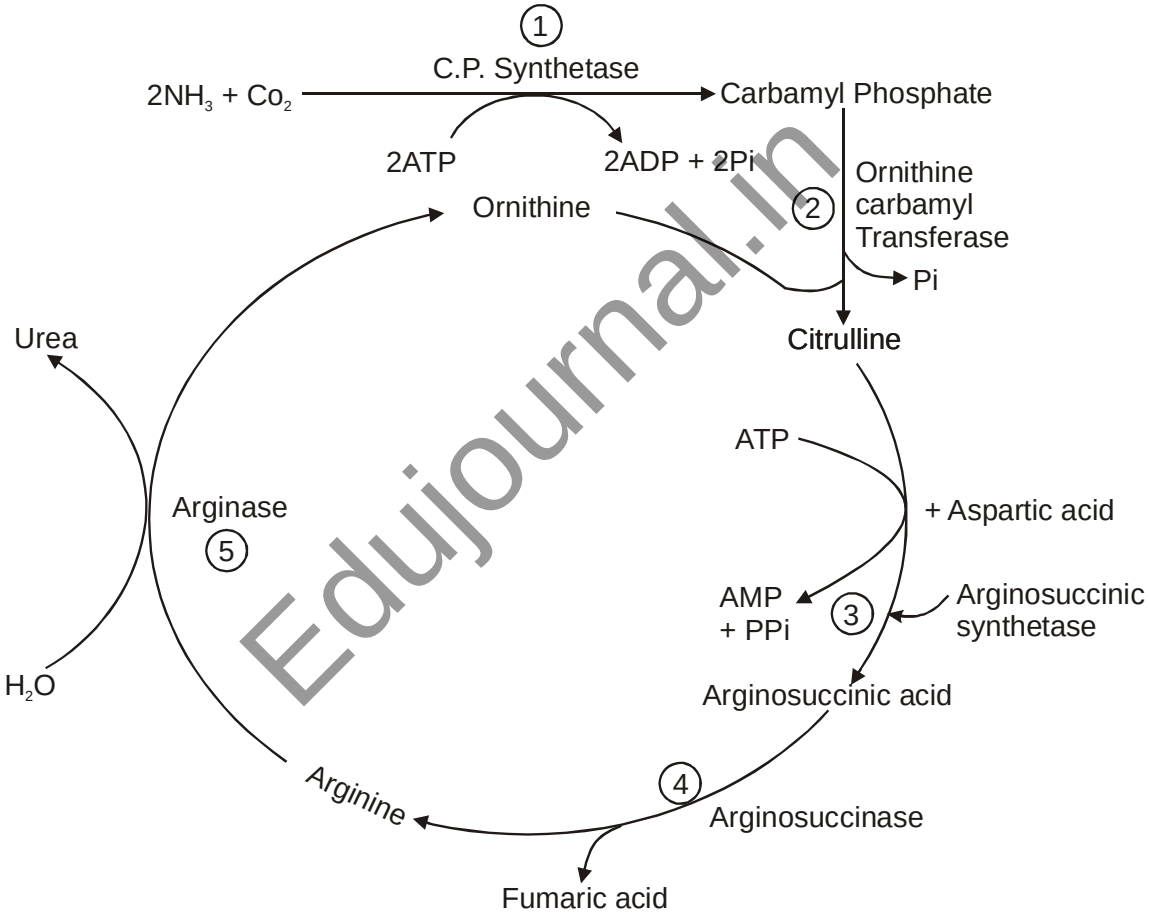
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

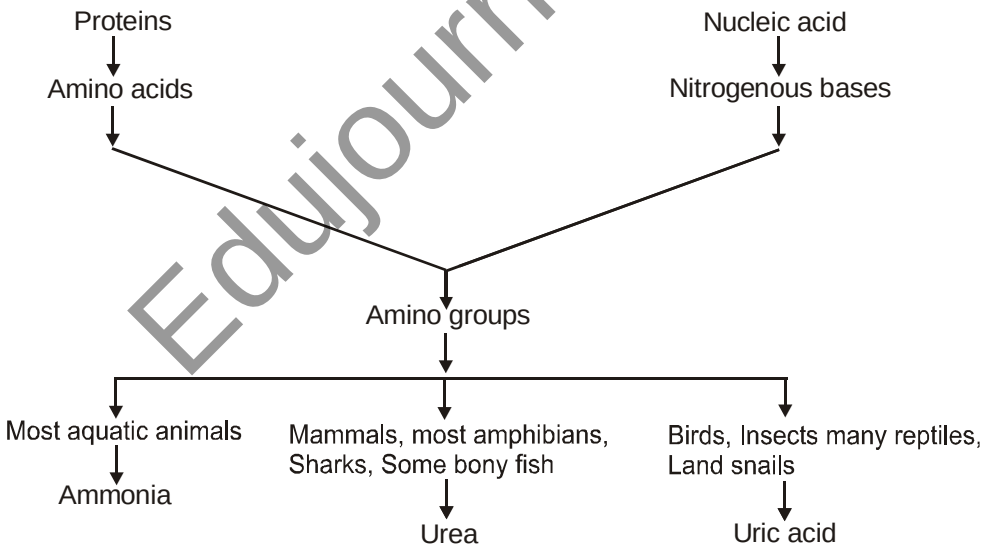
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

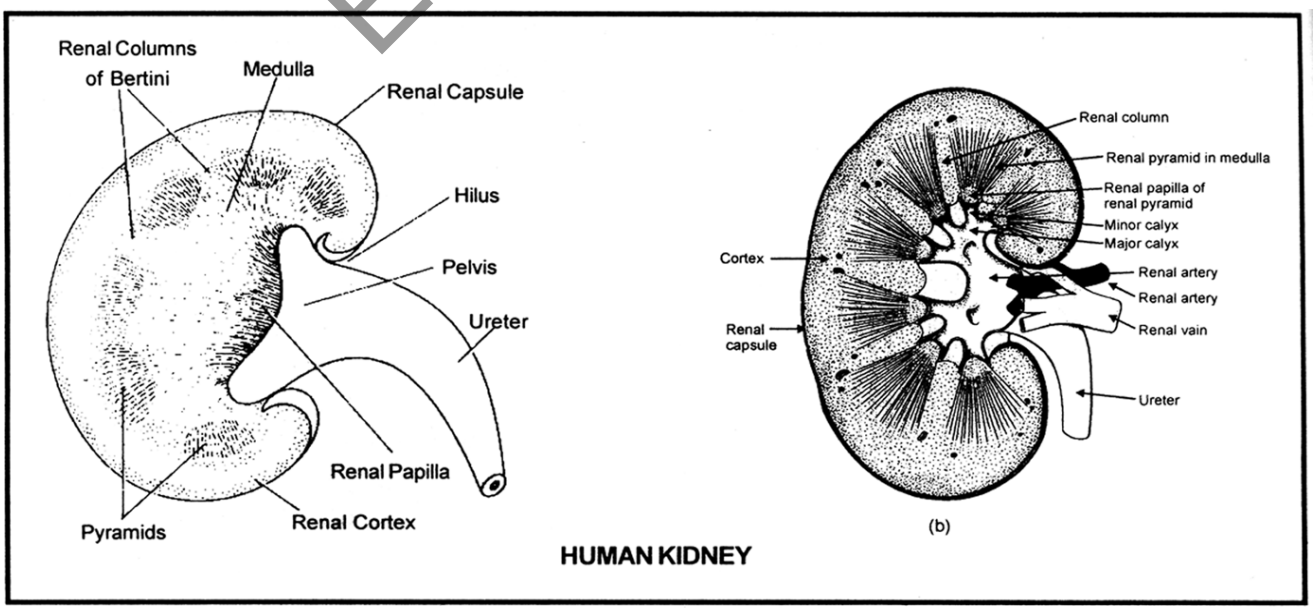
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

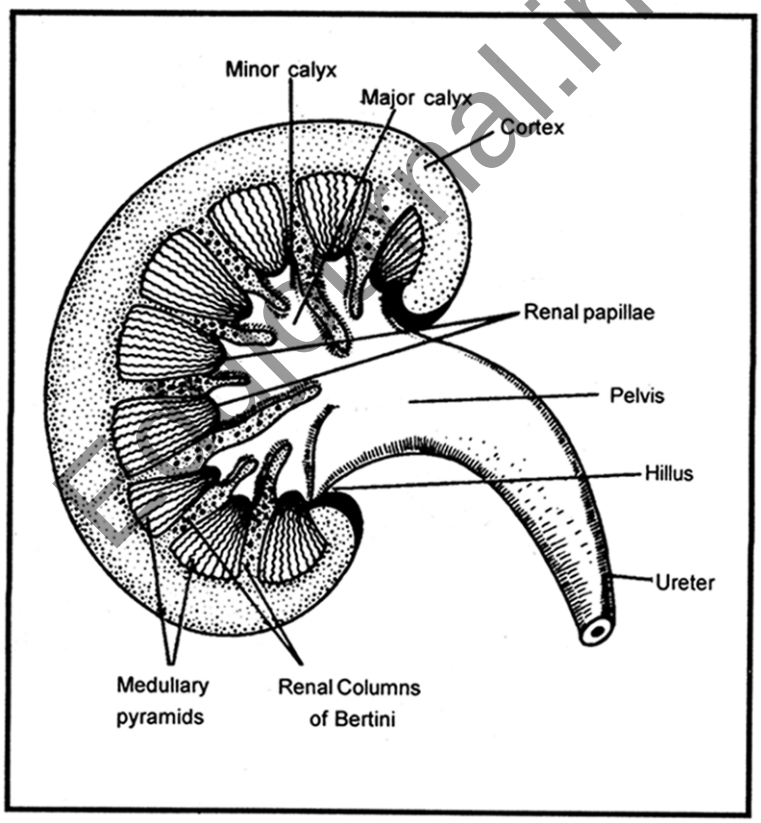
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

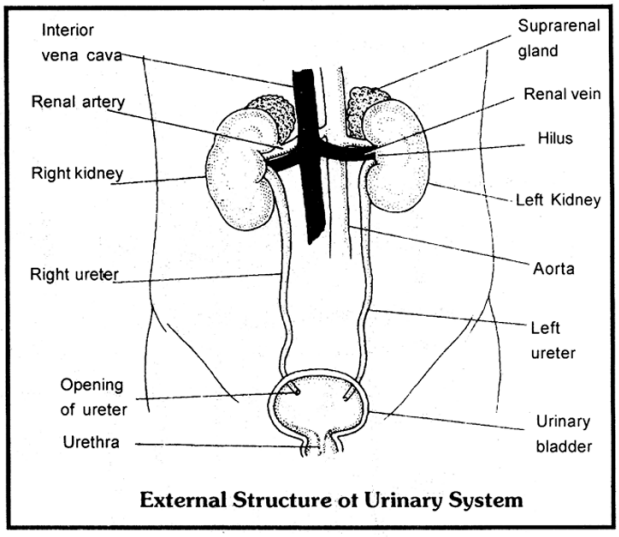
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

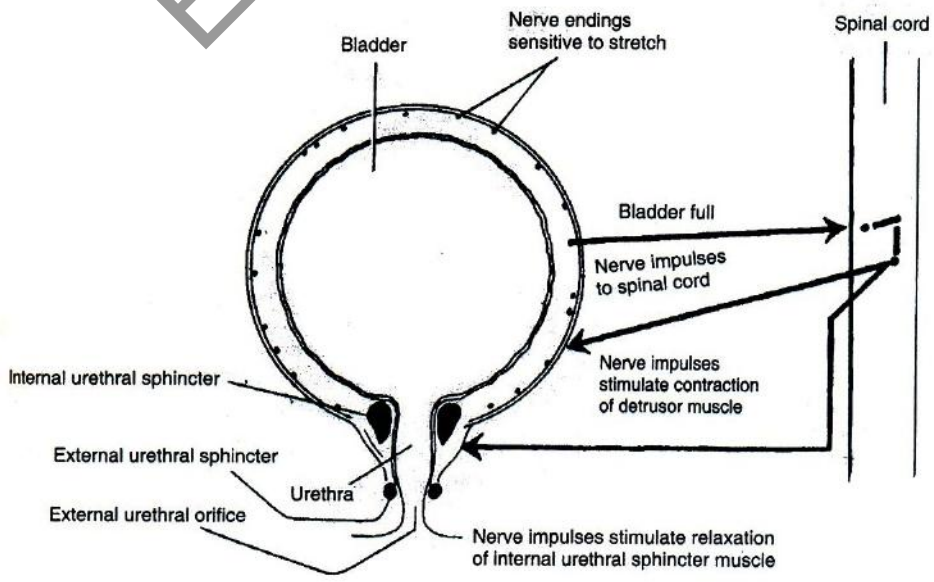
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

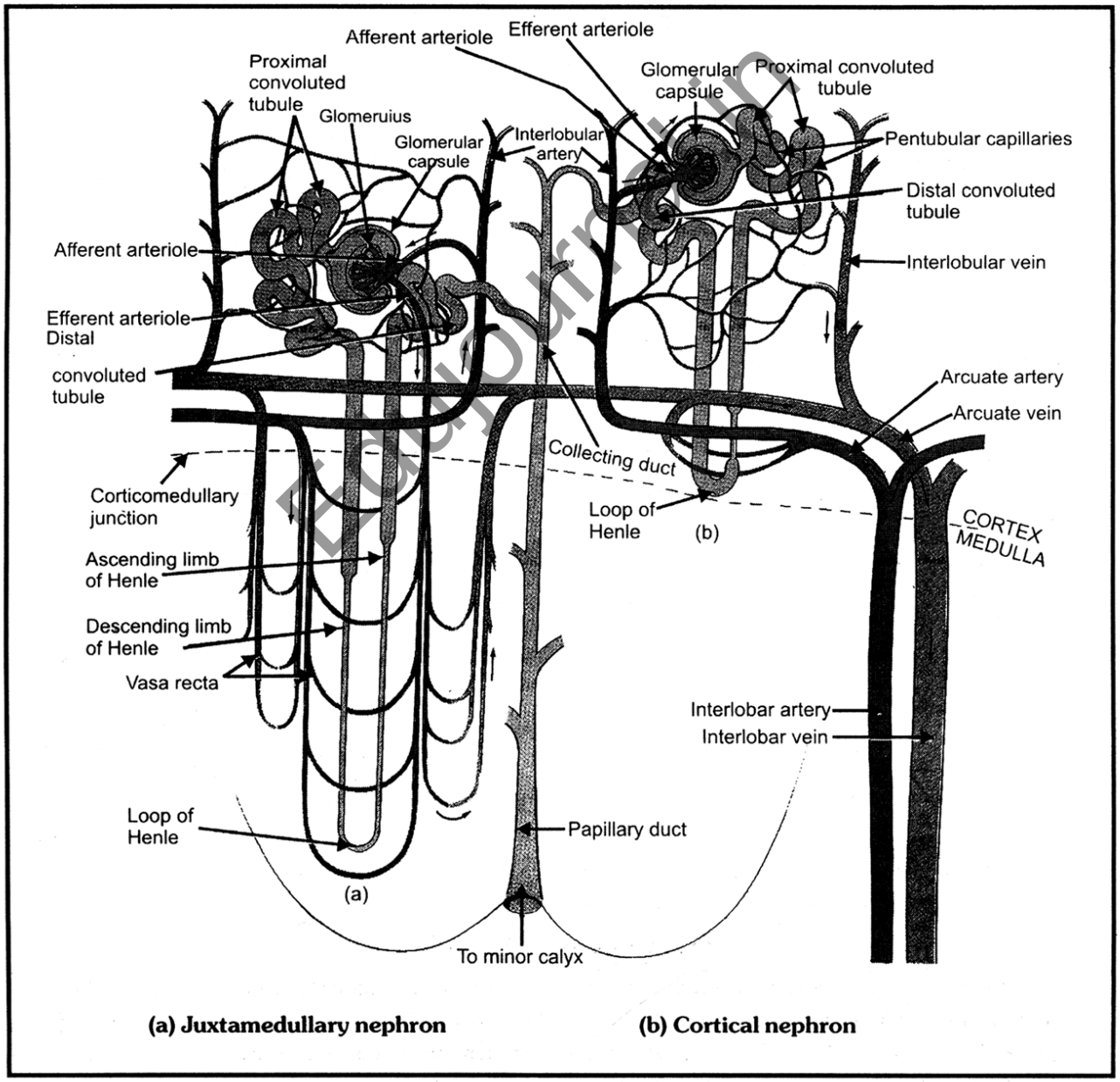
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



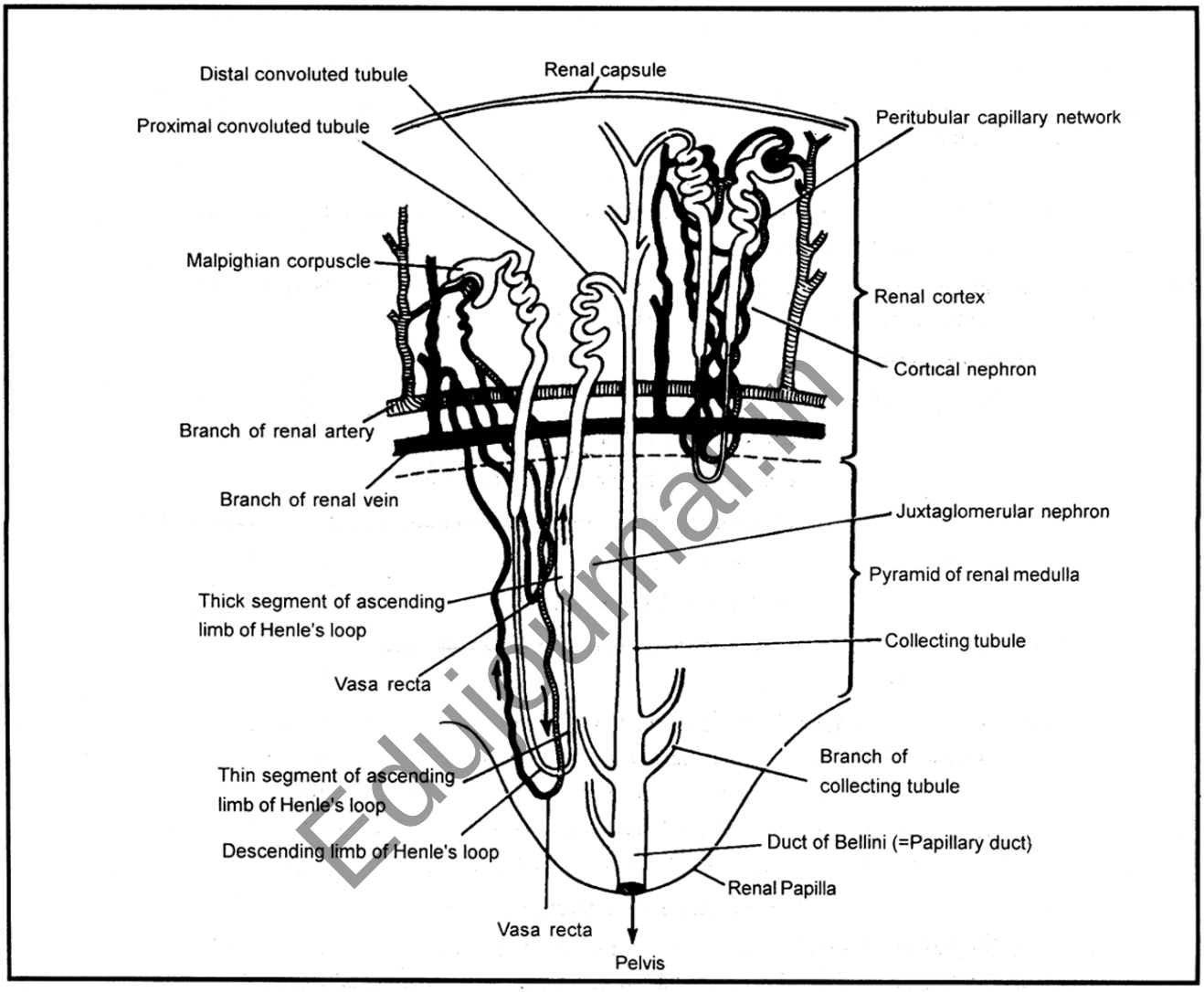
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

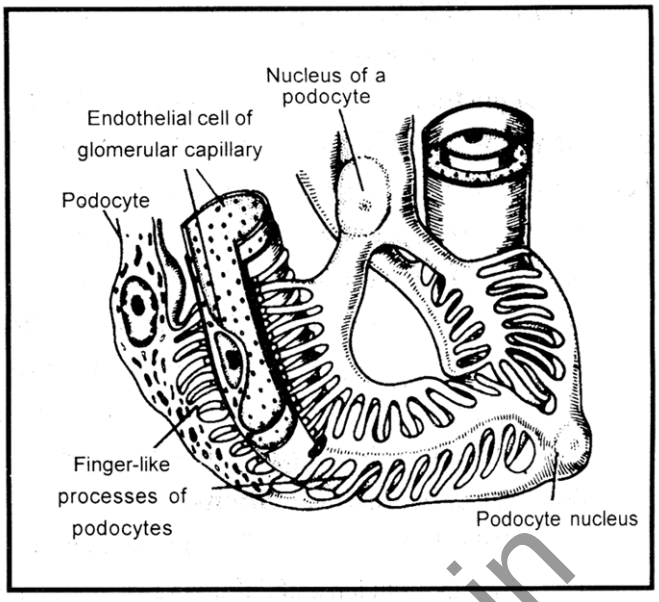
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

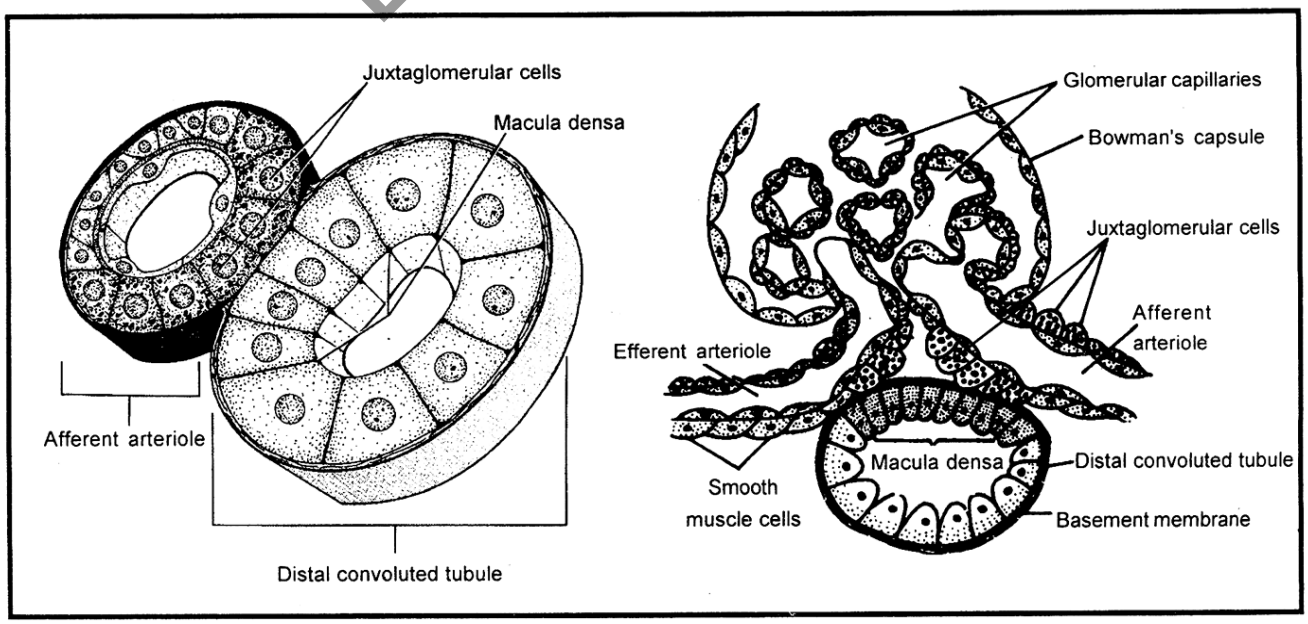
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

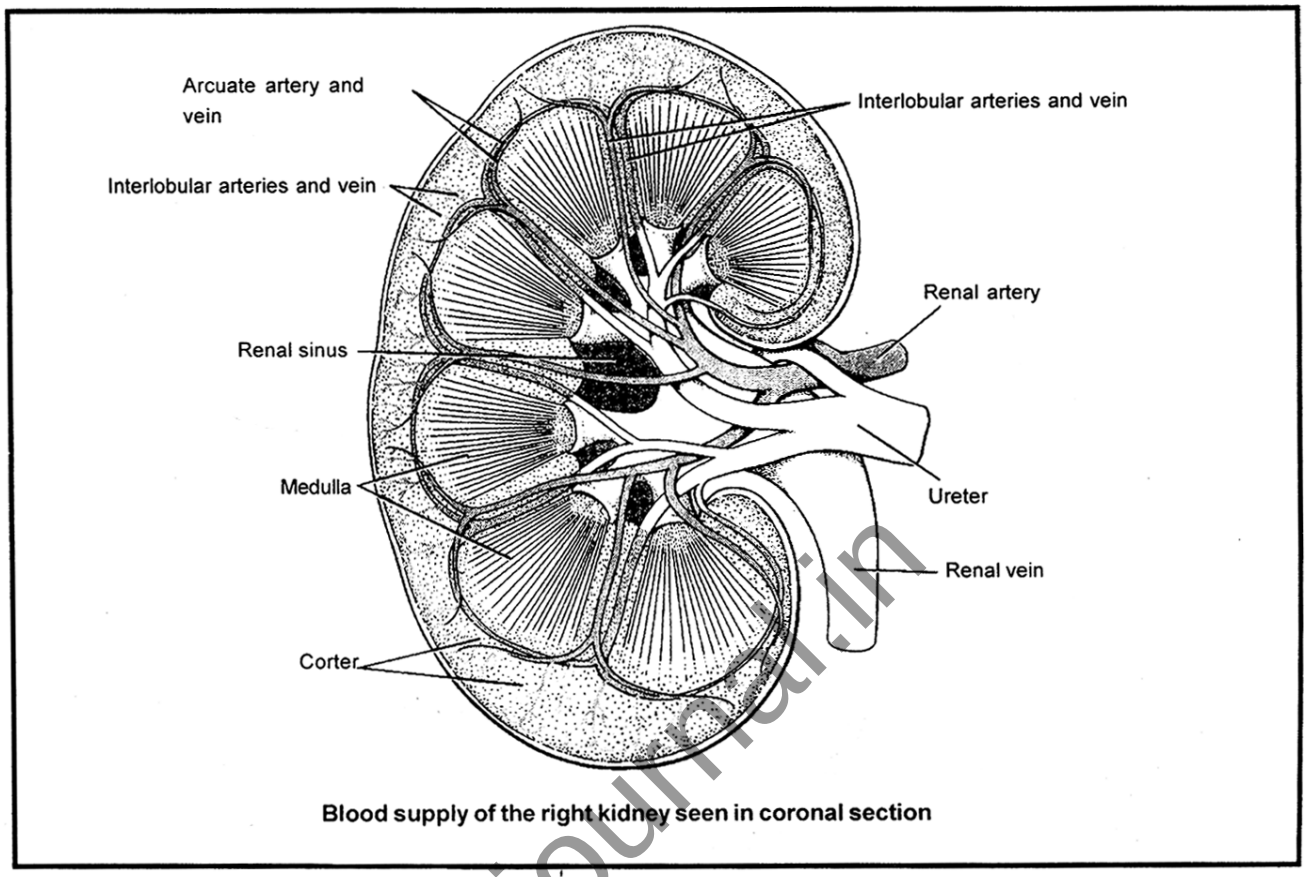
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

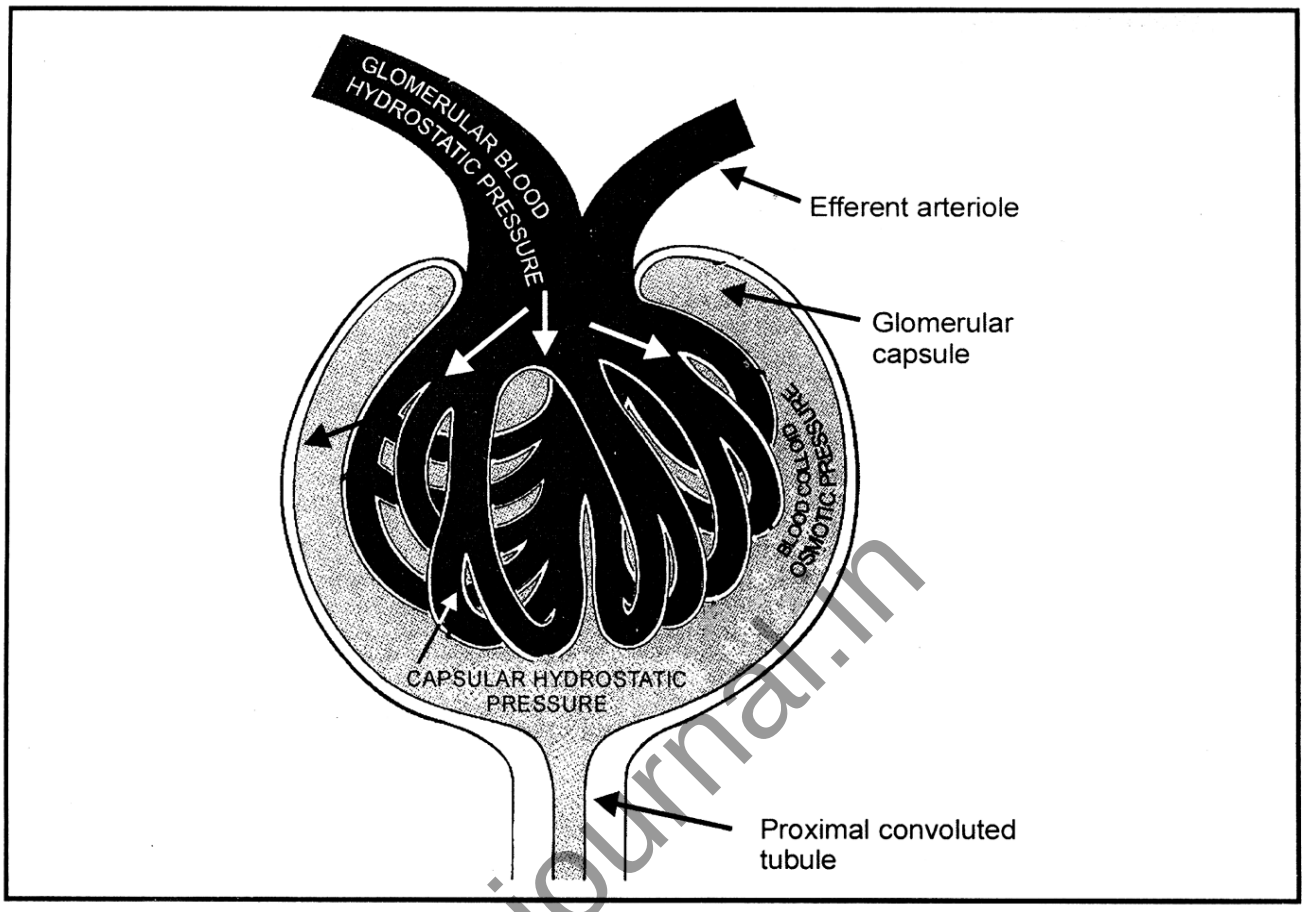
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

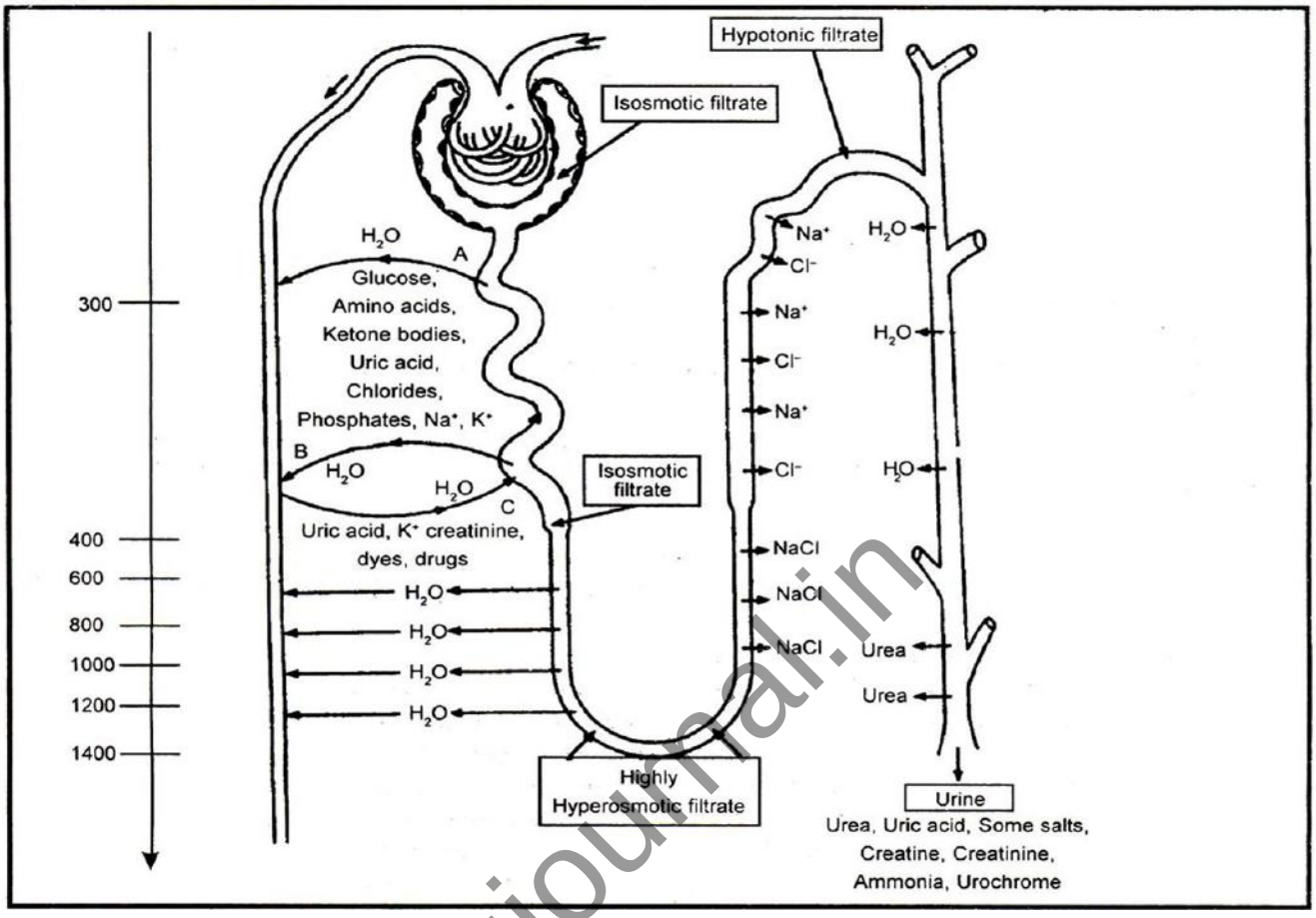
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

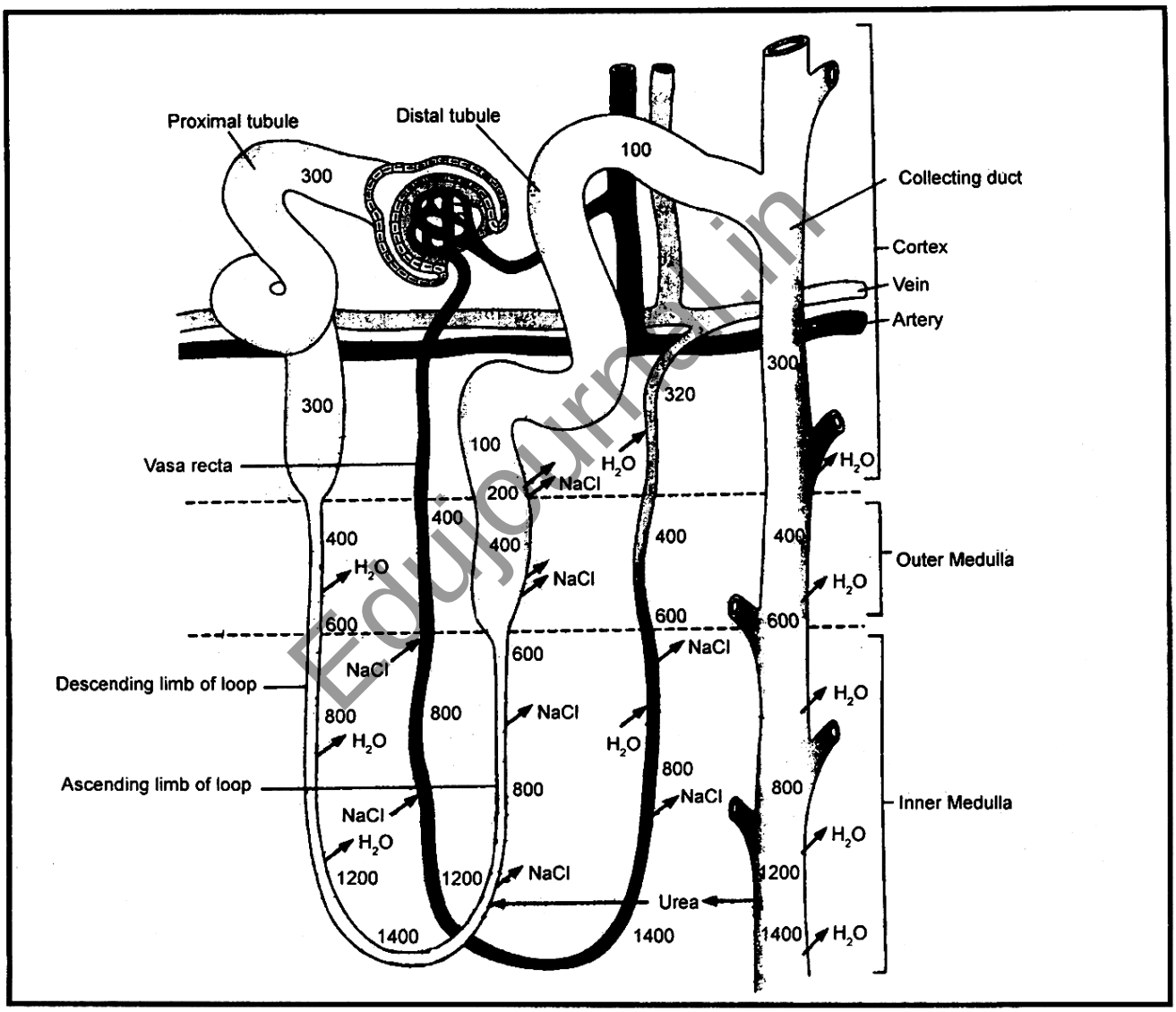
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

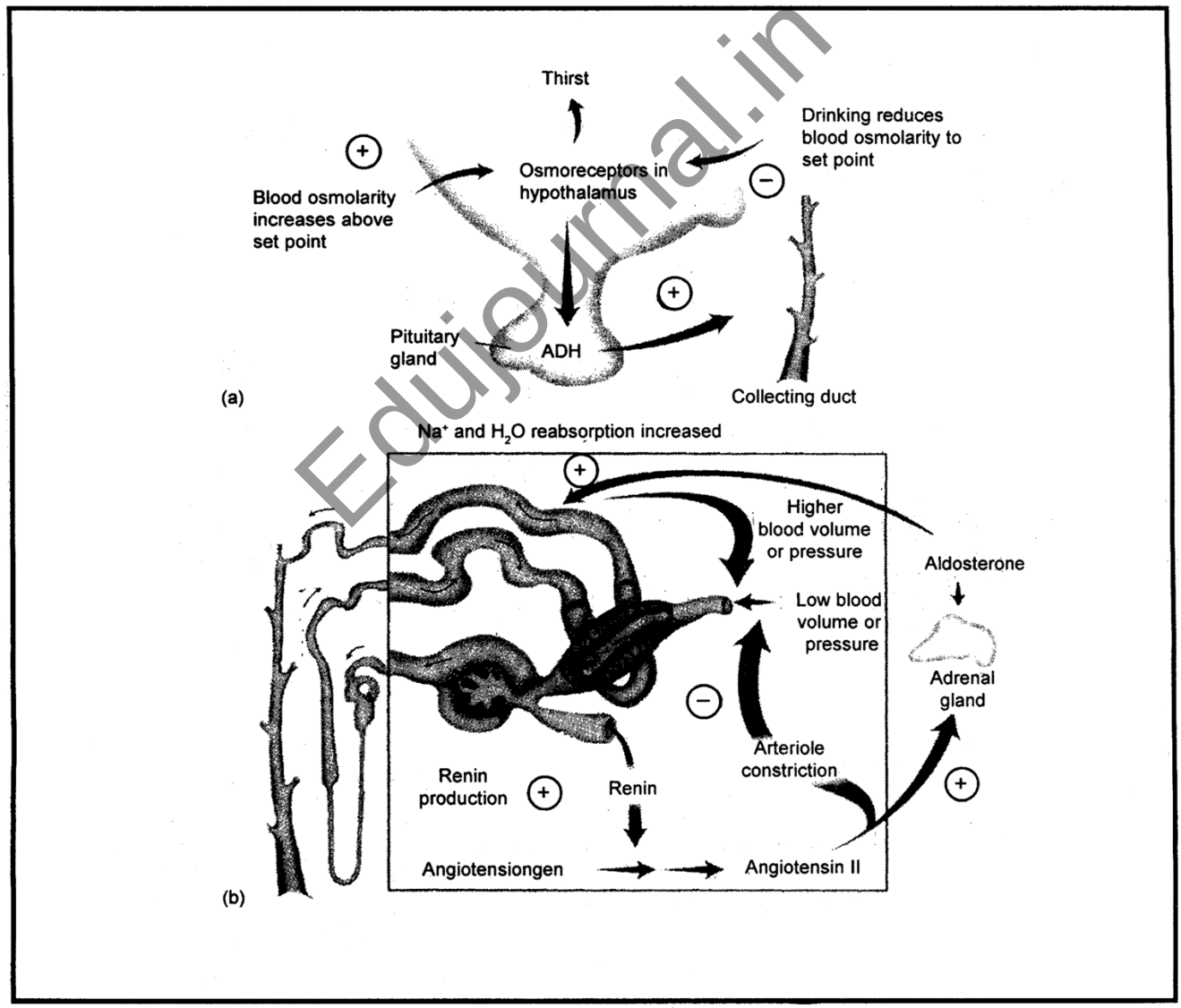
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

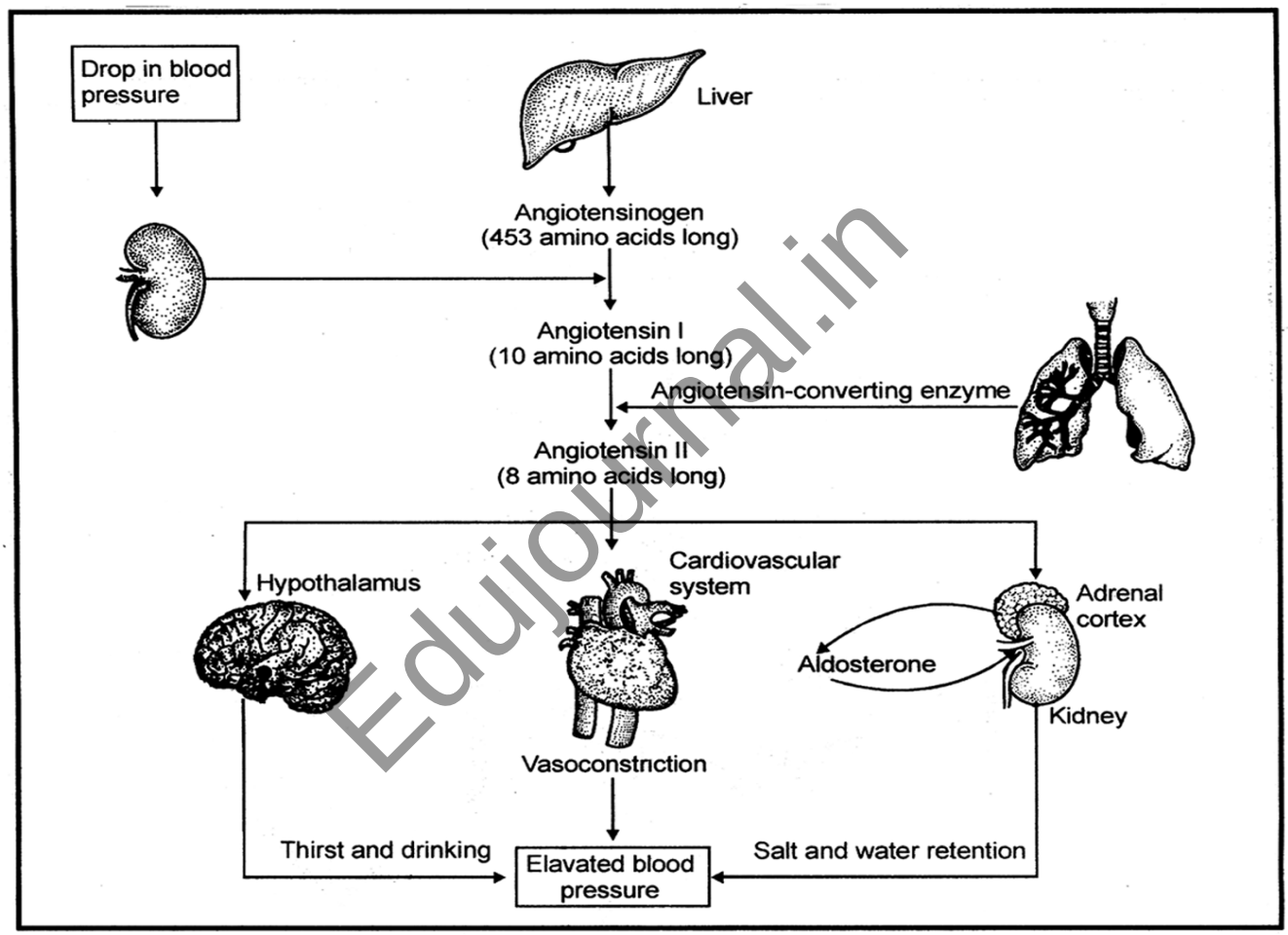
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

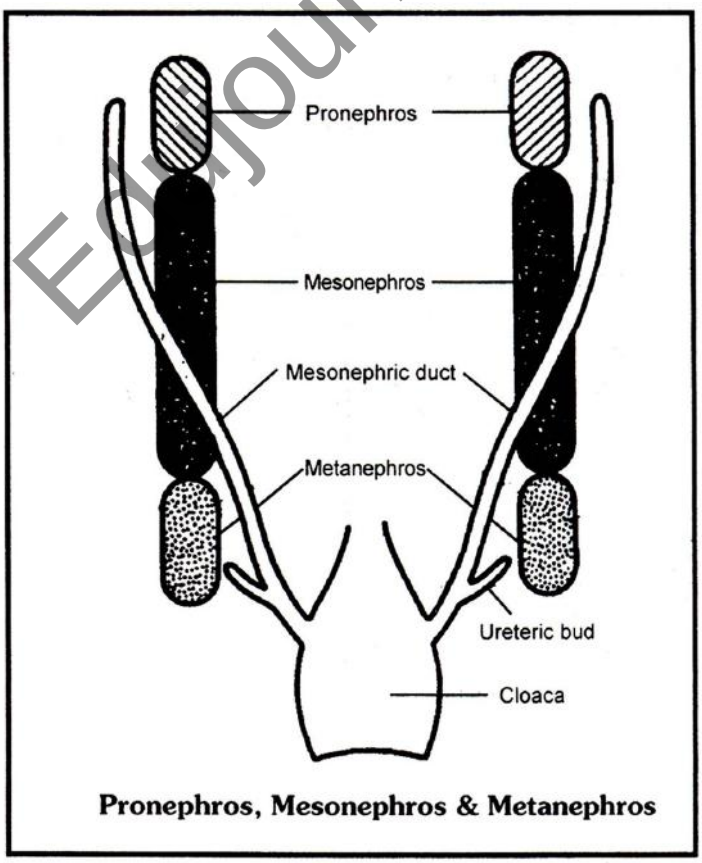
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

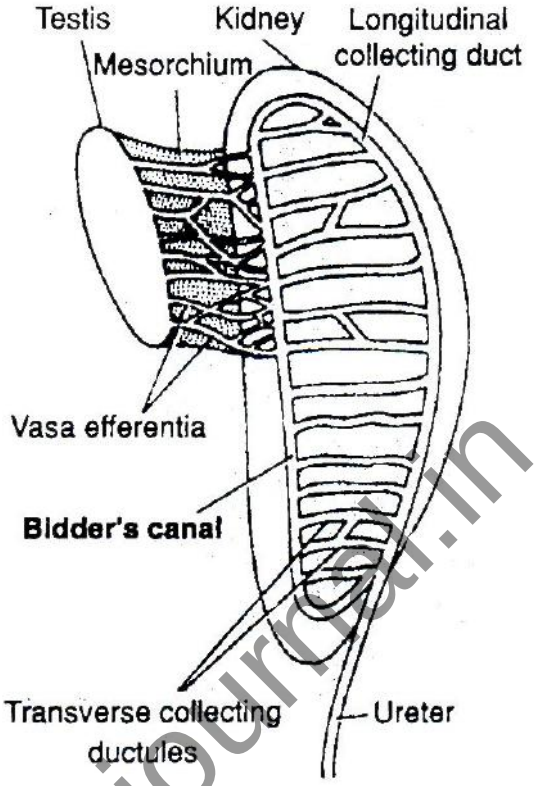


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

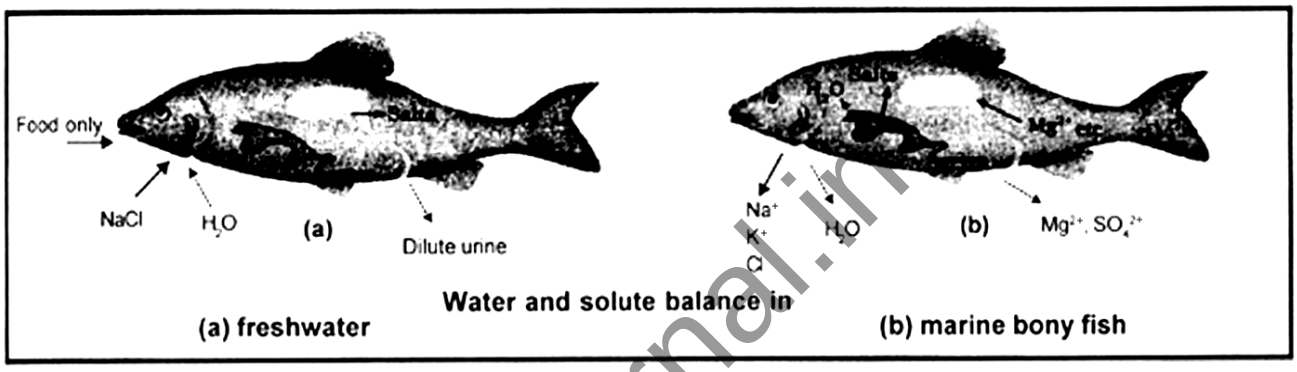
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

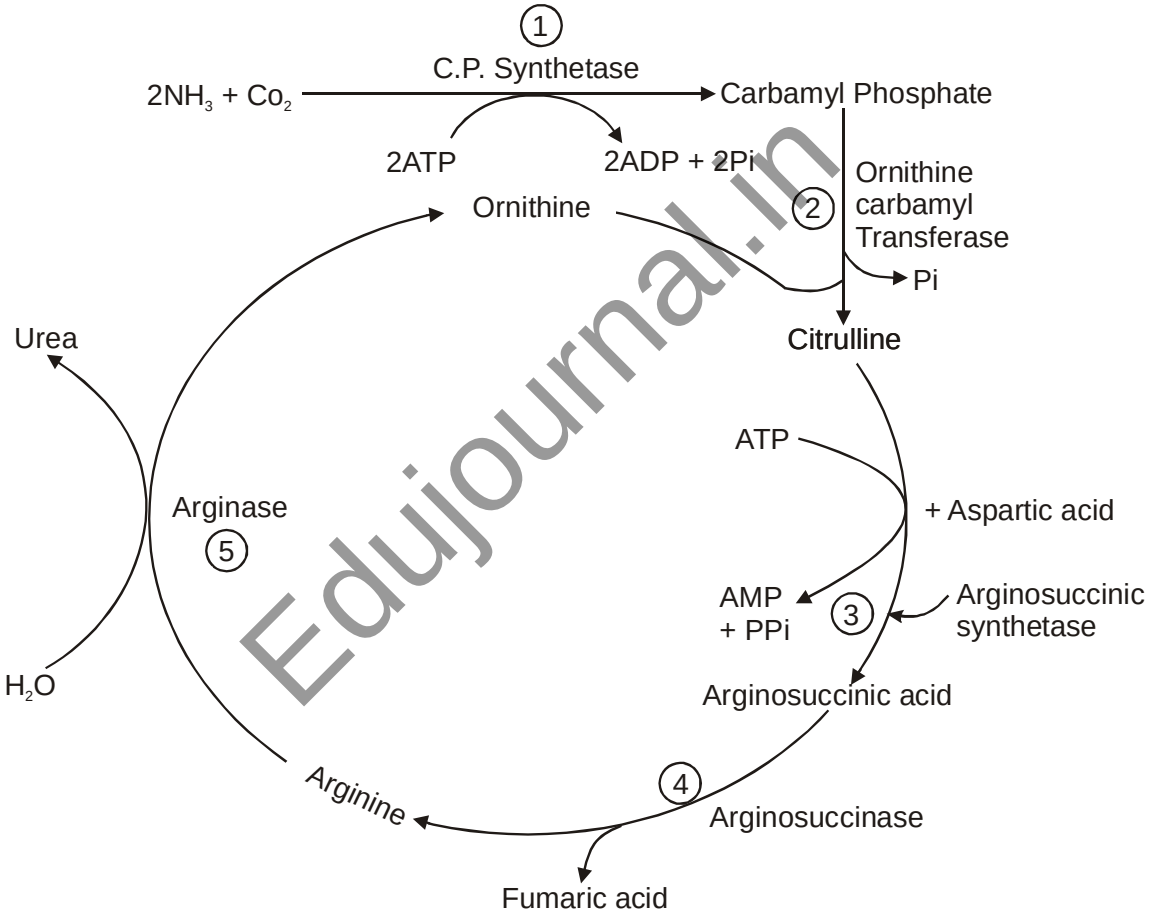
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

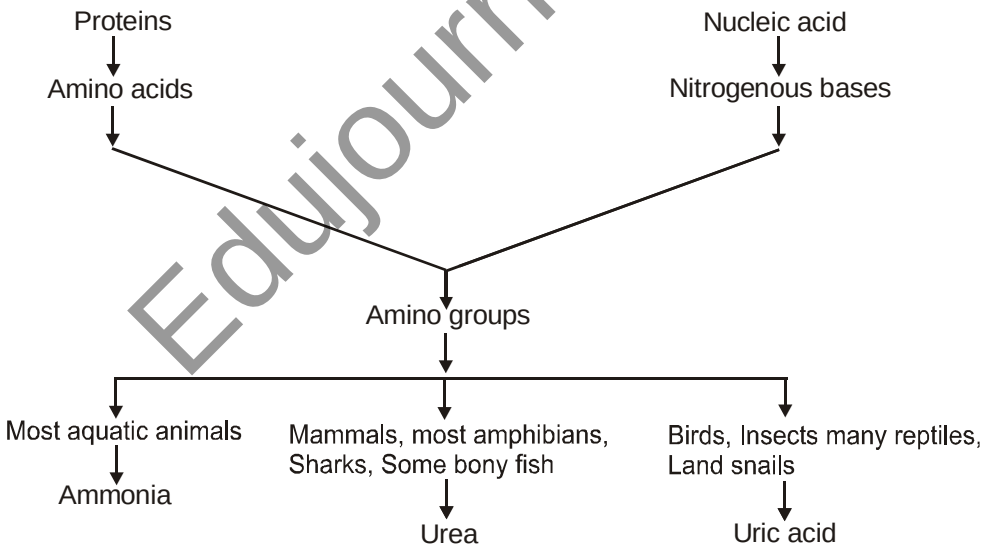
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

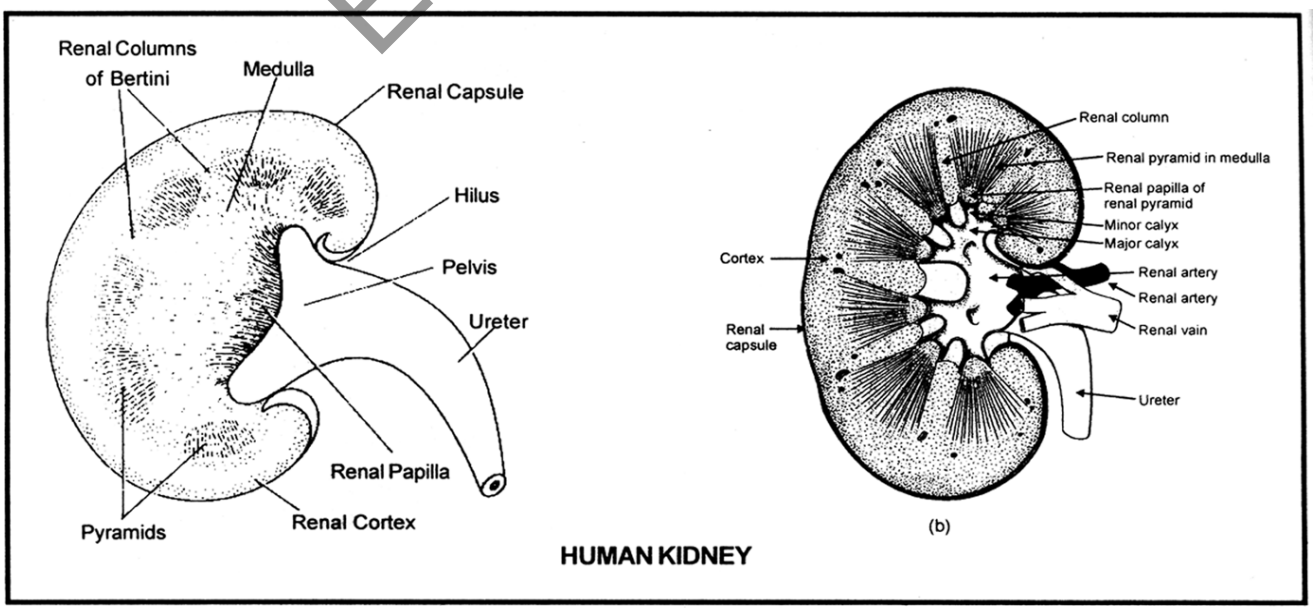
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

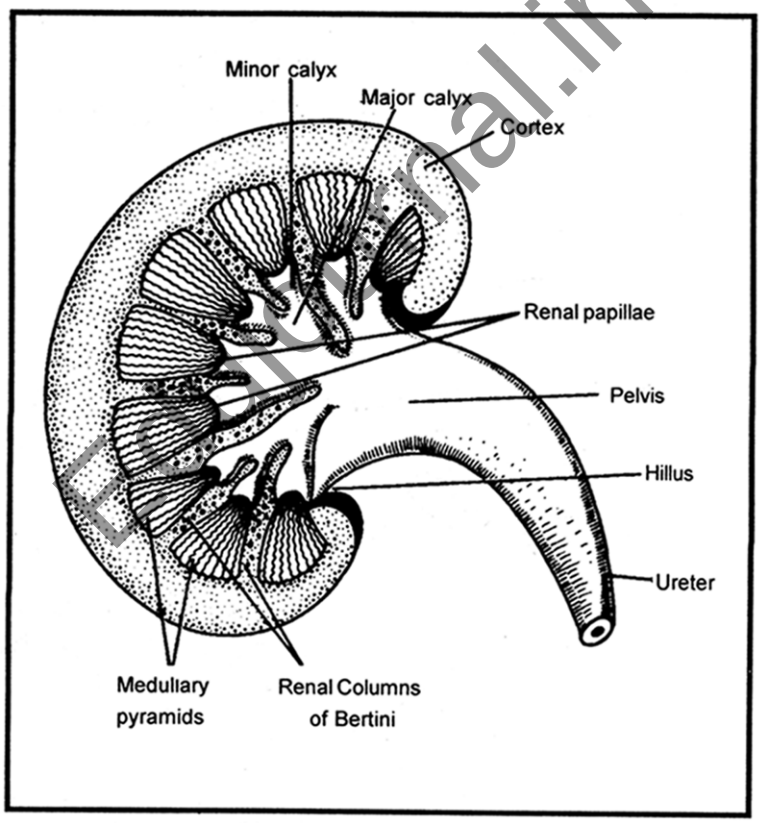
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

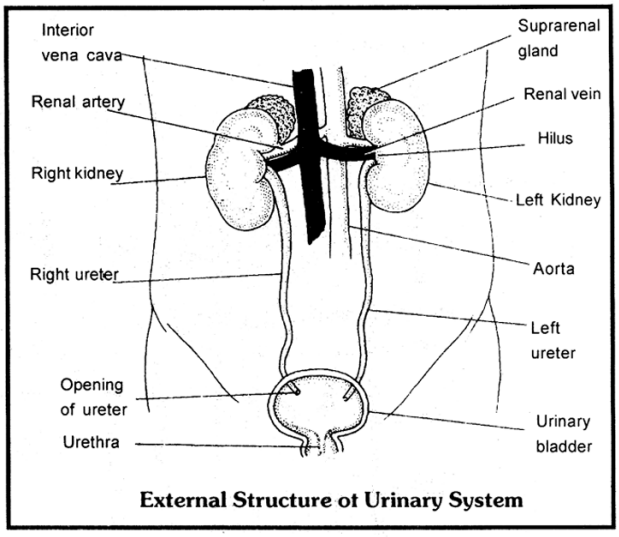
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

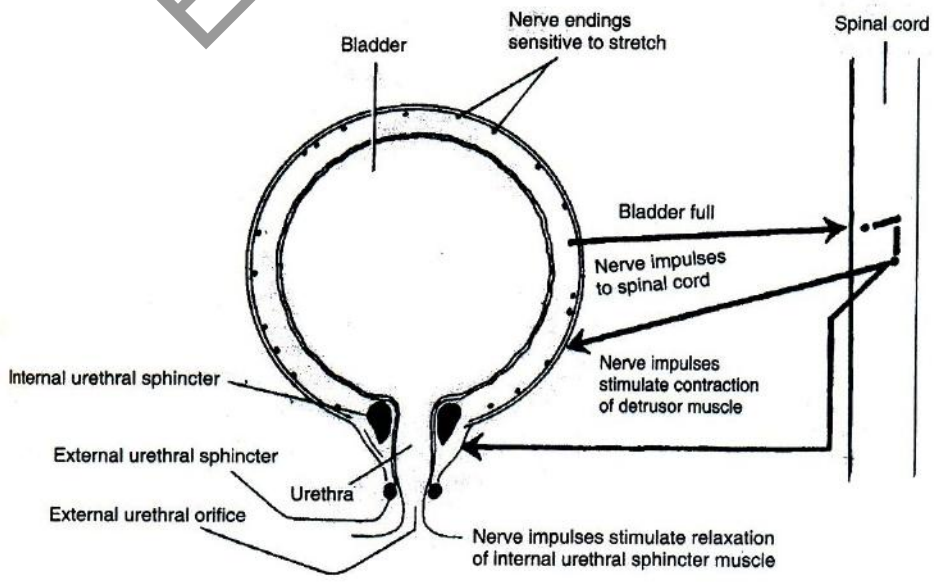
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

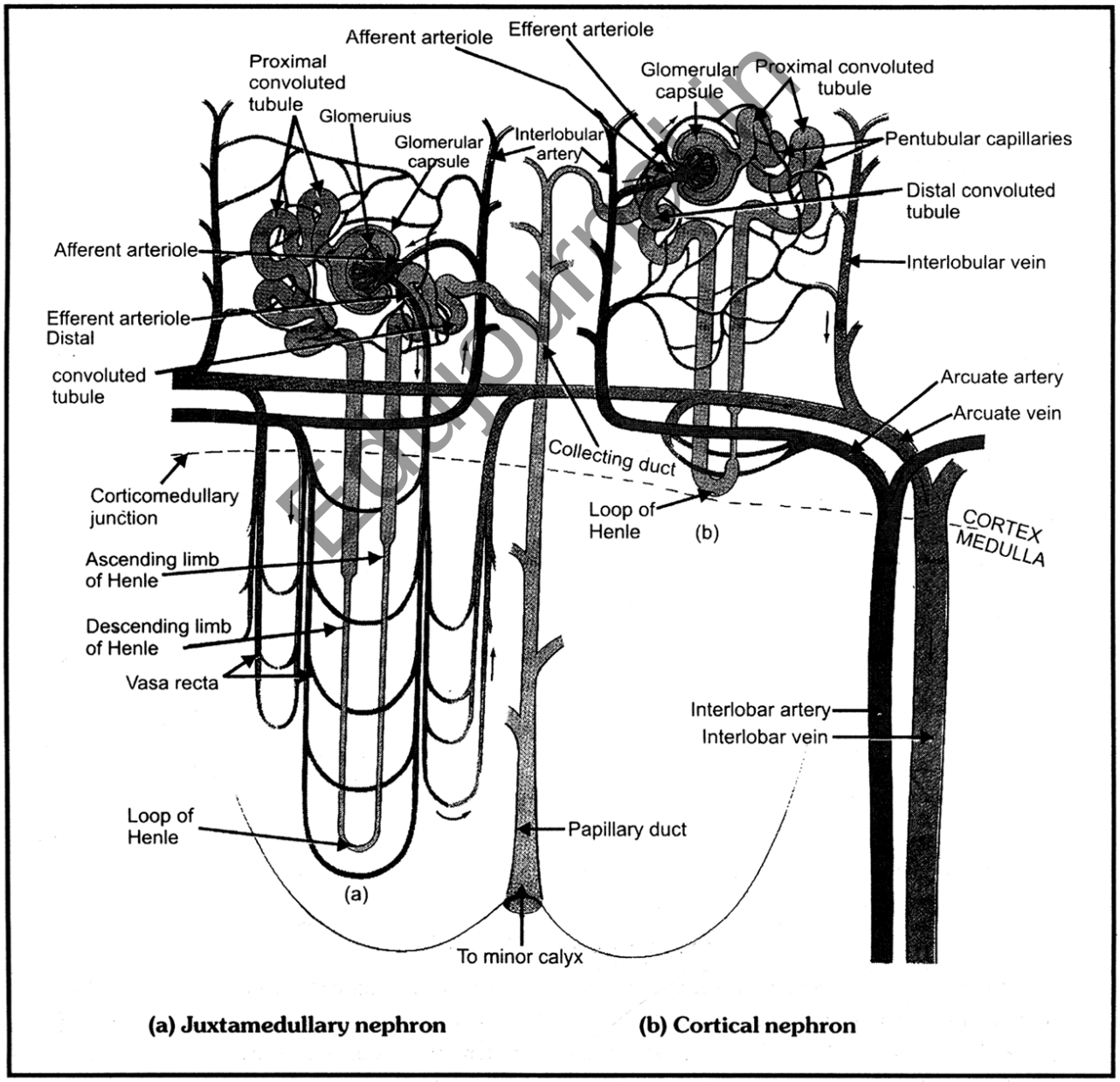
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



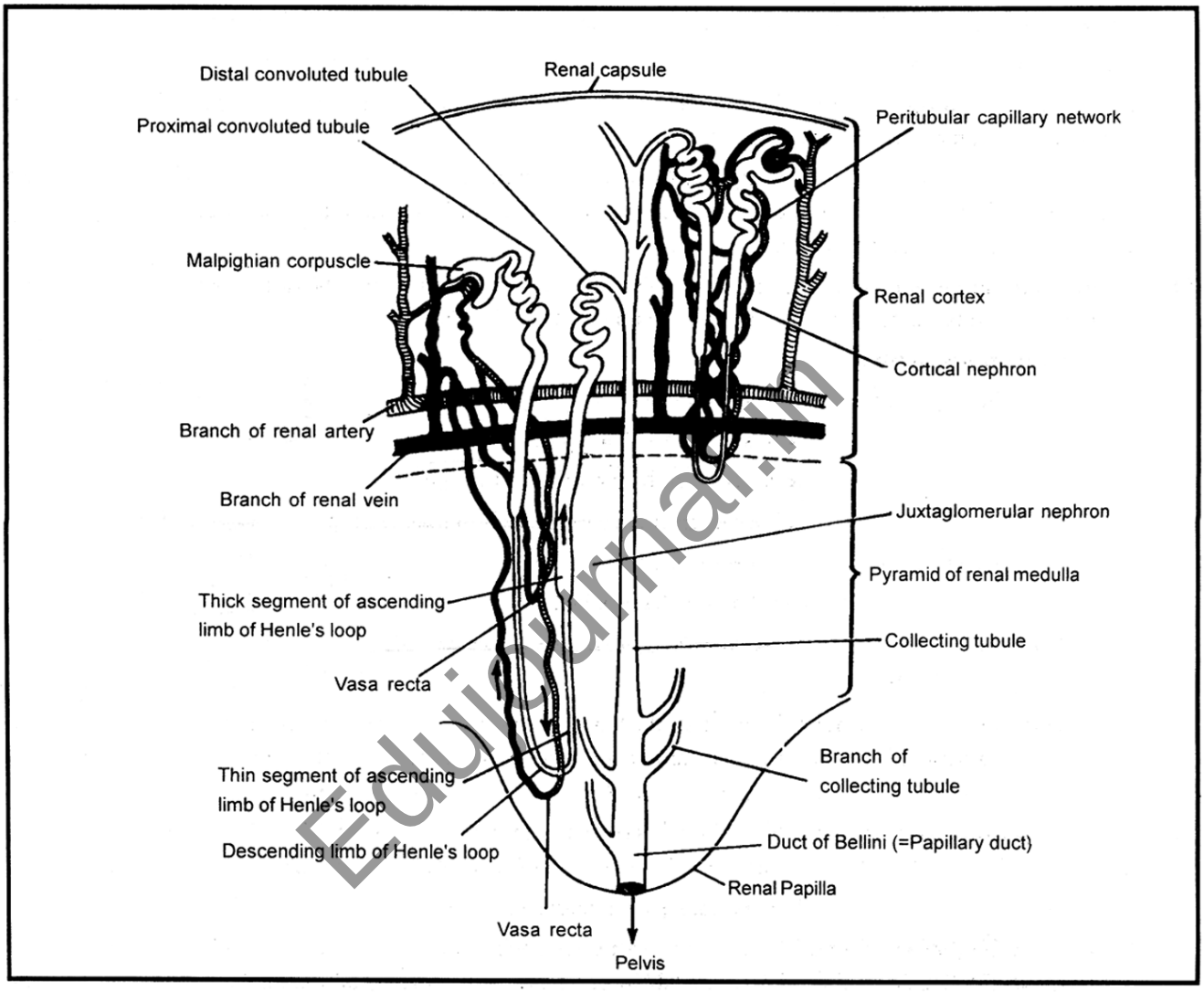
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

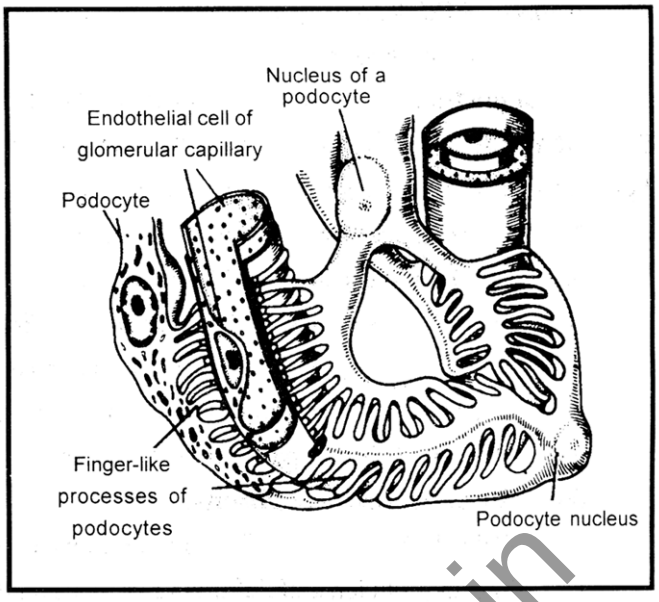
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

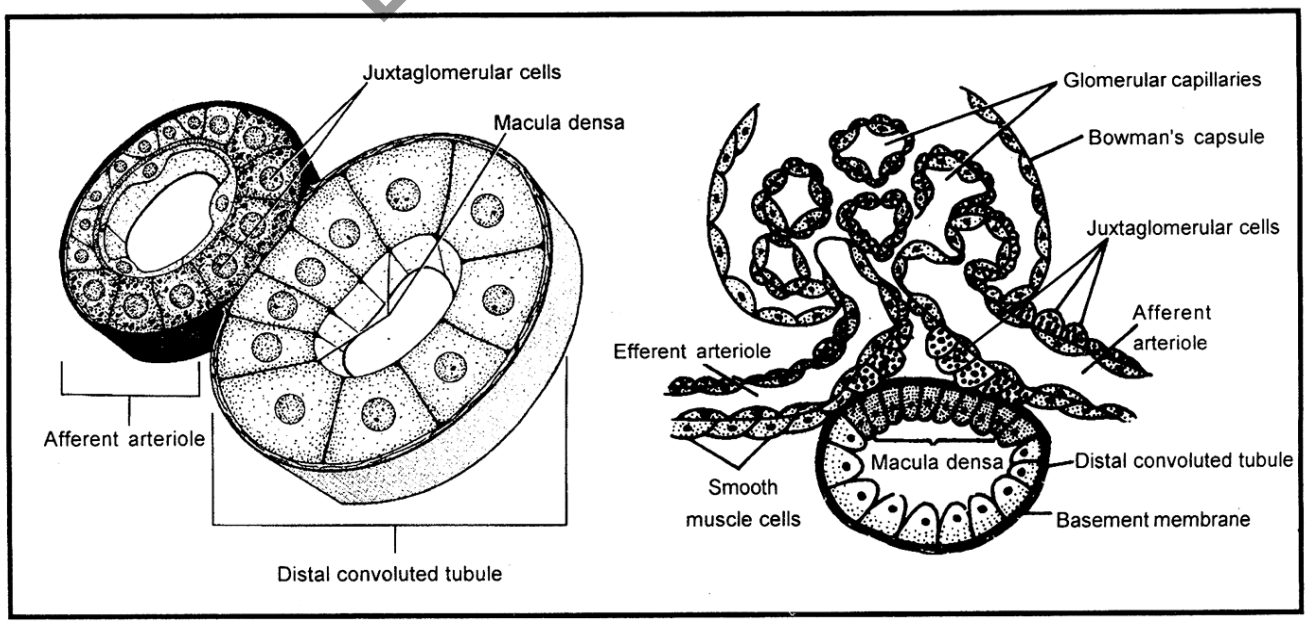
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

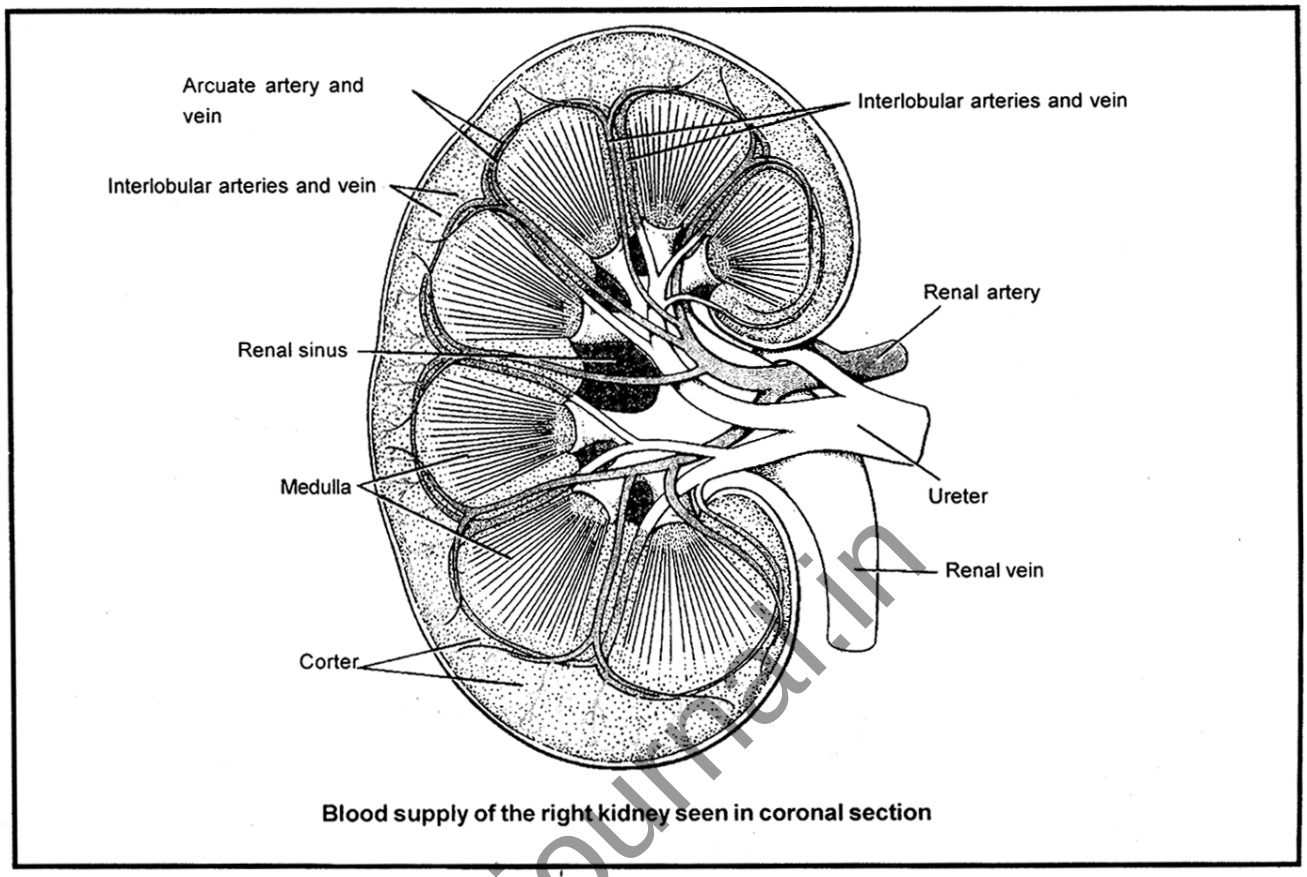
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

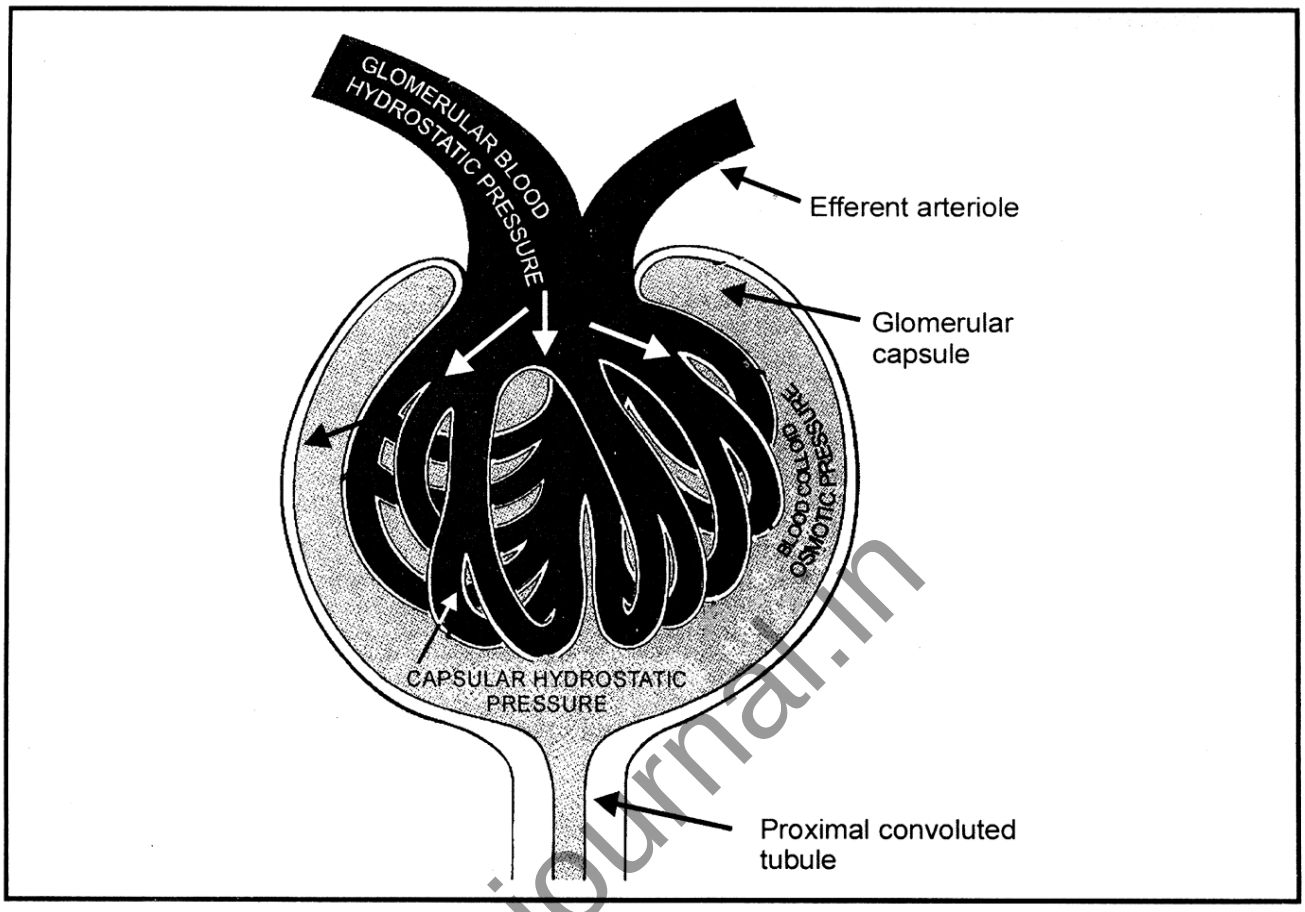
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

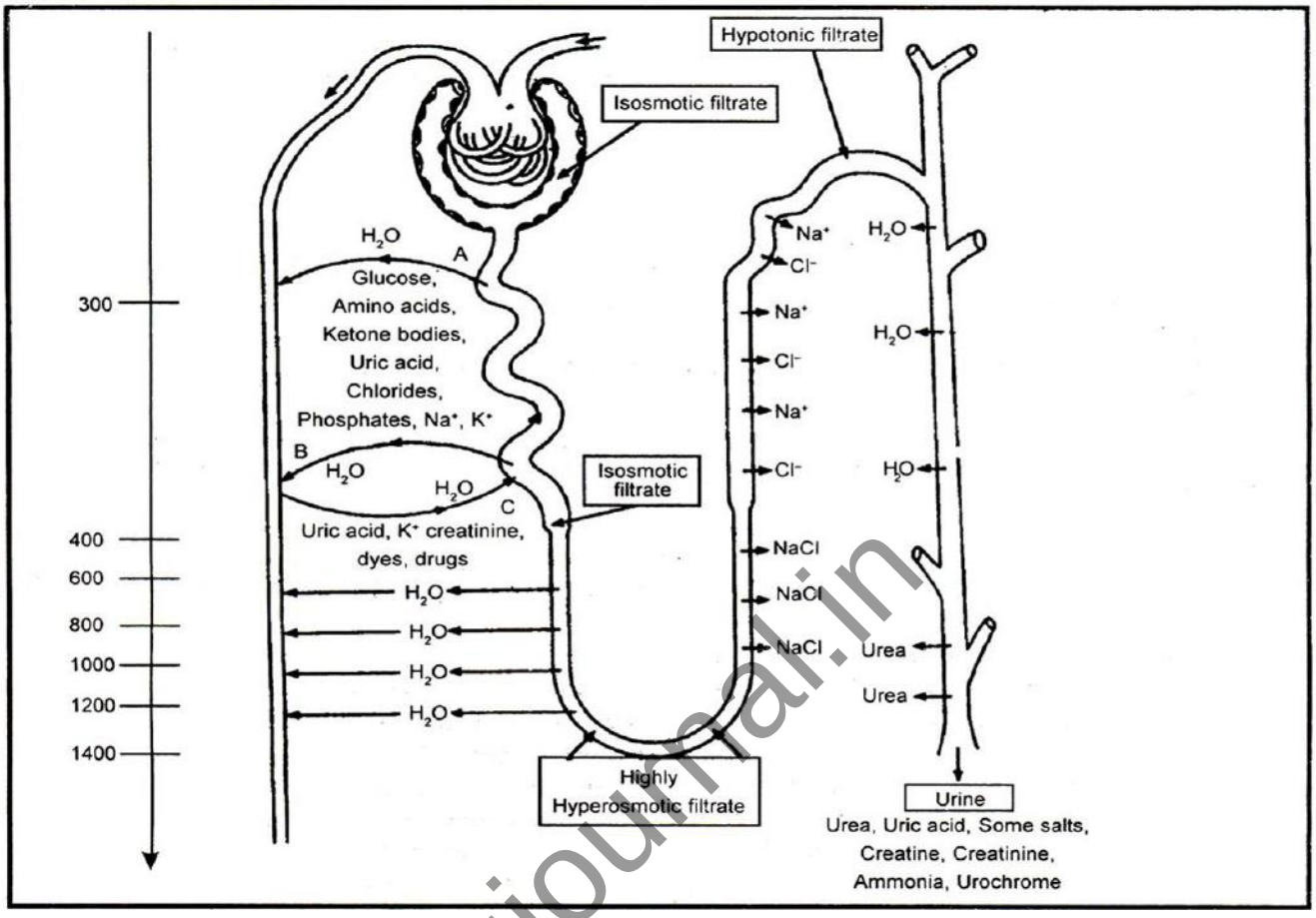
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

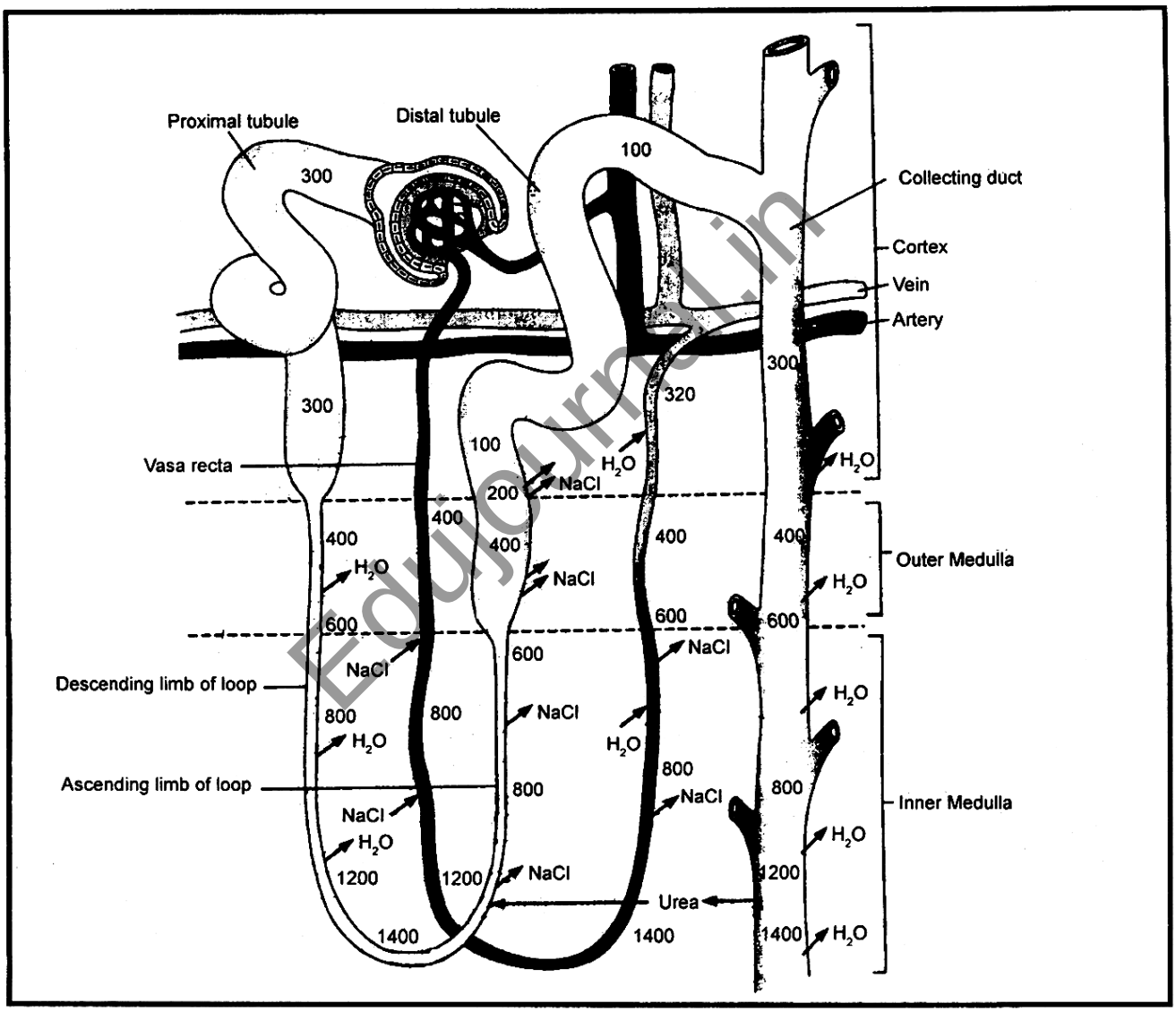
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

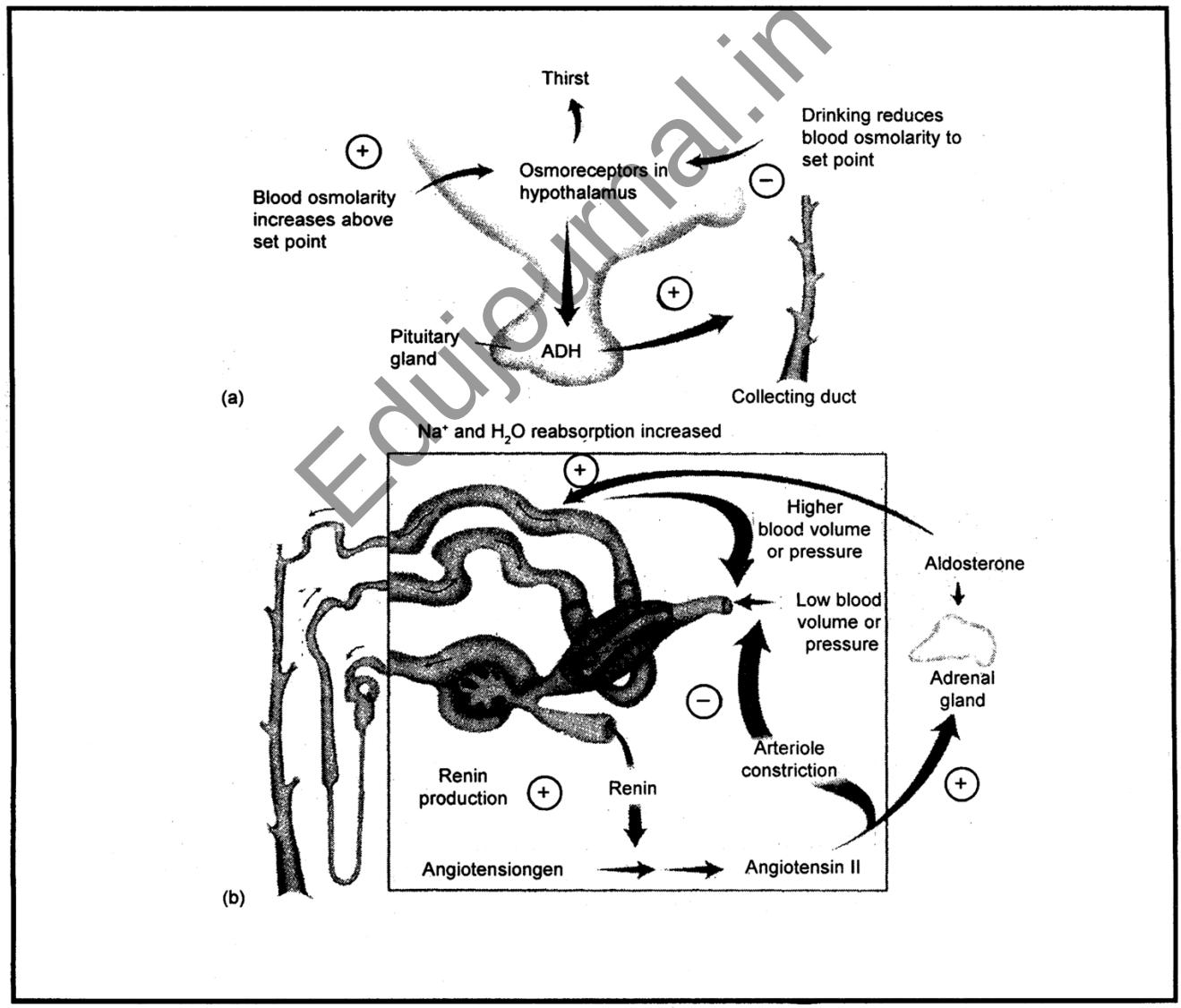
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

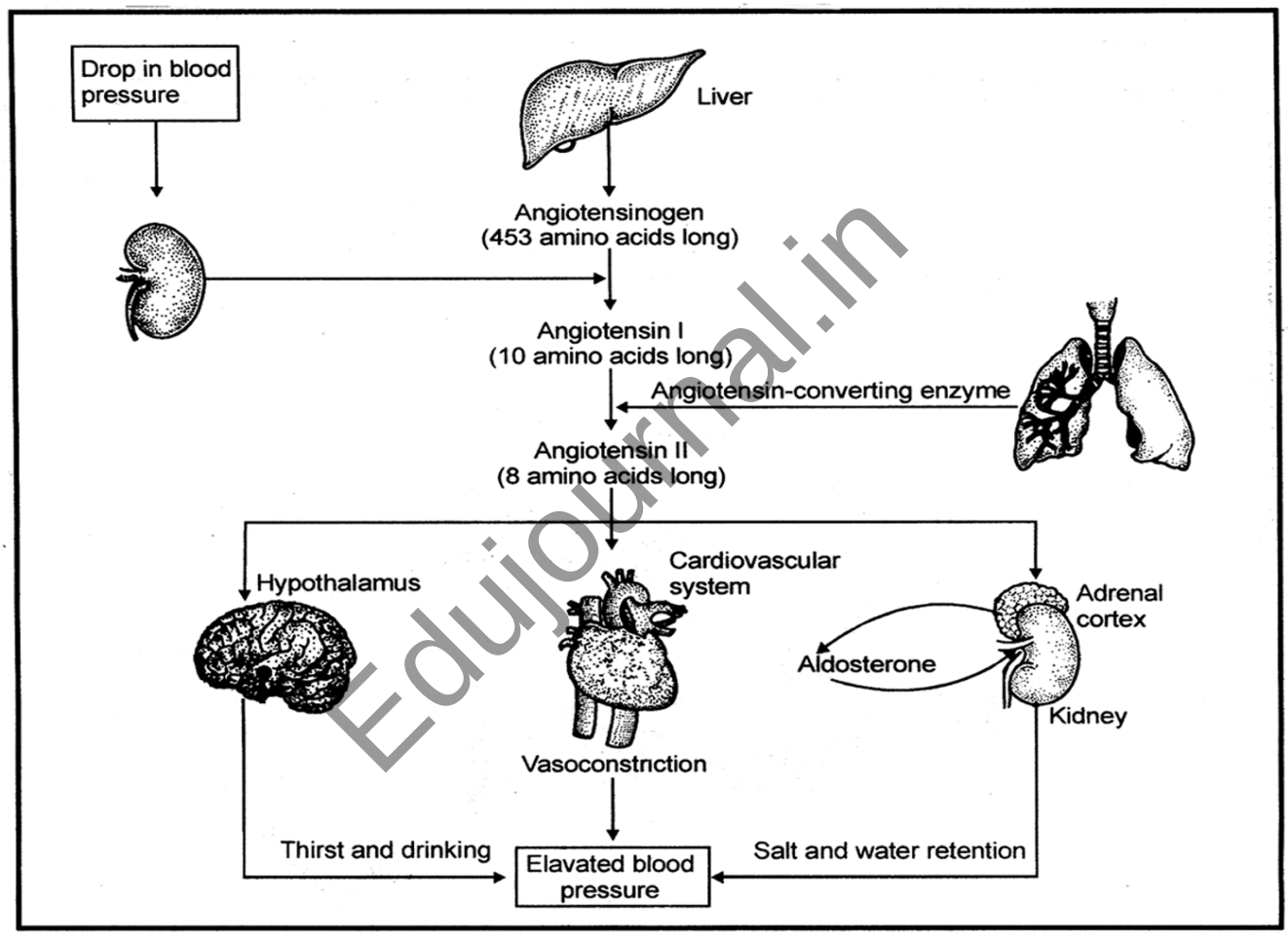
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

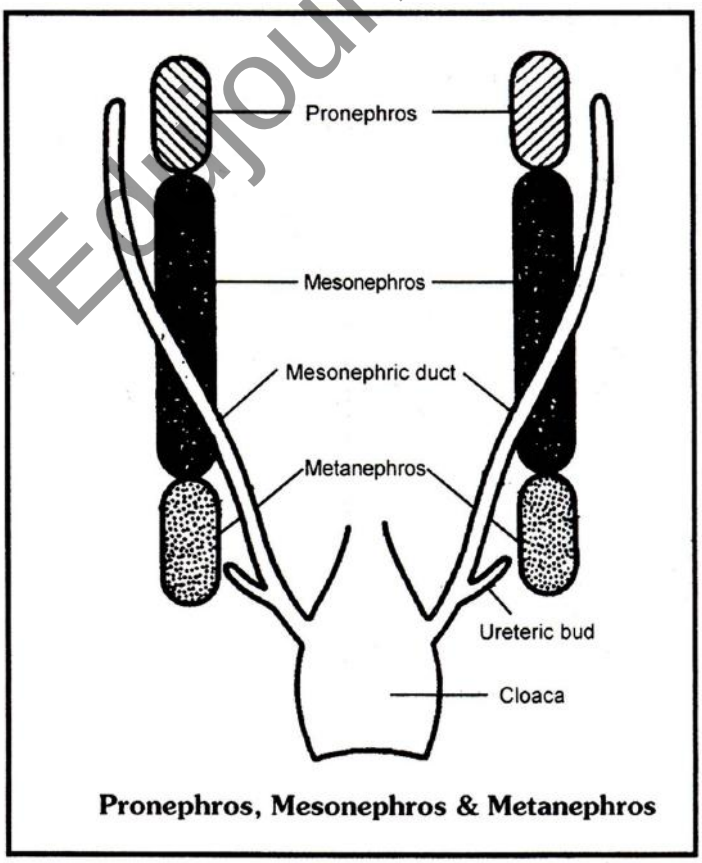
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

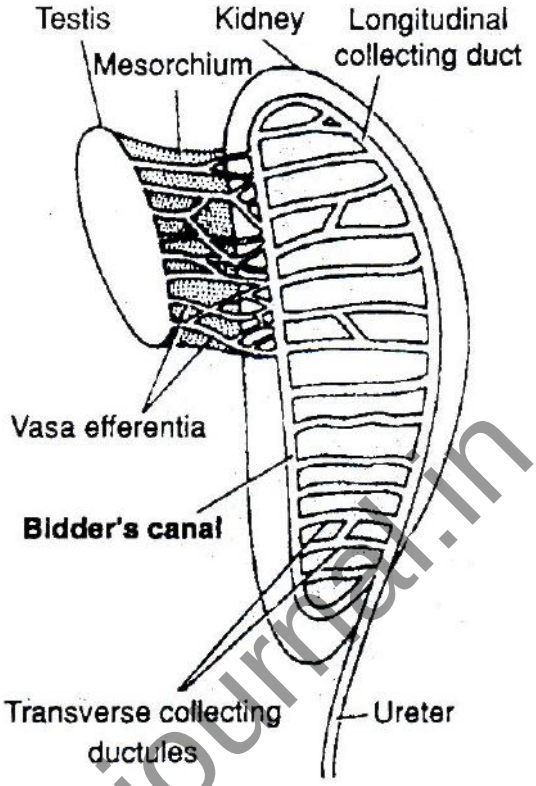


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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EXCRETORY SYSTEM

DEFINITION

(i) Elimination of metabolic waste from body is called **excretion**.

(ii) Due to metabolic activity in the body numerous waste substances are produced.

Carbohydrate metabolism, Produces CO_2 and H_2O. Protein metabolism produces nitrogenous wastes– **ammonia, urea** and **uric acid**.

HOMEOSTASIS

Maintenance of steady state (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, CO_2 , Ammonia, salts, excess water etc.) is termed excretion.

OSMOCONFORMERS & OSMOREGULATORS

Osmoregulation : The regulation of solute movement and hence water movement (which follows solutes by osmosis)

On the basis of osmoregulation, animals are either osmoconformer or ormoregulators.

Osmoconformers : These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

– All marine invertbrates and some fresh water invertebrates.

– Hagfish (myxine) which is marine cyclostome fish, is the only vertebrate osmoconformer.

Osmoconformes show an excellent ability to tolerate a wide range of cellular osmotic environments.

Osmoregulators :

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

Strict osmoregulators : Are animals which maintain the composition of body fluids within a narrow osmotic range.

Eg. most vertebrates (except Hag fish and elasmobranch like shark & rays fish)

Water and solute regulation in freshwater environment :

Body fluids of fresh water animals (osmolarity 200-300 m osm L^{-1}) are hypertonic to surrounding medium (osmolarity 50 m osm L^{-1}). Due to this, the freshwater animals constantly face two problems :

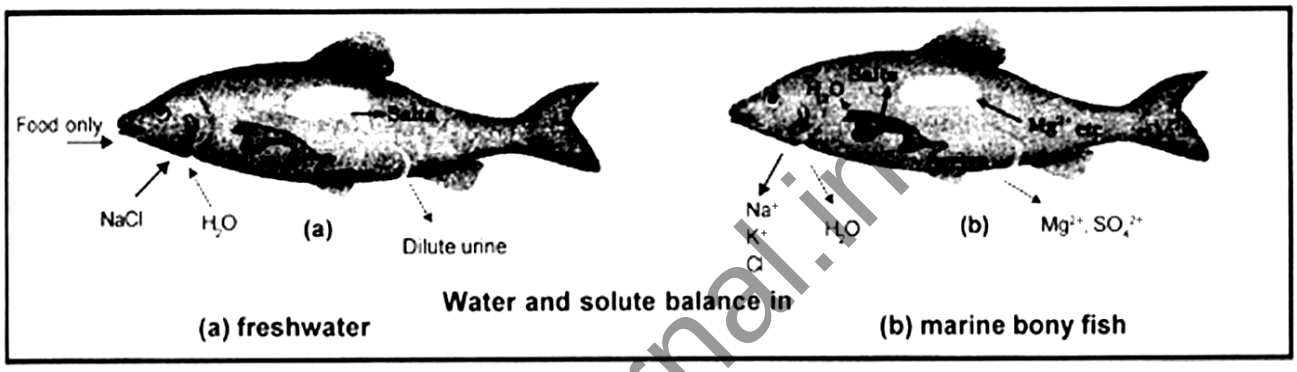
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(i) They gain water passively due to osmotic gradient

(ii) Continuous loss of body salts to surrounding low salt containing medium occurs.

To encounter these problems the fresh water fishes perform following acts :

- They do not drink water
- Specialised cells called ionocytes or chloride cells are present in the gill membrane of fresh water fish. These cells can actively import Na^+ & Cl^- from surrounding water (containing less than 1mM NaCl against concentration gradient.



Water and solute balance in
(a) freshwater (b) marine bony fish

Water and solute regulation in Marine environmemt :

Body fluids of marine bony fishes is hypotonic to seawater (osmolarity 1000 m osm L^{-1}). So the osmoregulatory problems are opposite here :

(i) Marine fishes loose water from the body through permeable surfaces (like gill membranes, oral and anal membranes.)

(ii) To compensate this water loss the marine fishes have to drink water, this drinking results in gain of excess salts.

These problems are encountered by marine bony fishes by following acts :

(i) The ionocytes or chloride cells of the gill membrae eject out excess of monovalent ions.

(ii) Excess of Divalent cations are excreted with faeces.

- When fishes like Hilsa & Salman (which live in both sea & fresh water) migrate from fresh water to sea water they drink water and excrete excess salts through gill membranes.
- Body fluids of marine invertebrates, ascidians and hag fishes are isosmotic to sea water.
- Elasmobranch fishes (shark & rays) and coelacanths (lobe fin fish) reduce the osmoregulatory challenges by raising the osmolarity of body fluids. This is done by accumulation of osmolytes like urea & trimethylanmine oxide (TMAO). This makes the body fluids of shark and coelacanths slightly hyperosmotic to sea water.
- Osmolarity of human blood is about 300 mosm L^{-1}

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Water and solute regulation in terrestrial environment :

Land animals continuosly loose water through oral, nasal or respiratory surface during breathing. A loss of 12 percent of body water may lead to death in humans. The water loss is compensated by drinking and eating moist food. Some example of water conservation in different animals are as follows.

- Kangaroo rats loose very little water, because they can recover 90 percent of the loss by using metabolic water.
- When water is not available, the camels do not produce urine but store urea is tissues and solely depend on metabolic water. When water is available they rehydrate themselves by drinking upto 80 litres of water in 10 minutes.

Water balance in humans and desert kangaroo rats

		Kangaroo rat	Human
Water gain	ingested in	0	1500 (60%)
(ml d^{-1})	Liquid ingested in food	6 (10%)	750(30%)
	Derived from metabolism	54 (90%)	250 (10%)
		60 (100%)	2500 (100%)
Water loss (ml d^{-1})	Evaporation	43.9 (73%)	900 (36%)
	Urine	13.5 (23%)	1500 (60%)
	Faeces	2.6 (4%)	100 (4%)
		60 (100%)	2500 (100%)

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ELIMINATION OF NITROGENOUS WASTES

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) Ammonotelics : Most aquatic animals excrete nitrogenous water as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia (NH_3) is lost as ammonium ions (NH_4^+) across the gill epithelium.

eg. of ammonotelic animals are teloest (modern bony fish), tadpoles and aquatic insects.

(2) Ureotelics : Animals like mammals, most adult amphibians living on land, marine fish and turtles, face the problem of conserving water. Excretion of urea is beneficial for these animals than ammonia becuase of following reasons.

(i) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

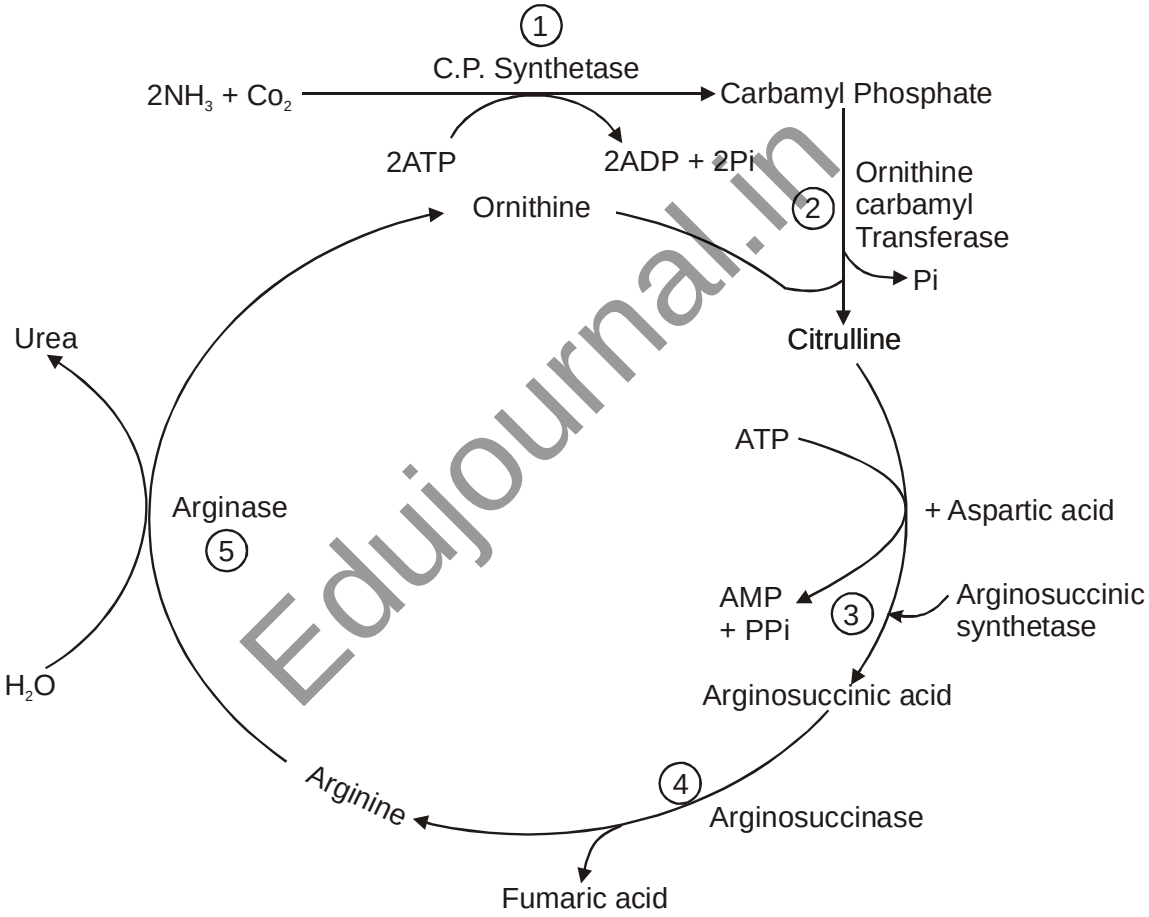
(ii) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.

For excretion of 1 gm of urea 50 ml of water is required.

In mammals **urea is excreted by kidney**. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidenys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
- Urea produced in the liver by urea cycle.

Ornithine Cycle : It is also termed as the **Kreb-Henseleit cycle.** In this cycle, 2 molecules of NH_3 react with 1 molecule of CO_2, as a result a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -



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- **Firstly** - 2 molecule of NH_3, 1 molecule of CO_2 combine to form carbamyl-Phosphate. This reaction is catalysed by the carbamyl-phosphate synthetase enzyme. 2 ATP's are used in this reaction.
- **In next step** - carbamyl-phosphate reacts with ornithine amino-acid to form the Citrulline amino-acid.
- **In next step** - Citrulline reacts with Aspartic acid to form Argino-succinnic acid. This reaction is catalysed by Argino-succinic synthetase. 1 moleucle of ATP is used in this process.
- **In next step** - Argino-succinic acid converts into Arginine and Fumaric-acid in the presence of Argino-succinase enzyme

- **Arginine,** now dissociates into ornithine and urea in presence of Arginase enzyme. Ornithine again enters the cycle.

3. Uricotelics : These animals excrete uric acid as waste products.

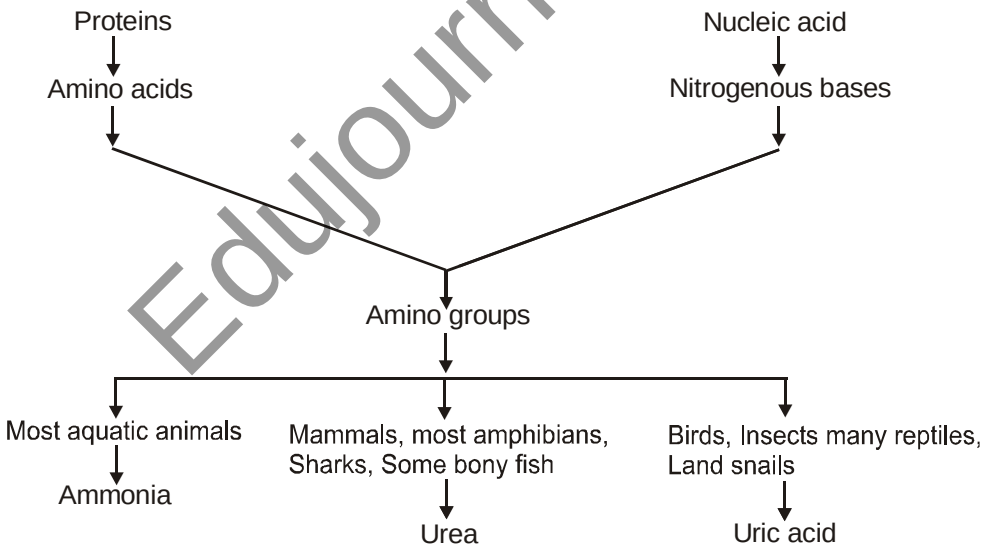
eg. Land snails, insects, birds & many reptiles.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

It is formed mainly in liver from **ammonia and purine**. An enzyme **xanthine oxidase** is needed for its production.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than NH_3 or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animals hatches.

- In birds and reptiles urine is eliminated in a paste like form along with faeces.
- Tadpole and aquatic amphibians excrete ammonia, while their terrestrial adult forms excrete urea.
- Aquatic turtles excrete both urea & ammonia. Some tortoise can change their nitrogenous wastes when the environment is changed.
- Most terresterial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.
- Uricotelics excrete uric acid as solid white crystal called **guano**.



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SOME OTHER EXCRETORY PRODUCTS

Other wastes

(i) Guanine - It is excretory waste of spider.

(ii) Ornithinic acid - It is excretory waste of birds.

(iii) Purine - It is excretory waste of butterfly.

(iv) Hippuric acid
(v) Creatine
(vi) Creatinine
— Excretory waste of mammals

(vii) Allantoin - It is excretory waste of foetus of **reptiles, aves** and **mammals**.

(viii) TMA (Trimethyl Amine oxide) - Marine Teleosts.

(ix) Amino acid - Some Molluscs **(*Pila*, *Unio*),** some Echinoderms **(Star fish, *Holothuria*)**.

CARBON DIOXIDE

It is formed during cellular respiration, upto annelida it is eliminated by general body surface through diffusion. In higher animals it is excreted by specialized respiratory organs.

MINERAL SALT

The excessive mineral salt like, potassium, calcium, magnesium, sodium are excreted in urine, sweat and faeces.

(i) Water

Excessive water is eliminated in faeces, urine, sweat and expired air.

(ii) Pigments

Pigments like bilirubin and biliverdin are eliminated in faeces, whereas, urochrome is eliminated in urine.

(iii) Drugs

Drugs are mainly removed through kidney.

Animals on the basis of excretory matter are divided into three categories :

	Character	Type of animals		
		Ammonotelic	**Ureotelic**	**Uricotelic**
1.	Excretory matter	Ammonia	Urea	Uric acid
2.	Requirement of water	Very large	Less than ammonia	Least
3.	Mechanism of excretion	By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion.	Ammonia prouduct by metabolism is Converted into urea in the liver and released into the blood which is filtered and excreted. out by the kidneys.	in form of thick paste
4.	Toxicity	Highest	Less than ammonia	
5.	Examples	Teloests, Tadpoles, Aquatic insects	Mammals, Sharks,	Least Birds, Insects, Land snails, many reptiles

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Excretory organs in animals :

Animals	Flatworms e.g. Planaria	Earthworm	Insects e.g., Cockroch	Crustanceans e.g., Prawn	All chordates
Excretory organs	Protonephridia (Flame cells)	Nephridia	Malpighian tubules	Green glands	Kidneys

HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

The main excretory organ in humans is kidney.

Other excretory orgains are skin, liver, lungs & large intestine.

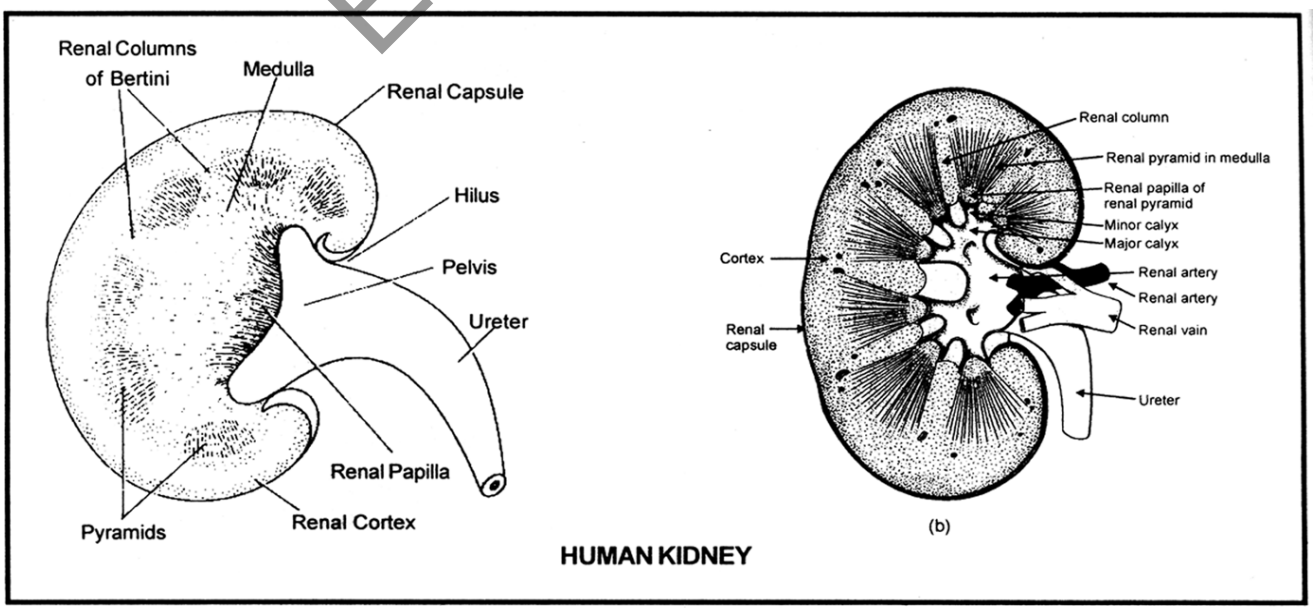
– Two kidney their blood supplies.
– A pair of ureters.
– urinary bladder
– Urethra

LOCATION AND STRUCTURE OF KIDNEYS

Each individual normally has two kidneys located lateraly on either side of vertebral column at the level to T_{12}, L_1 & L_2

Origin, location, form, size and external structure

- Kidney is mesodermal in origin and retroperitoneal i.e. covered by peritoneum on ventral side.
- Kidney is found in pair. It is **bean shaped**, dark red, sized. (10 cm long × 5 cm broad × 4 cm thick)



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- Both kidneys are situated in the anterior part of the abdominal cavity on either side of the median line (vertebral column). Last two pairs of ribs called floating ribs protect the kidney.
- In man the left kidney is slightly higher than the right kidney. In rabbit left kidney is slightly lower than right kidney.
- The concave side of each kidney faces inward whereas convex side faces outwards.
- Artery, vein, nerve and ureter enter or leave the kidney through the **hilus**.
- Externally kidney is covered by a layer of fibrous connective tissue called **renal capsule.**
- The structural & functional unit of kidneys is the Nephron.

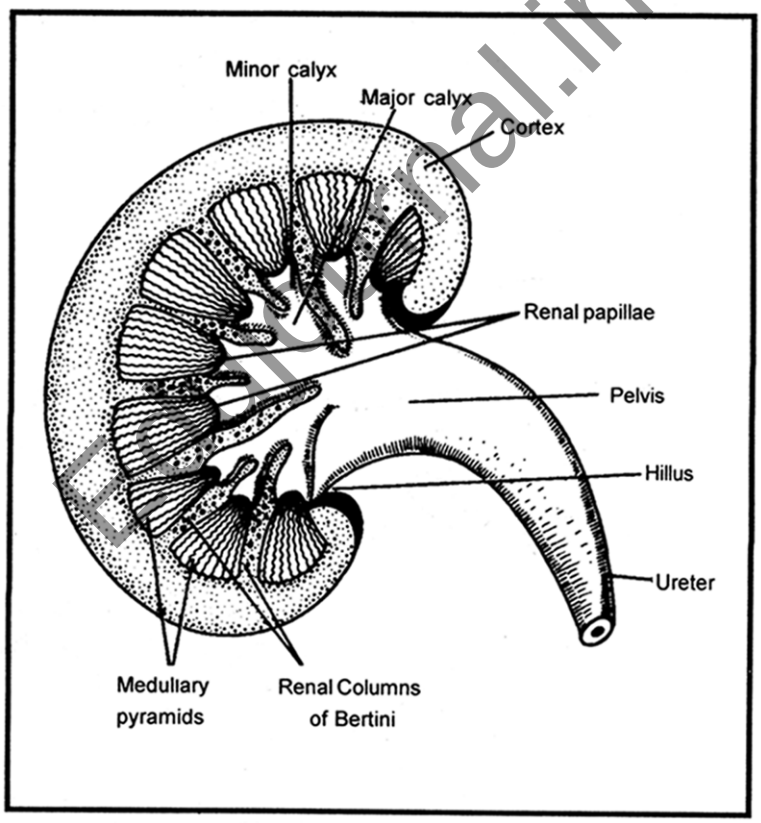
These nephrons are arranged in a radiating fashion within the renal pyramids.

Urine produced by each nephron empties into **collecting duct.**

The collecting duct passes through a **papilla** into the **renal calyx** (Pleural-calyces).

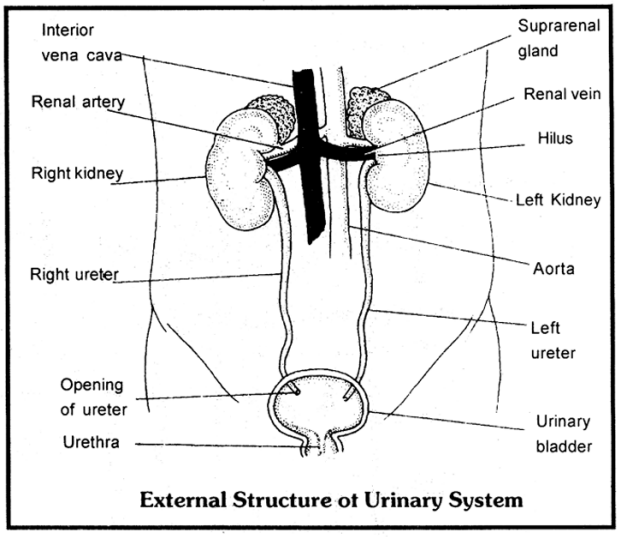
The renal calyces drain urine in the central cavity of renal pelvis.

In rabbit, renal pelvis is unbranched, so the calyces and renal column of Bertini are absent.



Post Renal Urinary Tract

Urine passes from the pelvis into the **ureter**. Both the ureters open through separate oblique openings into **urinary bladder.** The obliquity of the openings prevent the backflow of urine. Externally, the bladder is lined by transitional epithelium or urothelium. This epithelium has great capacity to expand so that large volume of urine can be stored if required. Opening of urinary bladder is controlled by sphincters made of circular muscles. These normally remain contracted and during micturition these relax to release urine. (In rabbit a single sphincter is present while in human two sphincters, inner involuntary & outer voluntary, are present.)



External Structure of Urinary System

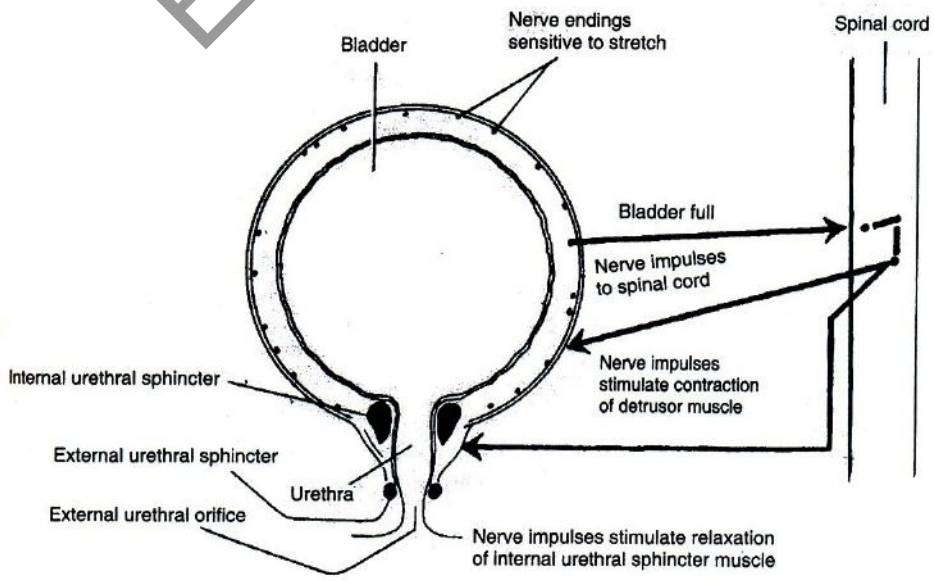
Passage of urine :

Nephron → Collecting duct → Papilla → Renal calyx → Penal pelvis → Ureters → Urinary bladder → Urethera

During act of micturition urine leaves the urinary bladder and enters the membranous duct called **Urethra.** The urethra leads to end of the penis in males and into the vulva in females. In males the urethra has three parts, prostatic, membranous & penile urethra prespectively. (Prostatic urethra & penile urethra are absent in females, therefore both sphincters are present in membranous urethra)

CONDUCTION OF URINE AND MICTURITION

(i) The urine produced in nephrone passed into the collecting tubules which opens in the **duct of Bellini**. Duct of Bellini converage towards hilium and pass through 15-16 conical renal pyramid which through minor and major calyxes pour their urine in renal pelvis of ureters. Both ureters carries the urine by peristalisis to urinary bladder.



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(ii) The process of passing out urine is called micturition

(iii) When urine get collected in urinary bladder muscular wall of urinary bladder get distended or expanded. Distension of wall of urinary bladder stimulates the sensory nerve endings in the bladder wall causing detrussor muscle to contract.

(iv) Micturition may voluntarily initiated or postponed. Urge for micturation starts when the bladder is little more than half full of urine.

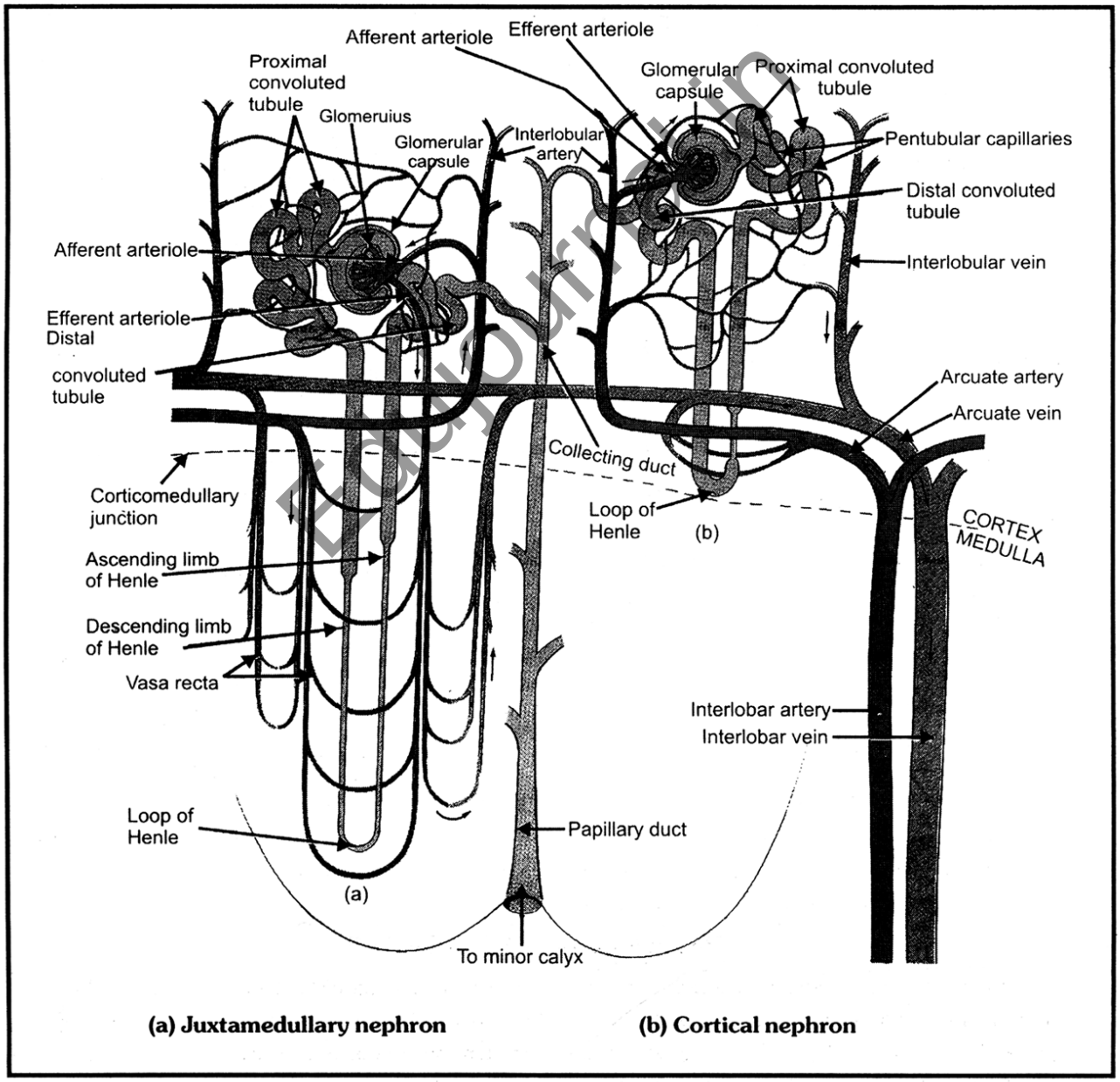
(v) A person feels desire of micturition when quantity of urine in the bladder is about 220 ml.

Note :

Sympathatic nerve fibre help in filling of bladder, whereas, parasympathatic helps in emptying of urinary bladder.

STRUCTURE OF NEPHRON

Nephron is the structural and functional unit of kidney. It is an epithelial tube which is about 3 cm long and 20-60 μm in diameter. (Each kidney has about one million nephrons in humans & 2 lakh in rabbit)



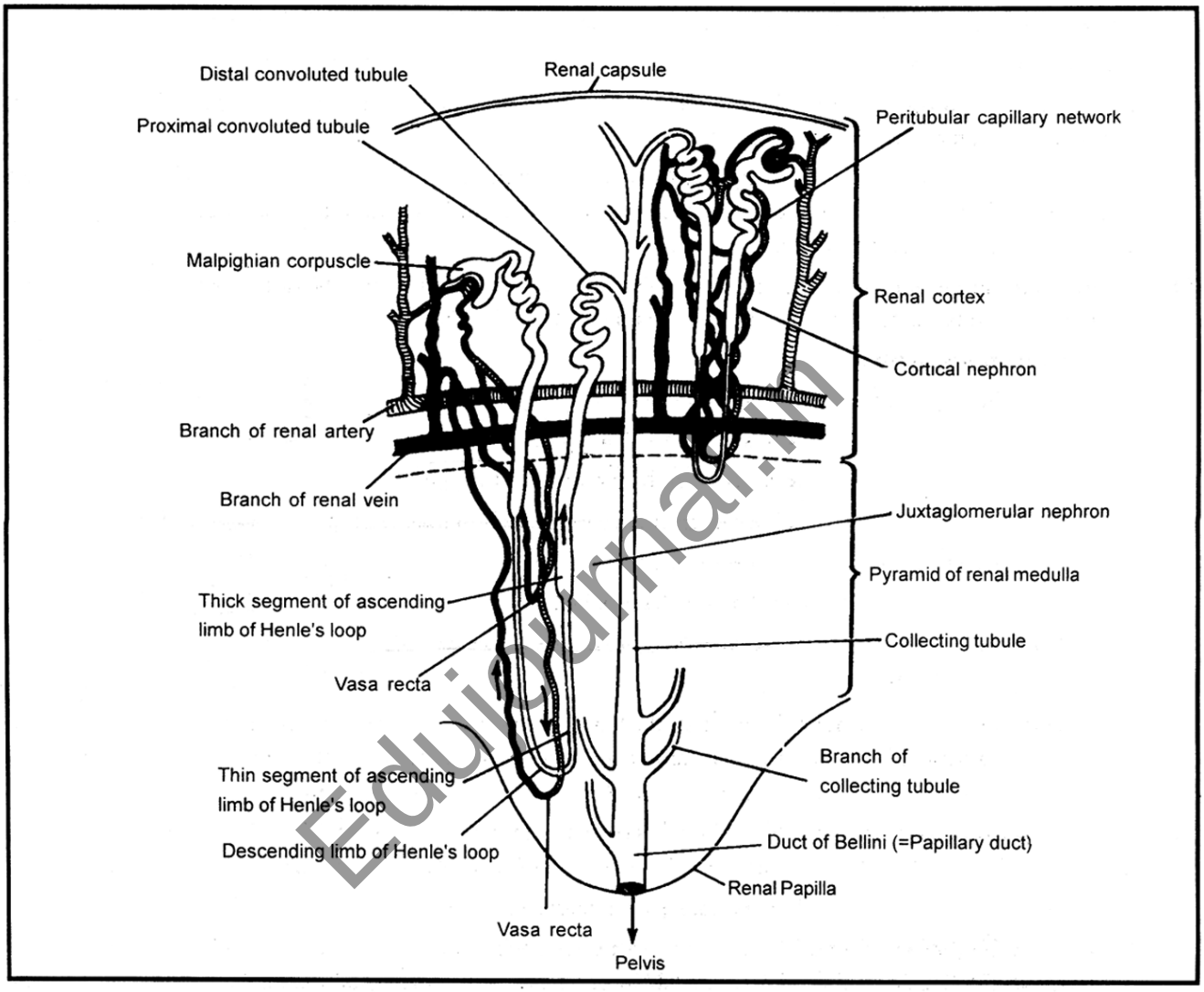
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A nephron can be divided into three regions :

(I) Proximal nephron (Bowman's capsule + Proximal convoluted tubule)

(II) Loop of Henle (Ascending + Descending limb)

(III) Distal nephron (Distal convoluted tubule which opens into collecting duct)



(I) Proximal nephron : Nephron tubule is closed at its proximal (starting) end but its distal end is open and continues into the loop of Henle. At the proximal or closed end the nephron is expanded and curved inwardly to form a double walled cup shaped **Bowman's capsule.** within bowman's capsule a network or tufts of capillaries is present, It is called **Glomerulus.** Diameter of afferent arteriole is greater than efferent arteriole.

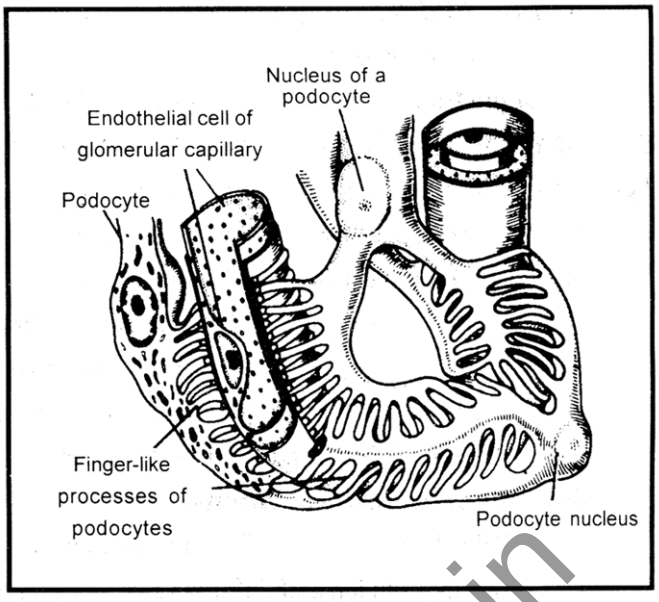
Malpighian corpuscles : Glomerulus and its surrounding Bowman's capsule together form this specialised structure.

The outer wall of Bowmans capsule is composed of flattened squamous cells.

The inner, invaginated wall that lines the concavity of bowmans capsule is composed of a special type of cells called **Podocytes.**

These cells bear finger like projections which are coiled around the capilaries of glomerulus.

The Bowmans capsule is followed by a short neck part lined by ciliated epithelium.



Proximal convoluted tubule : The epithelial cells of this region are specialised for transport of salts and other substances from the lumen to the interstitial fluid.

The membranes of these cells facing the tubule lumen has numerous microvilli (finger like projections or Brush Borders) which increase the surface area. Near its basolateral surface, the mitochondria are concentrated, to allow of reabsorption of salts by active transport.

(II) Loop of Henle : It starts after the proximal convoluted tubule, It ends before the distal convoluted tubule. This hairpin like loop has a descending limb, followed by an ascending limb.

Descending limb : Its upper part - constitutes thick segment has the same diameter as PCT and is also lined by cuboidal epithelium.

Its lower part - constitutes thin segment and is lined by flat epithelial cells

Ascending limb :

- This part too has a **thin segment** first which widens abruptly at medullary zone to form **thick segment.** Lower thin segment is lined by simple squamous epithelium while upper thick segment is lined by cuboidal epithelium.

(III) Distal nephron : The ascending limb of henle's loop merges into **distal convoluted tubule.** This is lined by cuboidal epithelial cells with a few microvilli. Coils of both PCT & DCT are intermingled.

The distal convoluted tubules of a number of adjacent nephrons open into a common **collecting duct** or tubule.

Collecting ducts (present in medullary pyramids) are long tubules which travel through the medulla in the pyramids. In the papilla of the medulla (in rabbit) or papilla of the individual medullary pyramid (in human), Several adjacent collecting ducts converge to open into a common short and thick **duct or Bellini.** (present in papilla or medulla)

All ducts of Bellini then open at the tip of the papillae into the pelvis.

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Renal cortex : The malpighian corpuscle, PCT & DCT of the nephrons are located here.

Renal medulla : Loop of henle, collecting duct and ducts of Bellini are found in this region.

TYPE OF NEPHRONS ::

According to their position, nephrons are of two types.

(i) Cortical nephrons :

- These consitute about 85% of total. (75-85%)
- Malpighian corpuscles of cortical nephrons are located close to the kidney surface.
- Their loops of Henle are small and a very small part of it runs in the medulla.
- Only peritubular capillary network is present & vasa recta is absent.

(ii) Juxtamedullary nephrons :

- About 15% of total. (15 - 25%)
- Malpighian corpuscles of these nephrons are located at the junction of cortex and medulla.
- The loop of Henle of these nephrons are long, dipping deep down into the medulla.
- Both, PTC network and vasa recta are present.

In these nephrons the initial part of the DCT is located close the mouth of Bowman's capsule, in contact with both afferent and efferent arterioles.

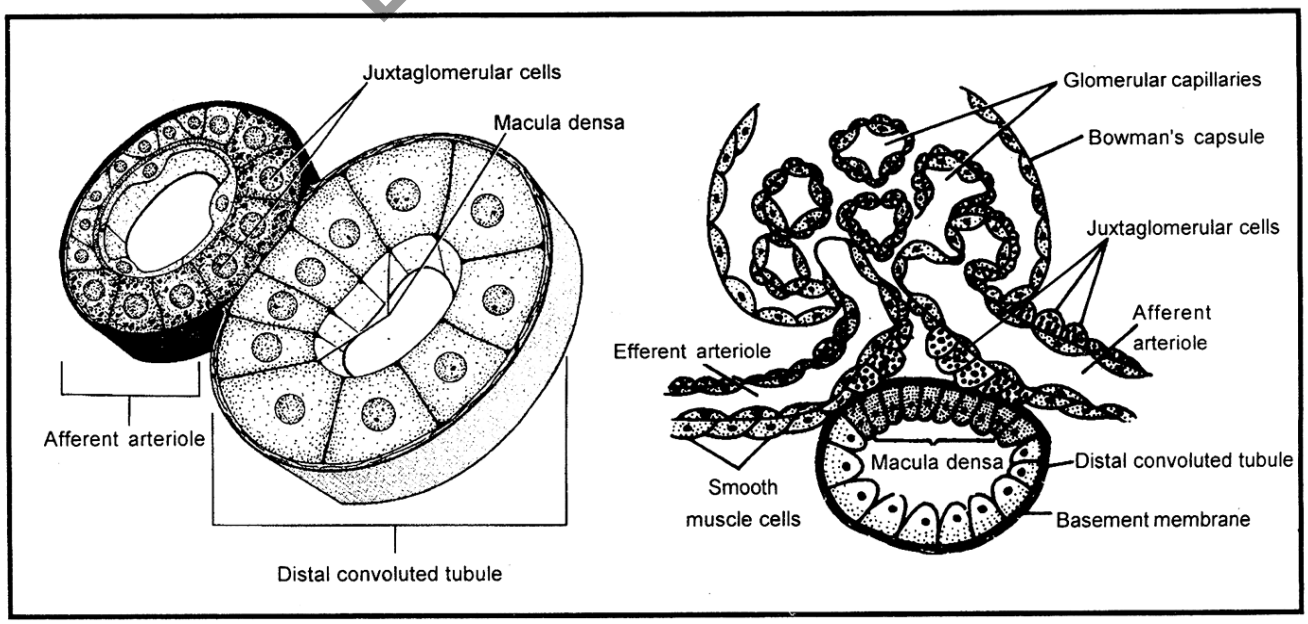
Juxtaglomerular apparatus : Juxtaglomerular cells + Macula densa.

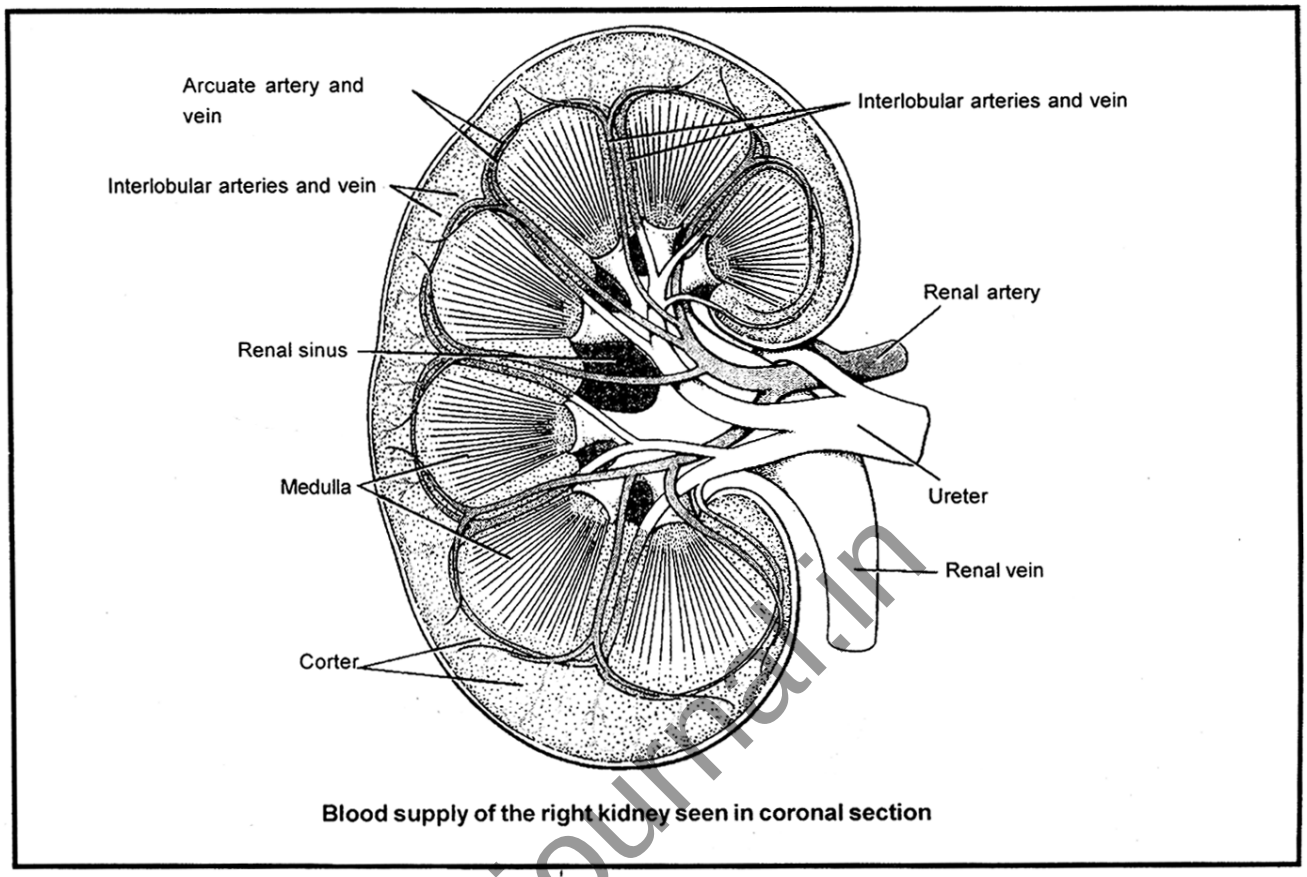
Macula densa : The cells of DCT epithelium in contact with the arteriolar wall are denser than other epithelial cells. These are collectively called macula densa.

Juxtaglomerular cells : The smooth muscle cells of the wall of both arterioles in contact with DCT epithelium are swollen and contain dark granules of inactive renin. These are called juxtaglomerular cells.

Juxtaglomerular apparatus secretes **renin** and **erythropoitein**.

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Blood supply of the right kidney seen in coronal section

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BLOOD VESSELS OF KIDNEY

Each kidney receives its blood supply by a single **renal artery** from dorsal aorta, and is drained off by a single **renal vein,** which opens in the inferior vena cava.

As the artery enters into the medulla after traversing through the hilum, it divides into a number of branches. These branches enter into renal cortex through the columns of Bertini and subdivide into **afferent arterioles** which form **glomerular capillaries.** These capillaries are drained, not by venules, but by **efferent arterioles.**

In Cortical nephrons :

The efferent arterioles break up into dense **Pertitubular network of capillaries** around their tubules.

In Juxtamedullary nephrons :

The efferent arterioles break up into a network of thin capillaries which form hair pin like loops called vasa recta.

This vasa recta dips into the medulla or its pyramids along side the loops of Henle.

Both peritubular capillaries of cortical nephrons and vasa recta of juxtaglomerular nephrons lead into venules which join and rejoin to form small and large veins, all of which ultimately join to the form renal vein.

MECHANISM OF URINE FORMATION

The mechanism of urine formation involves three steps or processes :

(I) Ultrafiltration or Glomerular filtration

(II) Selective tubular reabsorption

(III) Tubular secretion

(I) Ultrafiltration or Glomerular filteration :

This process occurs in the Malpighian corpuscles of the nephrons. The glomerulus of a Malpighian corpuscle is a network of several (about fifty in man) parallel capillaries. From the blood flowing through glomerular capillaries, about 20% of plasma fluid filters out into the Bowman's capsule through a thin **glomerular-capsular membrane** due to a net or **effective filtration pressure (EFP)** of about 10 to 25 mm Hg.

The glomerular-capsular membrane through which ultrafiltration occurs comprises three layer, **(I) endothelium, (2) basement membrane** of the wall of glomerular capillaries and **(3) squamous epithelial layer** of the finger-like processes ('foot processes' or pedicels) of podocyte cells of capsular wall entwining the walls of capillaries.

A special characteristic of glomerular-capsular membrane is that it is about 100 to 500 times more permeable than the walls of blood capillaries in other tissues of body. Such a tremendous permeability of this membrane is because of the presence of literally thousands of small pores, called **fenestrae,** in the walls of glomerular capillaries (fenestrated capillaries).

The effective filtration pressure that causes ultrafiltration is determined by three pressures : (1) glomerular hydrostatic pressure, (2) colloid osmotic pressure of blood and (3) capsular hydrostatic pressure.

The glomerular hydrostatic pressure is the blood pressure in glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration. (it is 60 to 75 mm Hg)

The **colloid osmotic pressure** is the osmotic pressure created in the blood of glomerular capillaries due to plasma proteins. It resists the filtration of fluid from the capillaries. (it is 30 to 32 mm Hg)

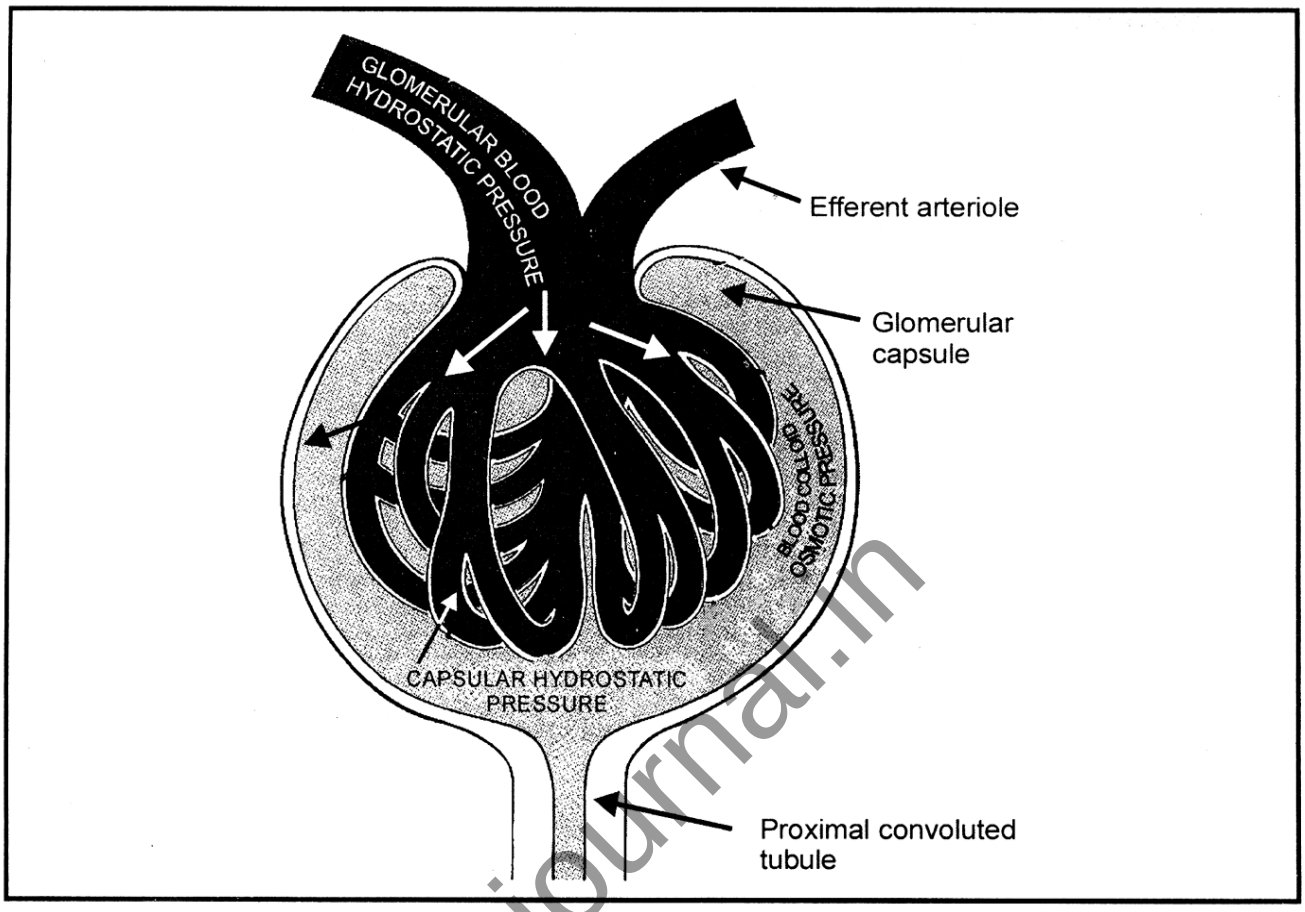
The **capsular hydrostatic pressure** is the pressure caused by fluid (filtrate) that reaches into Bownman's capsule and resists filtration. (It is about 10 to 18 mm Hg)

Normally, the blood pressure in an arteriole that feeds a typical systemic capillary network is about 30 to 40 mm Hg. The pressure in afferent arteriole of glomerulus is about 60 to 75 mm Hg and since the efferent arteriole is thinner in diameter than afferent arteriole, this blood pressure (glomerular hydrostatic pressure) is maintained throughout the glomerulus. The colloid osmotic and capsular hydrostatic pressures, which resist ultrafiltration , are respectively about 30 to 32 mm and 10 to 18 mm Hg. Thus, the **net effective effective filtration pressure is about 10 i.e. (60) – (32 + 18) mm hg.** That is why, the glomerulus is called a **'high pressure capillary bed',**

EFP = GHP – [COP + CHP]

∴ **EFP ranges from 10 to 25 mm Hg.**

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The plasma fluid that filters out from glomerular capillaries into Bowman's capsules of nephrons is called **glomerular filtrate.**

The quantity of glomerular filtrate, formed each minute in all the nephrons of both kidneys is called **Glomerular filtration rate (GFR).** In a normal adult human being, a glomerular filtration pressure of 1 mm Hg causes filtration of about 12.5 mL of plasma fluid from glomerular capillaries per minute. Thus the GFR in a normal adult person is 125 (12.5 × 10) mL of plasma fluid per minute. As already described in the chapter of circulatory system, an average adult person of about 70 kg possesses about five litres of blood all of which is pumped by the heart (cardiac output) into the arteries and received back through veins each minute. About 1250 mL (25% of total blood) of this blood circulated through kidneys each minute, and of this blood, about 650 mL is the blood plasma (52%). This 650 mL is called **renal plasma flow (RPF).** Obviously, 125/650 i.e. about one-fifth (20%) of the blood plasma, therefore, filters out into kidneys nephrons per minute. This is the ratio of GFR to RPF, and it is called **filtration fraction.**

With a glomerular filtration rate (GFR) of 125 mL per minute, about 180 litres of plasma fluid from about 1800 litres of blood circulating through both kidney of an average person each day filters out into kidneys nephrons. But only about 1.45 litres (about 0.8% part) of the total glomerular fitlrate is excreted out as **urine** per day, the rest is reabsorbed into the blood from the nephrons.

Due to continuous beating of the cilia of neck cells, the glomerular filtrate is continously made to flow behind from Bowman's capsules into the proximal convoluted tubules of the nephrons.

(II) Selective tubular reabsorption :

The glomerular filtrate is like blood plasma minus plasma proteins (colloids) in chemical composition. Thus it is mostly water with all soluble and diffusible solutes of plasma which include nutrients (glucose, amino acids, etc,) electrolytes of salts (Na^+, K^+, Cl^-, HCO_3^-, H^+ etc) and waste products of protein metabolism (urea, uric acid, creatinine, etc). In contrast to glomerular filtrate, the urine which is ultimately extracted from the filtrate in nephrons, contains water, urea, uric acid, creatinine and useless elctrolytes in considerably higher concentrations, whereas nutrients are almost absent in it. This proves that, while the filtrate flows through a uriniferous tubule, not only its volume is reduced, but its composition is also considerably changed. These changes are obviosuly due to an exchange of materials between the filtrate and the blood of Peritubular capillaries.

This exhange involves, (1) a **selective reabsorption** of useful materials into the blood form the filtrate and (2) Absorption of remaining unfiltered amount of excretory substance from blood flowing in the peritubular capillaries, by the cells of uriniferous tubules and then subsequent **secretion** of these substances into the filtrate. This selective reabsorption and secretion are finely tuned to maintain homeostatic balances in body fluids.

The blood flows rapidly in peritubular capillaries and with a very low pressure (only about 13 mm Hg). Due to this reason fluid can diffuse into these capillaries from surrouding tissue fluid, but cannot filter out of them. this reabsorption involves both active and passive processes.

(III) Tubular secretion :

In addition to its role in selective reabsorption of material from the glomerular filtrate back into the blood of peritubular capillaries via the renal interstitium, the distal part of proximal convoluted tubule also alters the composition of filtrate by a process of secretion. Epithelial cells in this part extract certain excretory substances from the blood of peritubular capillaries and secrete these into the filtrate. For example, uric acid filtered by glomerulus is almost completely reabsorbed in the first part of proximal tubule, but is later withdrown from blood and secreted into the filtrate in distal part of proximal tubule, Other secreted substances include H^+, K^+ , NH_4^+, creatinine, etc and certain dyes and drugs, like phenol red, penicillin, hippuric acid and its derivatives etc. Secretion of H^+ helps in controlling blood pH.

Permeability chart

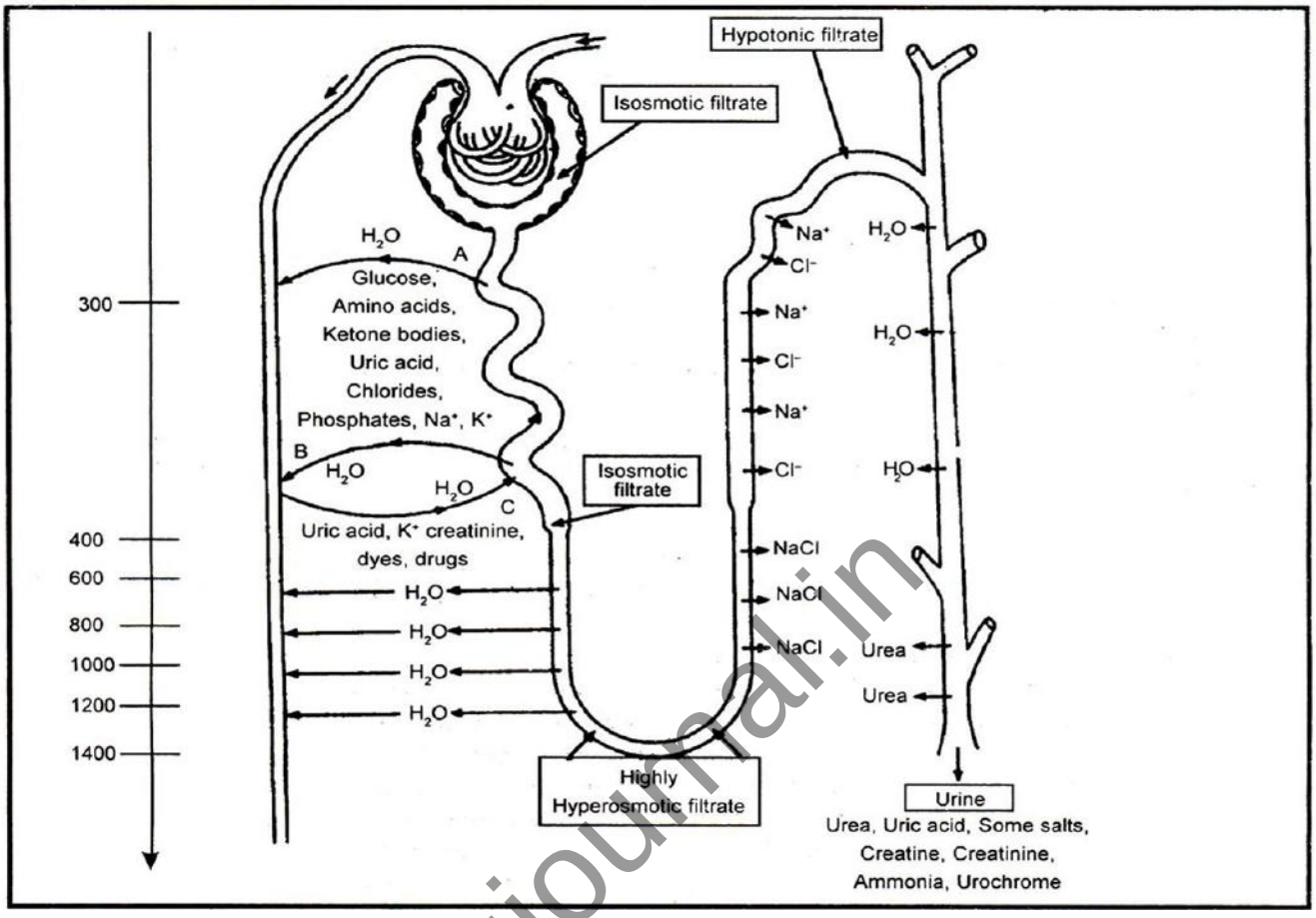
PCT $\longrightarrow$ Water, NaCl

Descending loop $\longrightarrow$ Water only

Thin ascending loop $\longrightarrow$ NaCl only and urea (inwards)

Thick ascending loop $\longrightarrow$ Na^+, K^+ Pumps and Cl^- follows passively

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Changes occurring stepwise in the filtrate while it flows through the tubules :

(1) Bownman's capsule : Since all plasma solutes, except proteins, freely enter into glomerular filtrate from blood, the total solute concentration (osmolality 300 milliosmoles per litre) of the filtrate is essentially the same as that of plasma. Here the filtrate is thus **isotonic** (isosmotic) to the plasma.

Concentration ↔ , *Volume* ↔

(2) Proximal convoluted tubule : The microvilli of the "brush-border" columnar cells of the epithelium of this tubule increase the internal surface of the epithelium about 20 times. Hence, this epithelium becomes most suitable for reabsorption . About 65 % to 80% of the filtrate is reabsorbed into the blood of peritubular capillaries through this epithelium and surrounding tissue fluid (renal interstitium). Most of the solutes like glucose, amino acids, vitamins, ketone bodies, acetoacetic acid, uric acid, chlorides, sodium. potassium, phosphates etc of the filtrate are reabsorbed into the blood by diffusion and active transport. Some urea is also reabsorbed. Sulphates, creatinine, inulin and PAH (para amino hippuric acid) are not reabsorbed. As most of the solutes are reabsorbed, water automatically goes back into the blood by osmosis leaving the osmotic pressure in the filtrate unchanged . Thus, the filtrate is reduced in volume, but it **still remains isotonic** to the plasma.

∴ Concentration ↔ , volume ↓

(3) Descending limb of henle's loop : The loop of Henle is divisible into four parts, namely Thick descending limb, the Thin descending limb, the Thin segment of ascending limb, and the Thick segment of ascending limb.

In mammalian kidneys, the osmolality of renal interstitium is different in renal cortex and medulla. Where as the cortical interstitium has the normal osmolality of 300 mL osmol/liter, the medullary interstitium has a gradient of increasing osmollity from the cortex upto the tips of the papillae. (300 to 1400 mL osmol/liter)

The thin wall of descending limb of Henle's loop is *permeable to water, but not to the solutes.* As the isotonic tubular fluid flows down this limb, it gradually loses water by exosmosis due to increasing osmolality of medullary interstitium through which this limb extends. This leaves a small volume of concentrated (**hypertonic** to blood plasma)tubular fluid to enter into the ascending limb of Henle's loop.

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

(4) Ascending limb of Henles loop : The thin segment of the ascending limb of henle's loop is structurally like the descending limb, but its permeability is different. It is *quite permeable to NaCl but not to water.* Due to decreasing osmolality of medullary interstitium towards cortex, the tubular fluid, therefore, loses Na^+ and Cl^- by diffusion, again becoming diluted and **isotonic** to plasma without changing in volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

The wall of the thick ascending limb of Henle's loop is virtually *impermeable to both water and solutes,*

but the plasma membrane of its cells is very rich in $Na^+ - K^+$ *pumps*. These pumps pump out Na^+ by active transport, and Cl^- passively diffuse out following the outflux of Na^+ . Thus the process of dilution of the tubular fluid continues in this limb. Consequently, the tubular fluid becomes considerably **hypotonic** to blood plasma without a change in its volume.

$\therefore$ *Concentration* $\downarrow$, *Volume* $\leftrightarrow$

(5) Distal convoluted tubule (DCT) : In the distal convoluted tubule, active reabsorption of Na^+ and that of Cl^- continues by facilitated diffusion and hence the tubular fluid becomes still more diluted . It also helps to regulate blood pH by reabsorption of HCO_3^- which is an important buffer.

$\therefore$ In proximal DCT *Concentration* $\downarrow$, *Volume* $\leftrightarrow$ While in distal DCT *Concentration* $\uparrow$, *Volume* $\downarrow$

(6) Collecting duct : From the distal convoluted tubule, the hypotonic tubular fluid flows into a collecting duct. This duct is *quite permeable to water but not to salt* (in presence of some ADH). Hence the tubular fluid loses considerble amount of water by exosmosis as the duct runs down through the hypertonic medullary interstitium to empty into the calyx. The distal part of collecting duct is permeable to urea also. Hence same urea is also reabsorbed from tubular fluid and it adds to the hyperosmolality of medullary interstitium .

$\therefore$ *Concentration* $\uparrow$, *Volume* $\downarrow$

After loosing considerable amount of water and some urea, while flowing through the collecting ducts, the filtrate ultimately becomes **urine.**

Chemical composition and physical characteristics of urine : Normal urine contains about 95% water 2% electrolytes (ions of salts, mainly chlorides, sulphates, phosphates and bicarbonates of

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sodium, potassium, ammonium, etc), 2.6% urea, 0.3% uric acid and traces of creatinine, ammonia, creatine etc. It is transparent but pale yellow due to the presence of a trace of urochrome pigment. Urochrome is a by product of haemoglogin degradation found in blood and filtered into glomerular filtrate Normal urine is slightly acidic with a pH of 6.00 (range is 4.5 to 8.2). Its specific gravity is 1.015 to 1.02. On standing, it becomes cloudy an acquires ammonia odour due to formation of ammonium carbonate.

OSMOREGULATION BY KIDNEYS

Kidneys also perform the important function of omoregulation (regulation of osmolality) by regulating the amount of water in body fluids. The normally functioning kidneys produce a large volume of dilute urine when more water is taken, and a small volume of concentrated urine when water intake by the body is poor or there is considerable loss of water from the body. This function of kidneys is regulated by the antidiuretic hormone **(ADH or Vasopressin)** secreted by the posterior lobe of pituitary gland. This hormone increases the water permeability of the last part of distal convoluted tubules and proximal part of the collecting ducts. In a absence of ADH, these parts are almost impermeable to water and therefore the urine is dilute. But in presence of ADH, these parts becomes quite permeable to water, so that much of the water present in tubular fluid is reabsorbed and the urine becomes concentrated. Besides ADH, the hormone **aldosterone**, secreted by adrenal glands, also plays important role in osmoregulatory function of kidneys by increasing Na^+, K^+ and Cl^- reabsorption from the filterate.

DILUTION MECHANISM (CORTICAL NEPHRONS)

The osmolality of body fluids normally remains about 300 mL osmol per litre of water. When amount of water increases, this osmolality decreases. This switches off the secretion of a ADH from pituitary gland, but stimulates secretion of aldosterone from adrenal glands. Absence of ADH makes the walls of distal convoluted tubules and collecting ducts almost completely impermeable to water. Contrarily, due to secretion of the aldosterone the walls of ascending limb of Henls's loop. distal convoluted tubule and collecting duct become quite permeable to sodium, postassium and chloride ions. As a result of this Na^+ and Cl^- ions are reabsorbed from the filtrate flowing up the ascending limb of Henle's loop and mostly water and waste products remain in the filtrate. By the time this filtrate reaches into the distal tubule, it becomes very hypo-osmotic with only about 100 mL osmol/litre osmolality. Then, as this diluted fluid passes through the distal tubule and collecting duct, some more of the remaining ions, especially of sodium (Na^+) are reabsorbed actively so that the osmolality of ultimate dilute urine is decreased to as low as about 65 to 70 mL osmol/litre. Dilution of urine mainly occurs in cortical nephrons.

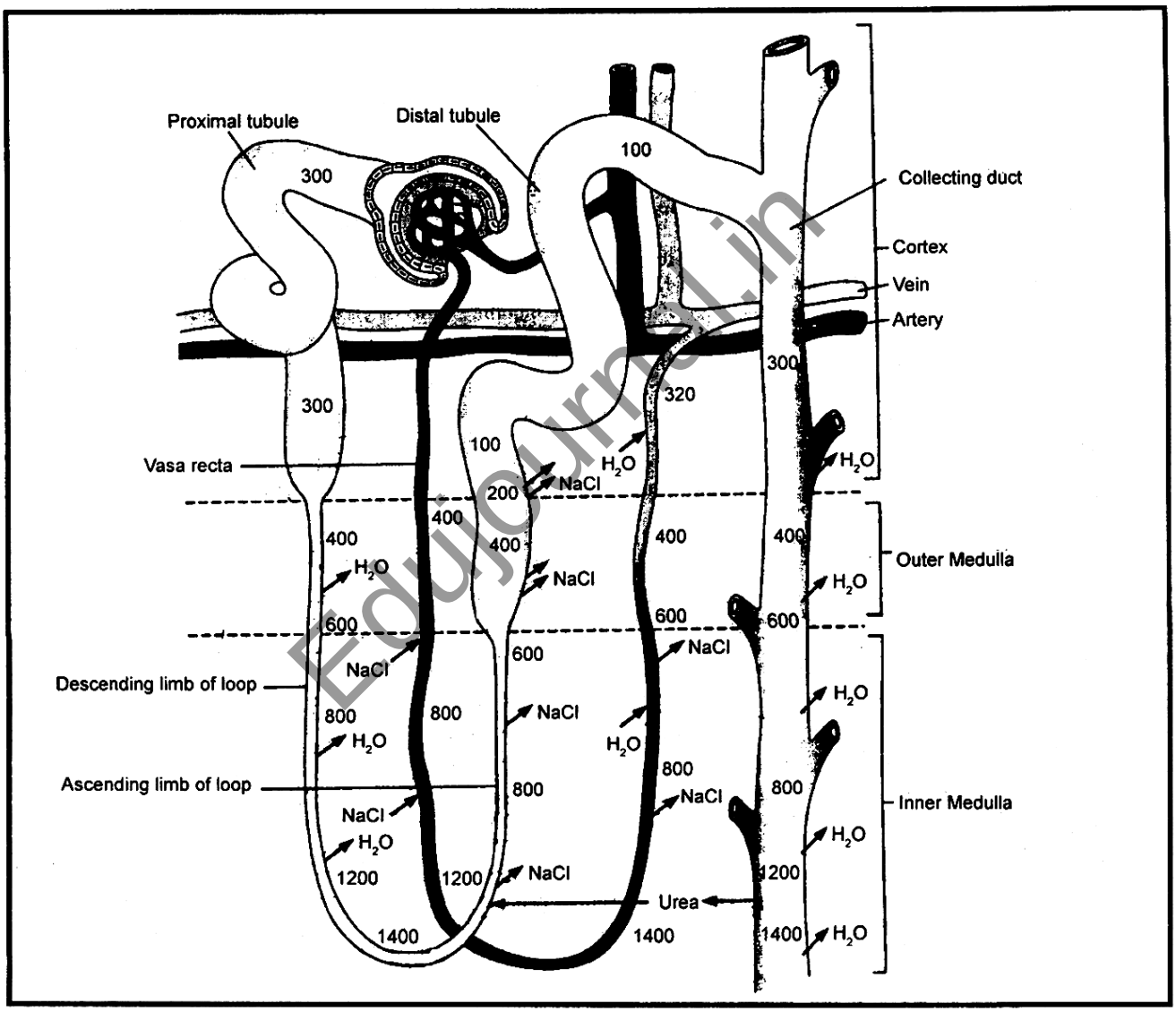
Diuresis and Hypertension : Normally, we excrete about 1.5 litres of urine per day. Diluted urine is excreted in larger volumes a condition called **diuresis.** When due to the inefficient regulation, the kidneys fail to adequatly dilute the uine, the body fluids are diluted and their increased volume cause hypertension (↑ BP).

Glucose, urea, mannitol and other diuretic substances are administered to such patients. The kidneys excrete these substances and water is automatically excreted out with these. Caffeine of tea is also diuretic. That is why, urination becomes more frequent when more tea is taken . contrarily, if secretion of ADH is permanently hampered or blocked in a patient, the urine becomes very dilute and tasteless (insipid),. This condition is called **diabetes insipidus**. intermittent urination at short intervals and thirst are the only discomforts in this condition.

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CONCENTRATION MECHANISM (JUXTAMEDULLARY NEPHRONS)

During times of low water intake or excessive water loss, for example, due to heavy perspiration , diarrhoea, vomiting, etc the kidneys must conserve water while still eliminating wastes and excess ions. The kidneys accomplish this by producing concentrated urine. It is primarily the long-looped juxtamedullary nephrons which establish the conditions for producing concentrated urine which may be four to five times more concentrated (1200 to 1400 osmol/litre) than plasma. concentrating the urine is under regulation of ADH and depends on presence of a steep gradient of increasing hyperosmolarity in the interstitial fluids of medullary pyramids.



Medullary heper osmolality : The osmolality of renal cortical interstitium is the same (300 mL osmol/litre) as in other tissues, but that of the interstitium of renal medulla is hypertonic with a gradient of hyperosmolality from renal cortex to the tips of medullary papillae. Under the conditions in which a concentrated urine is to be produced the hyperosmolality of medullary interstitium near the tips of the papillae is as high as 1200 to 1400 mL osmol/litre.

Countercurrent mechanism to maintain medullary hyperosmolality : The gradient of increasing hypersomolality of medullary interstitium is maintained by a peculiar countercurrent mechanism operated by the Henle's loops of juxtamedullary nephrons and vasa recta. About 15% to 20% of the nephrons in mammalian kidney are situated at the level where cortex and medulla meet and, hence called **juxtamedullary nephrons.**

The Henle's loops of these nephrons are thin and long and extend almost upto the tips of medullary papillae. The peritubular capillaries associated with these Henle's loops are also very thin and in the form of thin loops extending almost upto the tips of medullary papillae. These capillary loops are called **vasa recta.** A counter current can be defined as the flow of a fluid in opposite directions in the two arms of a U-tube if the arms are rather very close together. Thus, the Henle's loops of juxtamedullary nephrons and vasa recta are anatomically ideal for the operation of countercurrent mechanism.There are two aspects of this mechanism, **(1) countercurrent multiplication** and **(2) countercurrent exchange.** The Henle's loops play the role of contercurrent multipliers

The vasa recta plays the role of countercurrent exchanger.

Since the concentration of tubular fluid in descending limb reflects the concentration of medullary interstitium, and since the concentration in the interstitium is raised by extrusion of salt from ascending limb, a positive feedback mechanism is created. *The more salt the ascending limb extrudes, the more concentrated will be the fluid that enters into it from descending limb.* Obviously, this feedback mechanism is the key point in the **countercurrent multiplier system.**

Countercurrent exchange : In order for the countercurrent multiplier system to be effective in creating the gradient of medullary hyposmolality, most of the salt extruded by the ascending limb of Henle's loop must remain in medullary interstitium, while most of the water coming out of the descending limb must be drained off into the blood. This is accomplished by the vasa recta by means of the mechanism known as countercurrent exchange. **Salt** is thus recirculated and trapped within the medullary interstitium, But contrarily, the **water** diffuses into the blood of ascending limb of vasa recta and is carried away into general blood circulation.

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Significacne of urea :

Permeability to urea is found only in the deeper parts of thin ascending limbs of Henle's loops and collecting ducts. urea diffuses out of the collecting ducts and enters into the thin assending limbs down its concentration gradients. A certain amount urea recycle in this way is trapped in medullary interstitium.

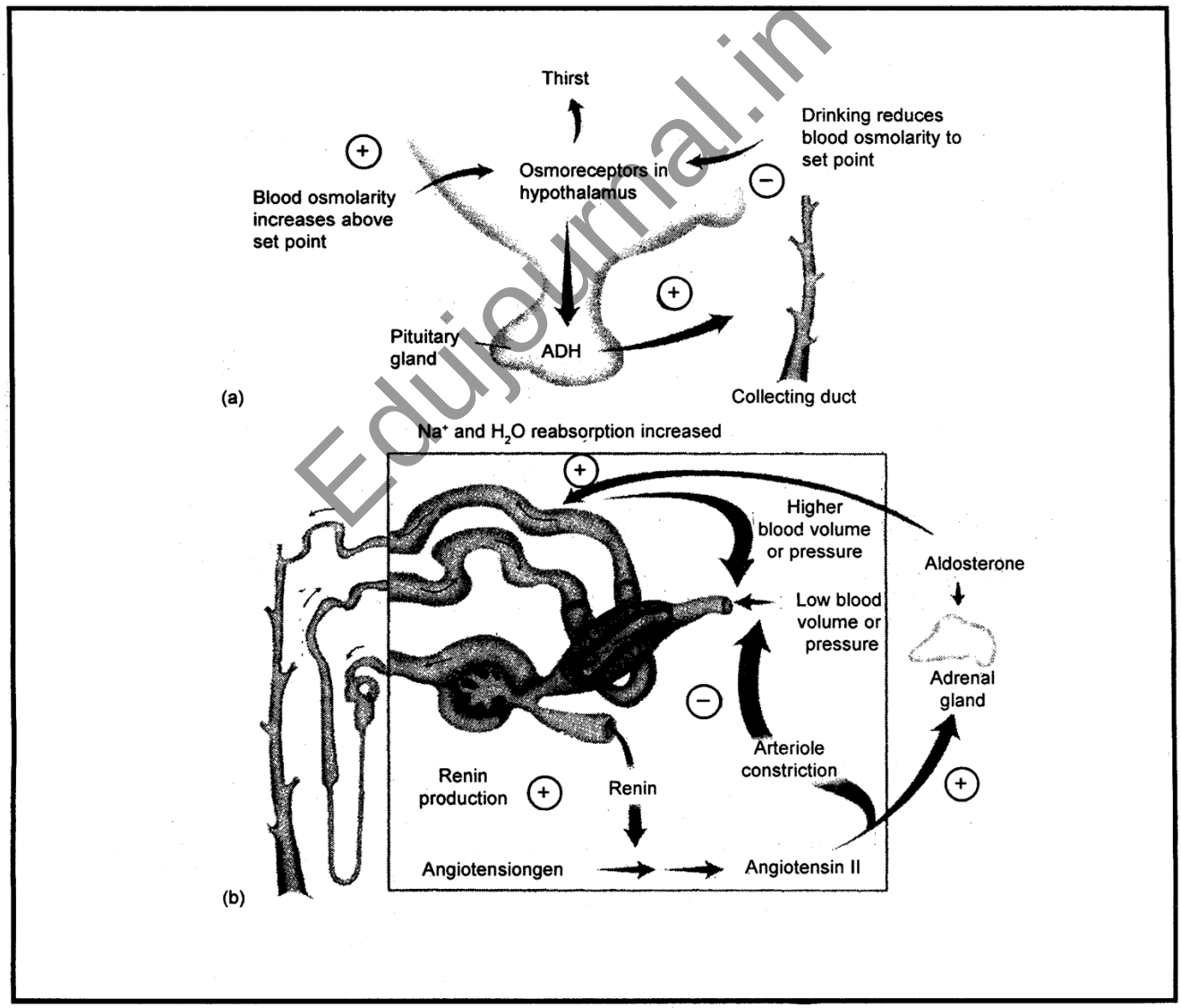
Role of distal convoluted tubule, collecting duct and ADH : As described above, the role of countercurrent mechanism is to proudce a small volume of highly hypotonic (osmolality only about 100 mL osmol/litre) tubular fluid which enters from the thick ascending limb of Henle's loop into the distal convoluted tubule and, thereafter into the collecting duct. To finally produce a very small volume of highly concentrated urine from this hypotonic tubular fluid is the role of distal convoluted tubule and collecting duct under the influence of the antidiuretic hormone (ADH). ADH triggers synthesis of a large number of molecules of a specific protein, named **aquaporin,** in the epithelial cells of distal convuled tubule and more particularly of collecting duct. Molecules of aquaporin become incorporated in the plasma membrane of these cells as integral proteins and act as water channels. Consequently some water is lost from hypotonic tubular fluid

by exosmosis while it flows through the distal convoluted tubule, but most of the water of tubular fluid is lost across the wall of collecting duct via aquaporin as this duct traverses through the medullary interstitium to empty into a calyx, Due to this, the osmolality of the urine emptied into the calyx becomes 1200 to 1400 mL osmol/litre.

REGULATION KIDNEY FUNCTION BY FEEDBACK CIRCUITS

Two important hormonal controal of the kidney function by negative feedback circuits. These ara as follows :

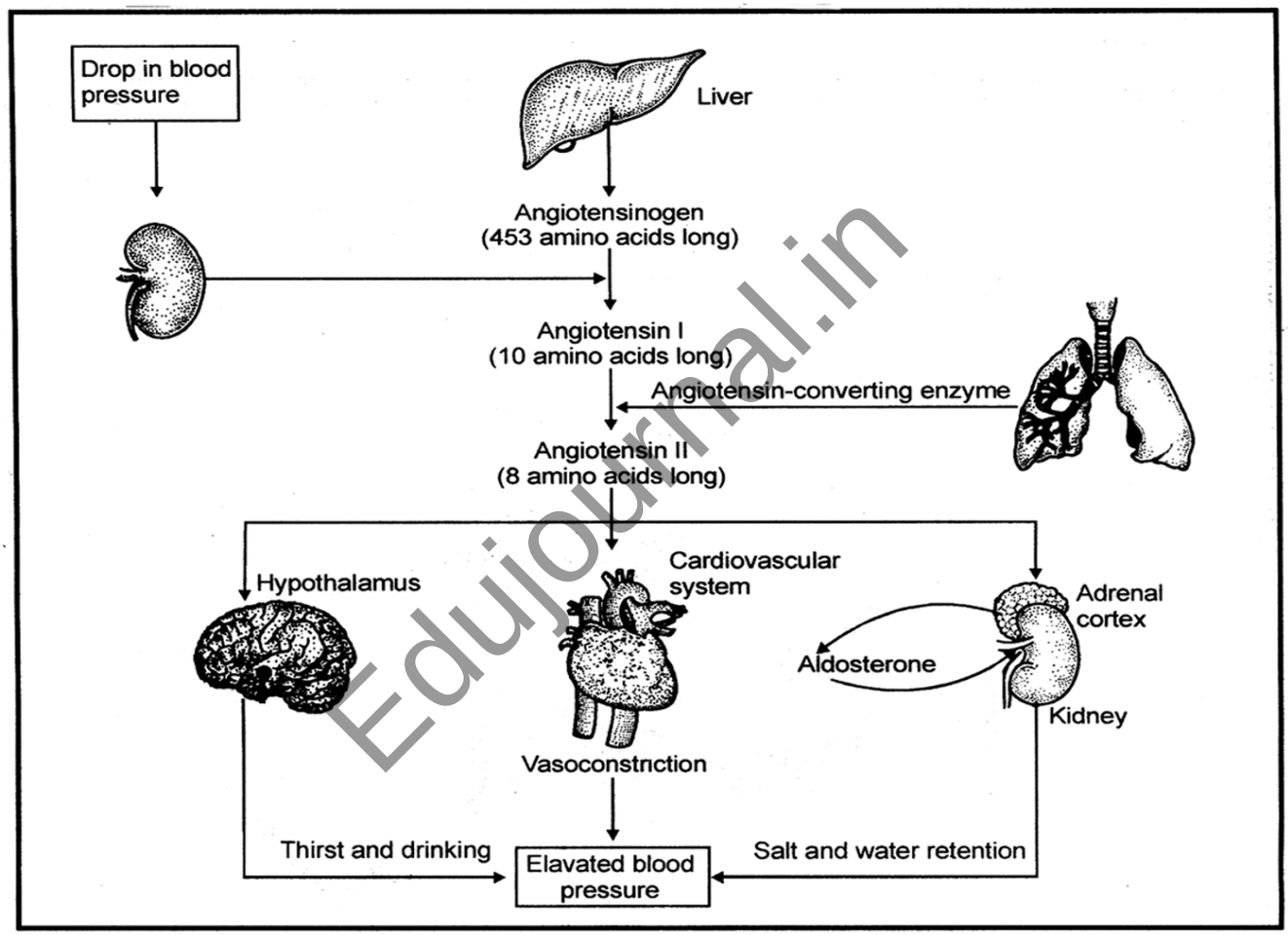
(i) Control by Antidiuretic Hormone (ADH) : ADH is produced in the hypothalamus from the pituitary glands. ADH enhances fluid retention by making the kidneys reabsorb more water. The release of ADH is triggered when osmorecepotors in the Hypothalamus detect an increase in the osmolaity of the blood above a set pont of 300 mosm L^{-1}. In this situation, the osmoreceptor cells also promote thirst. Drinking reduces the osmolarity of the blood, which inhibits the secretion of ADH, thereby completing the feedback circuit.



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(ii) Control by Juxtaglomerular Aparatus (JGA) : JGA operates a multi-hormonal **Renin-Angiotensin-Aldosterone System** (RAAS). Whenever there is a fall in BP or blood volume, the JGA responds to this decrease in blood pressure or blood volume in the afferent arteriole of the glomerulus and releases an enzyme called **renin,** into the blood stream. In the blood, renin initiates chemical reactions that convert a plasma protein, called **angiotensinogen** to a peptide, called **angiotensin II**, which works as a hormone. Angiotensin II increases blood pressure by causing arterioles to constrict. It also increases blood volume in two ways.

(1) Firstly, by signaling the proximal convoluted tubules to reabsorb more NaCl and water.



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(2) Secondly, by stimulating the adrenal gland to release **aldosterone,** a hormone that induces the distal convoluted tubule to reabsorb more Na^+ and water. This leads to an increase in blood volume and pressure, completing the feedback circuit by supporting the release of renin.

Still another hormone, a peptide called **Atrial Natriuretic Factor** (ANF), opposes the regulation by RAAS. Whenever there is rise in the BP or blood volume , the walls of the atrial of the heart release ANF in response to this increase in blood volume and pressure. ANF inhibits the release of renin from the JGA, and thereby, inhibits NaCl reabosorption by the collecting duct and reduces aldosterone release from adrenal gland. Thus ADH, the RAAS and ANF provid an elaborated system of checks and balance the regulate the kidney functioning, to control body fluid osmolarity, salt concentrations, blood pressure and blood volume.

Role of lungs in excretion :

Human lungs eliminate around 18 L of CO_2 per day and about 400 mL of water per day in normal resting condition. Water loss via the lungs is small in hot humid climate and large in cold dry climates. The rate of ventilation and ventilation pattern (ie.e. breathing through mouth or nose) also affect the water loss through the lungs. Different volatile materials are also readily eliminated throgh the lungs.

Role of skin in excretion :

Human possess two types of glands :

(1) Sweat glands : These excrete sweat, Sweat contain 99.5%, Water, NaCl, Lactic acid, Urea, Amino acid and glucose. Volume of sweat may vary from negligible to 14 litres a day.

(2) Sebaceous glands : These secrete sebum which conain waxes, sterols, other hydorcarbons and fatty acids.

Integument in many aquatic animals excretes ammonia in surrounding medium by diffusion.

Role of liver in excretion :

Liver is the main site for elimination of cholesterol, bile pigments (bilirubin & bilivirdin), inactivated products of steroid hormones, some vitamins and many drugs. Bile carries these materials to the intestine from where they are excreted with the faeces.

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SOME TERMS

1. **Oligouria** : less production of urea/urine
2. **Anuria** : No production of urine
3. **Polyuria** : Excess production of urine. More urine formation takes place due to less secretion of ADH. Due to less secretion of ADH, the amount of water increases in the urine. so, the patient feels thirsty again and again. This disease is called **Diabetes-insipidus.**
4. **Glycosuria** : Excretion of Glucose through Urine.This sign is present in **Diabetes-mellitus.** This disease is caused mainly due to less secretion of Insulin.
5. **Uremia** : Excess of urea in blood is termed as Uremia.
6. **Calculi and cast** : It is also termed as Kidney-stone. Due to deposition of Calcium-oxalate in the kidney, stone is formed. Sometimes, calcium-phosphate and calcium-sulphate are also found. These are insoluble-salts. Normally, these are not excreted by the urine but by faeces.
7. **Haematuria** : Excretion of blood through urine. It is a symptom of many disease like Black water fever, Bacterial-infection.
8. **Diuresis** : The process of excess formation of urine in the kidney's is termed as diuresis.
9. **Dysuria** : Condition of painful micturition
10. **Urinode** : Characteristic smell of the urine is due to urinode substances.
11. **Cystitis** : Infection of urinary-bladder is termed as cystitis.

12. A person who is starving, will have more urea and ketone bodies in his blood and less urea in urine.

13. (a) The urine on standing gives a pungent smell.It is due to conversion of urea into ammonia by bacteria

(b) The volume of urine proudced per day will increase on a cold day, due to ↓ ADH secretion.

14. Highest concentration of urea is found in hepatic vein. (Because urea is synthesized in liver) Least concentration of urea is found in renal vein. (Because urea is excreted through urine formed in kidney)

15. If one kidney is removed, the remaining on enlarges and performs function of both kidneys.

16. Camels can with stand water deprivation by reducing urinary water loss and water by sweat.

17. Earthworms excrete ammonia when sufficient water is available while they excrete urea instead of ammonia in drier surroundings.

18. When lung fishes and xenopus (African toad) live in water, they are normally ammonotelic by they become ureotelic when they live in moist air or mud during summer. Crocodiles = normally ammonotelic

19. Bean shaped kidney are present only in mammals.

20. Number of pyramids is man = 8 – 12

Number of pyramids in Rabbit = only 1

"Renal column of Bertini" absent in Rabbit

21. Uric acid is the last product of purine metabolism in human

2,6,8-trioxy purine is uric acid

22. Renal blood flow = 1200 – 1300 ml./mt.

Renal plasma flow = 650 ml./mt.

23. Inulin clearance can be used to Estimate GFR

24. PAH (Para Amino Hippuric Acid) clearance can be used to Estimate RPF (Renal Plasma Flow)

25. Test of urea in urine is **specific urease test.**

Urea $\xrightarrow{\text{Urease}}$ $NH_3 + CO_2$

Phenol Red is used as a indicator

Optimum temp for reaction 60°C.

26. In brain, the major mechanism for removal of Ammonia is glutamine formation & in liver, the most important pathway is urea formation.

27. Urinary Bladder - Stimulation for voiding urine = 220 cc.

Generally micturation occur – 300 – 400 ml.

Discomfort condition after 500 ml.

Capcity of bladder 1000 cc.

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28. Filtration fraction = $\frac{\text{G.F.R}}{\text{R.P.F}}$.

29. Basement membrane is a meshwork of collagen and proteoglycan fibrils. It prevents filteration of plasma proteins because of stronge neagtive charge present on it due to proteoglycans.

30. Urinary excretion rate = filteration rate – reabsorption rate + secretion rate.

31. High threshold substances are completely reabsorbed after filtration while athreshold substances like creatinine are freely filtered but not at all reabsorbed.

32. Number of functioning nephrons decrease 10% for every 10 years after the age of 40 years.

33. In each kidney there are about 250 collecting duct each of which collects urine from 4000 nephrons.

34. Functions of kidney :

- Regulation of water and electrolyte balance.
- Regulation of body fluid osmolality and elctrolyte concentration.
- Regulation of acid base balance.
- Regulation of arterial pressure.
- Excretion of metabolic waste and foreign chemicals
- Secretion of hormones like erythropoeitin and renin.
- Gluconeogenesis from amino acids.

DISEASES RELATED WITH KIDNEY :

1. **Renal failure :** It is a syndrome characterised by renal dysfunction, oliguria, anuria, sudden rise in metabolic waste proudcts like urea & creatinine in blood (Uremia). It is either of acute (sudden onset) or chronic (slow onset) nature.
2. **Glomerulonephritis :** It is a disease where due to infection or injury in the basement membrane, the inflammation of glomerulus progressively leads to renal failure and death.
3. **Diabetic nephropathy :** It is a complication due to diabetes mellitus where the kidney progressively gets damaged leading to death ultimately due to renal failure.
4. **Urolithiasis :** Formation of calculi (stone) in the urogenital tract at any point. These calculi are made of calcium phosphate, uric acid, cystine or calcium oxalate.

Abnormal urine :

Various metabolic errors of kidney malfunctioning is reflected in the changes of the composition of urine. Occurrence of ketone bodies, glucose, albumin, blood cells, excess pigments, pus cells, calculi or casts (kidney stones) are some of the major abnormal constituents of urine. Notable abnormal conditons are as follows :

Proteinuria - presence of protein level in urine.

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Albuminuria - presence of albumin in urine, usually occurs in nephritis (inflammation of glomeruli), when the size fo the filtering slits enlarges and basement membrane looses its negative charge.

Ketonuria - Presence of abnormally high ketone bodies in urine.

Haemoglobinuria - Presence of blood or blood cells in urine.

During embryonic development, nephrotome plate develops from mesoderm which is made up of fine tubules called **nephros.**

Nephrotome develops into kidney while neprons develops into Nephrons or Uriniferous tubules. On the basis of development, kidney are of 3 types.

(1) Pronephric Kidney : Develop from anterior part (Pronephros) of Nephrotome plate, Its nephrons are in simple tubular shape. Nephrons are not differentiated Eg. Cyclostomates & Tadpole of frog.

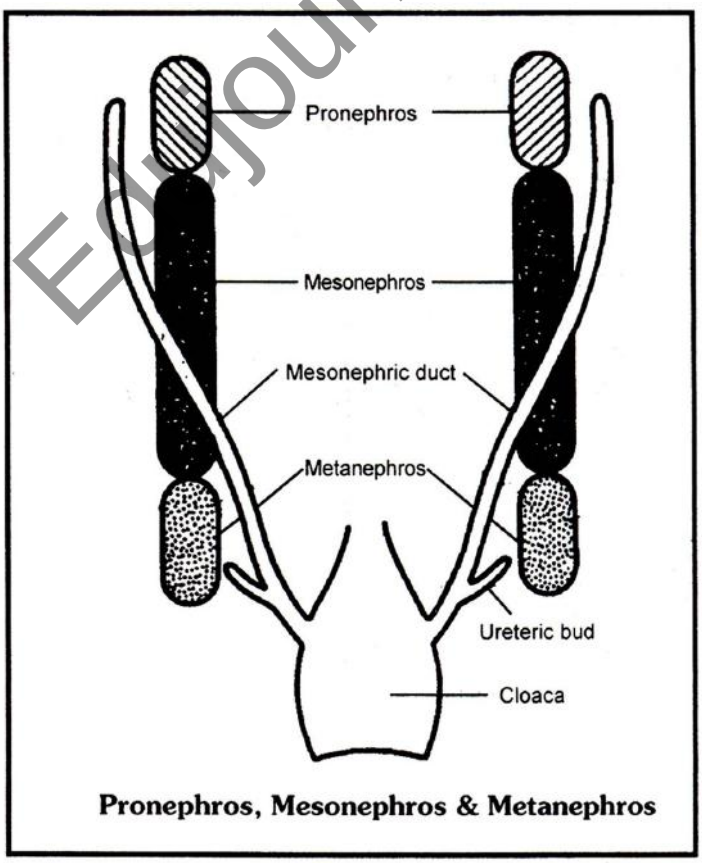
(2) Mesonephric Kidney or opisthonephros

develop from middle part (Mesonephros of) Nephrotome plate & remaining part of nephtotome is destroyed.Only Bowman's capsule is found in nephrons while remaining part is simple tubular.

Eg. Most of the fishes & adult Amphibians.

(3) Metanephric Kideny : Develops from posterior part (Metanephros) of nephrotome while remaining part is destoyed. Nephrons are will diffrentiated into Bowman's capusle PCT, DCT & loop of Henle's

Eg. Reptile, Aves, Mammals



Pronephros, Mesonephros & Metanephros

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Henle's Loop : -

- Less development in Reptiles
- Incompletely Developed in Aves
- Mammals have most developed Henles loops.

Autoregulation of GFR

Two important intrinsic mechanisms provide autoregulation of glomerular filtration rate :

(a) Myogenic mechanism : An increase in blood pressure will tend to stretch the afferent arteriole, which would be expected to increase the blood flow to the glomerulus. The wall of the afferent arteriole, however, responds to stretch by contraction, this reduces the diameter of the arteriole, and therefore causes increase in the resistance to flow. This myogenic mechanism, thus, reduces variations in flow to the glomerulus in case of fluctuations in blood pressure.

(b) Juxtaglomerular apparatus (JGA) : This specialised cellular apparatus is located where the distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles.JGA cells secrete enzymes like renin that modulate blood pressure, and thus renal blood flow and GFR are regulated. This discused earlier in the sheet.

Thus myogenic and Juxtaglomerular mechanisms work together to autoregulate the GFR Over a wide range of blood pressure

REGULATION OF URINE FORMATION

Hormonal regulation

1. Antidiuretic hormone or vasopressin

(i) It is secreted by posterior lobe of pituitary gland.

(ii) It inhances the reabsorption of water in the distal convoluted tubule and collecting duct.

2. Thyroxine

Deficiency of thyroxine leads to reduction in urine output.

3. Parathormone

It is secreted by parathyroid gland. It increase calcium reabsorption in renal tubule. It also reduces the reabsorption of phosphate in the renal tubules.

Nervous regulation

(i) Nerves arising from central nervous system are connected with both kidneys. The central nervous system sends impulse to the kidneys.

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(ii) Nerve impulses regulates constriction and dilation of blood vessels of renal tubule. All these changes regulates urine formation.

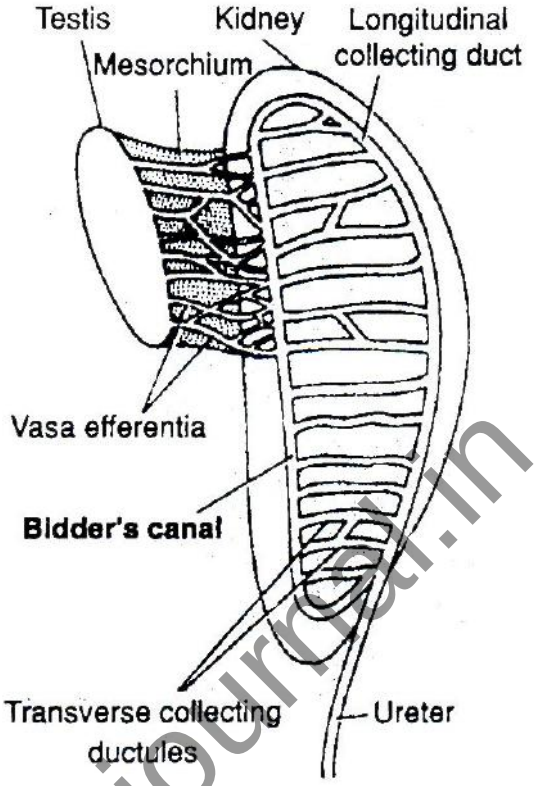


Fig.: Diagram showing relationship of collecting ducts

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EXERCISE

Q.1 Excretion involves process in which –
(1) Harmful substance are stored in cells before being eliminated
(2) Expulsion of urine from the urinary bladder and sweat from the skin
(3) Harmful substance in the body are chemically changed
(4) Substance of no further use or those present in excessive quantities are thrown out of the body

Q.2 In aquatic organisms the waste end product of nitrogen metabolism is –
(1) Urea (2) Ammonia
(3) Nitrogen (4) Allantois

Q.3 Ammonotelic animals are predominantly –
(1) Terrestrial (2) Parasitic
(3) Volant (4) Aquatic

Q.4 Which of the following is likely to accumulate in dangerous proportion in the blood of a person whose kidney is not working properly–
(1) Urea (2) Sodium chloride
(3) Ammonia (4) Lysine

Q.5 Urea is transported by –
(1) Blood plasma (2) Leucocytes
(3) RBCs (4) Haemoglobin

Q.6 Which of the following sets of animals are uricotelic –
(1) Fish, frog, lizard and fowl
(2) Fish, snake, fowl and man
(3) Camel, dog, monkey and man
(4) Crow, snake, cockroach and lizard

Q.7 Major nitrogenous waste product in ureotelic animals like rabbit and other mammals is –
(1) Ammonia (2) Amino acids
(3) Urea (4) Uric acid

Q.8 Which of the following sets of animals produce the same substance as their chief excretory product –
(1) Camel, housefly and snake
(2) Fish, pigeon and frog
(3) Amoeba, ant and antelope
(4) Frog, monkey and dog

Q.9 The blood which leaves the liver and moves to the heart has higher than the usual contents of –
(1) Oxygen (2) Urea
(3) Bile (4) Water

Q.10 Urea is a nitrogenous waste. Which of the following substance contribute to the nitrogen–
(1) Mineral salts (2) Amino acids
(3) Vitamins (4) Lipids

Q.11 A man, has taken a large amount of protein in his diet. He will excrete more of –
(1) Uric acid (2) Salt and water
(3) Urea (4) Sugar

Q.12 Most insects are –
(1) Uricotelic (2) Ammonotelic
(3) Aminotelic (4) Ureotelic

Q.13 Uric acid is chief excretory product in –
(1) Insects (2) Earthworms
(3) Amphibians (4) Mammals

Q.14 The snakes living in deserts are mainly –
(1) Ammonotelic (2) Aminotelic
(3) Uricotelic (4) Ureotelic

Q.15 The least toxic nitrogenous waste is –
(1) Ammonia + urea (2) Ammonia
(3) Uric acid (4) Urea

Q.16 In reptiles, uric acid is stored in –
(1) Anus (2) Cloaca
(3) Liver (4) Fat bodies

Q.17 If benzoic acid is present in the food of mammals, it is excreted out in the form of–
(1) Hippuric acid (2) Ornithinic acid
(3) Uric acid (4) Aspartic acid

Q.18 The excretory product of excess metabolism of creatine is
(1) Oxalic acid (2) Uric acid
(3) Creatinine (4) Urea

Q.19 Column of Bertini is found in –
(1) Liver (2) Kidney
(3) Ovaries (4) Testes

Q.20 Man is –
(1) Ammonotelic (2) Ureotelic
(3) Uricotelic (4) None of these

Q.21 The retroperitoneal kidney is –
(1) Kidney covered by peritoneum on ventral side
(2) Kidney of fish
(3) Kidney uncovered by peritoneum on dorsal side
(4) Kidney covered by peritoneum on dorsal side

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Q.22 The position of kidney is –
(1) Inter peritoneal (2) Retroperitoneal
(3) Intraperitoneal (4) None of these

Q.23 The kidneys not only remove the waste products from the blood but also play a very important role in maintaining –
(1) Constant composition of the blood irrespective of the nature of the food or fluid intake
(2) Blood pressure constant
(3) Temperature of the body
(4) Equilibrium of the body

Q.24 The functional part of the kidney of adult reptiles, birds and mammals is –
(1) Holonephros (2) Pronephros
(3) Mesonephros (4) Metanephros

Q.25 Kidney is not distinguished into cortex and renal medulla in
(1) Frog (2) Man
(3) Rabbit (4) Camel

Q.26 The main function of pyramids of kidney is to-
(1) Direct the urine to flow in ureter
(2) Contain collecting tubules of kidney
(3) Store fats and protein
(4) Support the openings of collecting canals

Q.27 Which of the following influences the activity of kidney –
(1) Vasopressin and adrenalin
(2) Gonadotrophins
(3) Thyroxine
(4) Vasopressin

Q.28 Which feature enables the mammalian kidney to concentrate urine in the medullary region –
(1) Rapid removal of sodium ions form the medullary tissues
(2) Maintaining a high osmotic pressure in the tissues between the tubules
(3) High oxidative metabolism of medullary cells
(4) Rapid flow of blood through the medulla

Q.29 In the kidney of the rabbit, the Loop of Henle is the part of –
(1) Collecting duct
(2) Glomerulus
(3) Uriniferous tubule
(4)Bowman's capsule

Q.30 Trimethylamine oxide (TMAO) is excreted by–
(1) Molluscs
(2) Fresh water fishes
(3) Marine teleosts
(4) Amphibians

Q.31 In the kidney, the formation of urine involve the following processes arranged as –
(1) Reabsorption, filtration and secretion
(2) Glomerular filtration, selective reabsorption and tubular secretion
(3) Filtration, secretion and reabsorption
(4) Secretion, absorption and filtration

Q.32 Which one is not the function of kidney –
(1) Acid-base balance (2) Osmoregulation
(3) Urea synthesis (4) Salt balance

Q.33 Kidney are not only the organs of excretion their work is supplemented by –
(1) Large intestine (2) Lungs
(3) Liver (4) Skin

Q.34 A severe fall in blood pressure disturbs the function of kidneys and reduces –
(1) Reabsorption of useful substances
(2) Glomerular filtration
(3) Secretion of nitrogenous waste
(4) Renal filtration

Q.35 The loop of Henle is most highly developed in-
(1) Mammals (2) Desert lizards
(3) Fresh water fishes (4) Salamanders

Q.36 The animal that excretes amino acids without deamination is –
(1) Spider (2) Unio
(3) Housefly (4) Frog

Q.37 Ammonia is the chief nitrogenous excretory material in –
(1) Cartilaginous fishes (2) Fowl
(3) Fresh water fishes (4) Mosquitoes

Q.38 A nephron does not have loop of Henle in –
(1) Rabbit (2) Dog
(3) Frog (4) Man

Q.39 In a glomerulus –
(1) Afferent capillaries are thicker than efferent capillaries
(2) Afferent arteriole is thicker than efferent arteriole
(3) Afferent arteriole is thinner than efferent arteriole
(4) Afferent capillaries are thinner than efferent capillaries

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Q.40 Malpighian body is constituted by –
(1) Glomerulus, Bowman's capsule and efferent vessel
(2) Glomerulus and efferent vessel
(3) Glomerulus and Bowman's capsule
(4) Glomerulus only

Q.41 Which one of the following substance is completely reabsorbed from the filtrate in the renal tubule under normal condition –
(1) Urea (2) Uric acid
(3) Salt and water (4) Glucose

Q.42 High blood pressure is maintained in glomeruli than in other capillaries because –
(1) The variability of the diameters of arterioles causes higher resistance to blood flowing out of the glomeruli than to out of the capillaries
(2) Glomeruli has low hydrostatic pressure than capillary
(3) Capillary has less diameter than glomeruli
(4) All the above

Q.43 The afferent and efferent vessels are –
(1) Arterial in nature
(2) Venous in nature
(3) One is arterial and the other is venous
(4) None of the above

Q.44 Blood vessel leading to glomerulus is called
(1) Afferent arteriole (2) Renal artery
(3) efferent arteriole (4) Renal vein

Q.45 Juxtaglomerular cell of the kidney secrete –
(1) ADH
(2) Aldosterone
(3) Renin
(4) Angiotensin

Q.46 Ultrafilatration occurs in a glomerulus when-
(1) Osmotic pressure exceeds hydrostatic pressure
(2) Hydrostatic pressure exceeds osmotic pressure
(3) Colloidal osmotic pressure plus capsular pressure remain less than glomerular hydrostatic pressure
(4) Capsular hydrostatic pressure exceeds glomerular hydrostatic pressure

Q.47 Workers in deep mines usually suffer from dehydration because –
(1) Water is lost due to defecation
(2) Water is lost due to evaporation
(3) Water is lost along with salts in the form of sweat
(4) Water is lost in the form of urine

Q.48 If humidity is high in the presence of high temperature, we feel unpleasant due to –
(1) More sweating
(2) No sweating
(3) Less sweating
(4) Failure of sweat to evaporate due to excessive humidity

Q.49 The yellow colour of urine is due to –
(1) Urea (2) Melanin
(3) Uric acid (4) Urochrome

Q.50 Excretion is a continuous process but urine is not passed out continuously because of –
(1) Ureter (2) Rectum
(3) Urinary bladder (4) Cloaca

Q.51 The effect of antidiuretic hormone (ADH) on the kidney is to –
(1) Increase the excretion of Na^+
(2) Increase the excretion of water
(3) Increase the glomerular filtration rate
(4) Increase the permeability of the distal convoluted tubule of nephron to water

Q.52 ADH will be released from the posterior pituitary when there is a decrease in –
(1) Plasma potassium concentration
(2) Plasma pH
(3) Plasma sodium concentration
(4) Plasma volume

Q.53 If we remove the pressure receptors from the urinary bladder wall –
(1) Micturition will continue
(2) Their will be no micturition
(3) Urine will collect in the bladder
(4) There will be no collection of urine in bladder

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Q.54 Mammalian kidney serve to excrete –
(1) Excess salts, urea and excess water
(2) Excess water, urea and amino acids
(3) Excess salts, urea and glucose
(4) Excess salts, excess water and excess amino acids

Q.55 Aquatic animals are mostly ammonotelic because –
(1) Excretion of ammonia requires large amount of water which is available to these animals
(2) Ammonia helps in checking inflow of water into body
(3) These get less light
(4) Water contains less nitrogen

Q.56 Aldosterone stimulates the reabsorption of–
(1) Keto acids (2) Glucose
(3) K^+ ions (4) Na^+ ions

Q.57 Percentage of which increases in blood if liver becomes functionless –
(1) Uric acid (2) Proteins
(3) Urea (4) Ammonia

Q.58 Which blood vessel carries least percentage of urea –
(1) Renal artery (2) Pulmonary vein
(3) Hepatic portal vein (4) Renal vein

Q.59 Glomerular filtration rate would be decreased by –
(1) an increase in renal blood flow
(2) Compression of the renal capsule
(3) An increase in afferent arteriolar pressure
(4) Constriction of the efferent arteriole

Q.60 One of the following substance is not found in mammalian urine –
(1) Ammonium salt (2) Sucrose
(3) Sodium chloride (4) Water

Q.61 In which part of excretory system of mammals can you first use the term 'urine' for contained fluid –
(1) Urinary bladder
(2) Collecting tubule
(3) Bowman's capsule
(4) Loop of Henle

Q.62 In public urinals, the urine on standing gives a pungent smell, due to –
(1) Conversion of uric acid into ammonia by ornithine cycle
(2) Conversion of both urea and uric acid into ammonia
(3) Conversion of urea into ammonia by bacteria
(4) None of these

Q.63 A person who is starving, that is not having food, water and beverages will have –
(1) Less urea in his urine
(2) Less fats in his urine
(3) More glucose in his blood
(4) More urea in his urine

Q.64 When certain marine organisms are placed in distilled water, they ultimately die. Which could be the most likely explanation –
(1) Excess of water in the tissues
(2) Loss of water from the tissue
(3) Loss of permeability of some membranes
(4) Loss of salts

Q.65 An advantage of excreting nitrogenous wastes in the form of uric acid is that –
(1) The formation of uric acid requires a great deal of energy
(2) Uric acid can be excreted in almost solid form
(3) Uric acid may be excreted through the lungs
(4) Uric acid is the first metabolic breakdown products of acids

Q.66 The amount of the original filtrate volume which is reabsorbed by the time the tubular fluid enters the Henle's loop is approximately–
(1) 75% (2) 95%
(3) 85% (4) 90%

Q.67 What is "renal threshold" –
(1) The highest concentration of substances upto which it is totally reabsorbed from glomerular filtrate
(2) At which all the substances are reabsorbed
(3) At which the filtration of a substance starts
(4) At which no substance is filtered in the glomerulus

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Q.68 Which group of the following contains the final excretory product –
(1) Allantois, hippuric acid, ornithinic acid
(2) Ornithine, cytosin, citruline
(3) Trimethyl aminoxide, citruline, arginine
(4) Creatine, cretinine, citruline

Q.69 The glomerular filtrate contains –
(1) Blood minus cells
(2) Blood minus cell and proteins
(3) Plasma minus cells and proteins
(4) Blood minus proteins

Q.70 The vessel leading blood (containing nitrogenous waste) into the Bowman's capsule is known as –
(1) Afferent arteriole (2) Renal vein
(3) Efferent arteriole (4) Renal artery

Q.71 High threshold substances are the substances which can be –
(1) Excreted by the nephrons
(2) Ultrafiltered in the glomerulus
(3) Reabsorbed actively
(4) Secreted actively

Q.72 Which of the following is not an intermediate product in the biosynthesis of urea –
(1) Orinithine (2) Citrulline
(3) N-acetyl glutamate (4) Arginine

Q.73 Ornithine is converted into citrulline by an enzyme –
(1) Aspartic glutamic transaminase
(2) Glutamic dehydrogenase
(3) Ornithine carbamyl transferase
(4) Carbamyl phosphate synthetase

Q.74 Urea cycle in liver was discovered by –
(1) Bowman and Krebs
(2) Krebs and Henseleit
(3) Landsteiner and Weiner
(4) Bayliss and Sterling

Q.75 Which of the following terms refer to painful urination –
(1) Enuresis (2) Dysuria
(3) Anuria (4) Ketosis

Q.76 In diabetes mellitus, the patient drinks more water as there is urinary loss of –
(1) Protein (2) Salt
(3) Insulin (4) Glucose

Q.77 Presence of RBCs in urine is called –
(1) Glycosuria (2) Pyuria
(3) Albuminuria (4) Haematuria

Q.78 A patient who excretes large quantity of sodium in urine has –
(1) Diseased adrenal cortex
(2) Diseased adrenal medulla
(3) Diseased parathyroid
(4) Diseased thymus

Q.79 A kidney stone is –
(1) Deposition of sand in kidney
(2) Blockage by fats
(3) Blockage by proteins
(4) A salt such as oxalate crystallised in pelvis

Q.80 Glycosuria is the terms used for –
(1) Loss of glucose in urine
(2) Loss of blood in the urine
(3) Loss of salts in the urine
(4) None of these

Q.81 Uraemia is an excretory disorder in which –
(1) Concentration of urea goes high in the blood because the tubules are not able to remove it from the blood
(2) The tubules of kidney reabsorb urea in large amount
(3) Urea is produced in excess in the body
(4) None of these

Q.82 Part not belonging to uriniferous tubule is– **[AIPMT 94]**
(1) Glomerulus
(2) Henle's
(3) Distal convoluted tuble
(4) Collecting duct

Q.83 Which pair is correct– **[AIPMT 2000]**
(1) Sweat = temperature regulation
(2) Saliva = sense of food taste
(3) Sebum = sexual attraction
(4) Humerus = Hind leg

Q.84 Malpighian corpuscles are present in– **[RPMT 2001]**
(1) Cortex (2) Medulla
(3) Germinal cells (4) None of them

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Q.85 In rabbit and humans, the kidney is– **[BHU 82, CPMT 91]**

(1) Metanephric (2) Mesonephric
(3) Pronephric (4) Opisthonephric

Q.86 Brush border is characteristic of **[AIPMT 90]**

(1) Neck of nephron
(2) Collecting tube
(3) Proximal convoluted tuble
(4) All the above

Q.87 Which type of kidneys are found inamphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Meta nephric

Q.88 Difference between glomerular filtrate and plasma is of– **[DPMT 85]**

(1) Proteins
(2) Potassium
(3) First is whit where as later is yellow
(4) First is yellow whereas later is white

Q.89 Effective filtration pressure in the glomerulus in kidney of man is about **[CPMT 90]**

(1) + 75 mm Hg (2) + 10 mm Hg
(3) + 35 mm Hg (4) + 50 mm Hg

Q.90 Nitrogenous waste products are eliminated mainly as– **[AIPMT 91]**

(1) Urea in tadpole & ammonia in adult frog
(2) Ammonia in tadpole and urea in adult frog
(3) Urea in both tadpole & adult frog
(4) Urea in tadpole and uric acid in adult frog

Q.91 Reabsorption of useful substances from glomerular filtrate occurs in **[AIPMT 89]**

(1) Collecting tube
(2) Loop of henle
(3) Proximal convoluted tuble
(4) Distal convoluted tuble

Q.92 Blood fraction remaining unchanged after circulation through kidney is – **[MP PMT 88]**

(1) Urea and uric acid
(2) Urea and Proteins
(3) Urea and glucose
(4) Glucose and proteins

Q.93 Which one is the most soluble in water. **[MP PMT 90]**

(1) Uric acid (2) Urea
(3) Fatty acids (4) Casein

Q.94 ADH controls water permeability of– **[BHU 90]**

(1) Collecting tube (distal part)
(2) Proximal convoluted tuble
(3) Distal convoluted tuble (distal part)
(4) All the above

Q.95 What will happen if one kidney is removed from the body of a human being– **[MP PMT 98]**

(1) Death due to poisoning
(2) Ureamia and death
(3) Stoppage of urination
(4) Nothing, the person will survive and remain normal kidney will become hypertrophied

Q.96 Occurance of excess urea in blood due to kidney failure is– **[CPMT 91]**

(1) Urochrome (2) Uraemia
(3) Uricotelism (4) Ureotelism

Q.97 What is true about distal convoluted tubule **[MP PMT 91]**

(1) Na^+ reaborption requires energy
(2) K^+ reabsorption does not require energy
(3) Ammonia is excreated
(4) Water reabsorption requires energy

Q.98 Total filtrate formed in 24 hours in human kidney is – **[BHU 92]**

(1) 1.8 litres (2) 8.0 litres
(3) 18 litres (4) 180 litres

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Q.99 In kidney glomerulus is involved in – **[CPMT 92]**

(1) Reabsorption of salts
(2) Urine collection
(3) Urine formation by blood filtration
(4) All th above

Q.100 Glomerular filtrate contains glucose in comparison to plasma **[CPMT 92]**

(1) More (2) Same
(3) Less (4) Nill

Q.101 Which of the following is totally reabsorbed in renal tubes **[CPMT 93]**

(1) Na (2) K
(3) H_2O (4) $C_6H_{12}O_6$

Q.102 Ammonia is converted into urea in **[RPMT 95, Manipal 95]**

(1) Heart (2) Spleen
(3) Liver (4) Brain

Q.103 Which vitamin is excreted out in high quantity through urine in man–

(1) Vit. C (2) Vit. B
(3) Vit. E (4) Vit. K

Q.104 If the afferent arteriole diameter is less than efferent arteriole than what happen

(1) No effect
(2) Ultrafiltration reaction is slow
(3) Ultrafiltration is not possilbe.
(4) Ultrafiltration will stop & tubular secretion is start

Q.105 Concentration of urine depends upon which organ– **[AIPMT 2000]**

(1) Bowman's capsule
(2) Length of Henle's loop
(3) P.C.T.
(4) Network of capillaries arising from glomerulus

Q.106 Conversion of ammonia to urea is done by ..... **[AIPMT 2000]**

(1) Ornithine cycle (2) Arginine cycle
(3) Fumaric cycle (4) Citrulline cycle

Q.107 The movement of Ions against the concentration gradient will be– **[AIPMT 200]**

(1) Active transport (2) Osmosis
(3) Diffusion (4) All

Q.108 If henle's loop were absent from mammalian nephron, which of the following is to be expected– **[AIPMT 2003]**

(1) There will be no urine formation
(2) There wil be hardly any change in the quality and quntity of urine formed
(3) The urine will be more concentrated
(4) The urine will be more dilute

Q.109 Correct order of excretory organs in Cockroach, Earthworm and Rabbit respectively– **[PRMT 2001]**

(1) Skin, malpighi tubules, kidney
(2) Malpighi tubules, nephridia, kidney
(3) Nephridia, malpighi tubules, kidney
(4) Nephridia, kidney, green gland

Q.110 Which one does not filter out from blood to Bowmans capsule in glomerular ultrafiltration– **[RPMT 2001]**

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.111 Which one of the following body functions is not performed by kidneys **[RPMT 2002]**

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Detruction of dead blood copuscles

Q.112 Which of the following is excreted in mammals in the form of nitrogen– **[RPMT 2003]**

(1) Ammonium ion (2) Ammonia
(3) Uric acid (4) Urea

Q.113 The net pressure gradient that causes the fluid to filter out of the glomeruli into the glomeruli into the capsule is– **[AIPMT 2005]**

(1) 20 mm Hg (2) 50 mm Hg
(3) 75 mm Hg (4) 30 mm Hg

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Q.114 Whic one of the following blood vessel in mammals contains least amound of urea– **[RPMT 2005]**

(1) Hepatic portal vein
(2) Hepatic vein
(3) Dorsal aorta
(4) Renal vein

Q.115 A person who is on a long hunger strike and is surviving only on water, will have : - **[AIPMT 2007]**

(1) Less urea in his urine
(2) More sodium in his urine
(3) Less amino acids in his urine
(4) More glucose in his blood

Q.116 Water reabsorption in the distal parts of kidney tubules is regulated by : **[CPMT 1984,91,2002 MP PMT 1992, PB. PMT 1999, DPMT 1992]**

(1) STH (2) TSH
(3) ADH (4) MSH

Q.117 Due to insufficient filtration in the Bowman's capsule, all are likely to happen except : **[AIIMS 1992]**

(1) Accumulation of fluid in the body
(2) Increase in blood pressure
(3) Incrase in blood urea level
(4) Loss of glucose through urine

Q.118 The appearance of albumin in the urine is most likely due to : **[AIIMS 1987]**

(1) Increase in the blood pressure
(2) Decrease in the blood osmotic pressure
(3) Damage to the Malpighian corpuscles
(4) Damage to the proximal convoluted tubules

Q.119 Urinary excretion of Na is regulated by : - **[AIIMS 1992]**

(1) Anterior pituitary
(2) Posterior pitultary
(3) Anrenal cortex
(4) Adrenal medulla

Q.120 Kidney crystals are solid clusters of : **[AIPMT 1990]**

(1) Calcium nitrate and uric acid
(2) Phosphate and uric acid
(3) Clacium carbonate and uric acid
(4) Calcium metabisulphite and uric acid

Q.121 The yellow colour of urine of vertebrates is due to : **[NCERT 1973. AIPMT 1992, DELHI PMT 2004]**

(1) Cholesterol (2) Urochrome
(3) Uric acid (4) Melanin

Q.122 Which one of the four parts mentioned below does not constitute a part of a single uriniferous tubule: **[AIPMT 1994]**

(1) Bowman's capsule
(2) Distal convoluted tubule
(3) Loop of Henle
(4) Collecting duct

Q.123 Diuresis s a specific pathological condition which lead to : **[CPMT 1990, MP PMT 2001]**

(1) Increased volume of urine excretion (2) Decreased volume of urine excretion
(3) Increased glucose excretion
(4) Decreased electrolyte concentration

Q.124 Which one of the following pair of waste substances is removed from blood in ornithine cycle : **[AIMPT 1996, AFMC 2000, BHU 2001]**

(1) CO_2 and urea
(2) Ammonia and urea
(3) CO_2 and ammonia
(4) Urea and sodium salt

Q.125 Maximum basorption of water in mammals is in : **[JIPMER 1986, BHU 1996]**

(1) Lunge (2) Skin
(3) Kidneys (4) Small intestine

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Q.126 The term haematuria is used to describe :
[DELHI PMT 2004]
(1) Internal bleeding (2) Blood in urine
(3) Blood cancer (4) Blood poisoning

Q.127 Match the following :

	'A'	'B'
I	Loop of Henle	1. Carries blood the kidney
II	Renal artery	2. Area where a considerable amount of reabsorption takes place
III	PCT	3. Area of secretion
IV	Glomerulus	4. Filtration of blood
V	DCT	5. Plays a role in concentration of urine

(1) 5, 1, 2, 4, 3 (2) 5, 1, 2, 3, 4
(3) 1, 5, 3, 4, 2 (4) 2, 1, 3, 5, 4

Q.128 Which of the following is not a function of kidneys :
(1) Regulation of blood pressure
(2) Removal of urea
(3) Regulation of acidity of fluids
(4) Secretion of antibiotics

Q.129 In the kidney, the formation of urine involve the following processes arranged as
[NCERT 1979]
(1) Glomerular filtration, reabsorption and tubular secretion
(2) Reabsoption, filtration and secretion
(3) Secretion, absorption and filtration
(4) Filtration, secretion and reabsorption

Q.130 The urine of man suffering from Diabetes insipidus is : **[CPMT 1988]**
(1) Sweaty and watery
(2) Sweaty and thick
(3) Tasteless and watery
(4) Tasteless and thick

Q.131 Anadvntage of excreting nitrogenous wastes in the form of uric acid is that :
[AIEEE 2003]
(1) Uric acid can be excreted in almost solid form
(2) The formation of uric acid requires a great deal of energy
(3) Uric and is the first metabolic breakdown products of acids
(4) Uric acid may be excreted through the lungs

Q.132 Which of the following is correct :
[CPMT 1984]
(1) Afferent arteriole is narrower than efferent arteriole
(2) Afferent venule is narrower than efferent venule
(3) Efferent arteriole is narrower than afferent arteriole
(4) Efferent venule is narrower than afferent venule

Q.133 What for the ascending limb of Loop of Henle is permeable?
[MP PMT 1997, JIPMER [MED.] 2002]
(1) Glucose
(2) NH_3
(3) Na^+
(4) Water

Q.134 Why do we pass more urine in wet and cold season?
[MP PMT 1997]
(1) Impairment of water absorption by nephrons
(2) Kidney becomes mor active
(3) Sweating is much reduced
(4) ADH seretion is increased

Q.135 Aquatic reptiles are–
[AIPMT, 1999, BHU 200, CPMT 2003]
(1) Ammonotelic
(2) Ureotelic over land
(3) Ureotelic
(4) Ureotelic in water

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Q.136 If Henle's loop were absent from mammalian nephron. Which of the following is to be expected– **[AIPMT PMDT 2003]**

(1) The urine will be more in volume
(2) There will be no urine formation
(3) There will be hardly any change in the quality and quantity of urine formed
(4) The urine wll be more concentrated

Q.137 All Bowman's capsules of the kidney are found in –

[AIIMS 1998, CPMT 1999, JIPMER[MED.] 2001]

(1) Cortex (2) Medulla
(3) Pelvis (4) None of these

Q.138 A conditon of failure of kidney to form urine to form urine is caled– **[AIPMT 1998]**

(1) Deamination (2) Entropy
(3) Anuria (4) None of these

Q.139 Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are–

[PB. PMT 199, CPMT 200]

(1) Birds and lizards
(2) Mammals and mollusc
(3) Insects and bony fishes
(4) frogs and cartilaginous fishes

Q.140 In micturition– **[PB. PMT 1999]**

(1) Uretha relaxes (2) Ureter contracts
(3) Ureter relaxex (4) Urethra contracts

Q.141 What is the characteristic of metanephric kidney– **[MP PMT 2000]**

(1) Hypotonic urine production
(2) Excess secretion of uric acid
(3) Loop of Henle
(4) Hormone production

Q.142 The hormone sereted by kidney is–

[MP PMT 2001]

(1) Gastrin (2) Secretin
(3) Erythropoietin (4) Aldosterone

Q.143 Which one do not filter out from blood to bowman's capsule in glomerular utrafiltration –

[RPMT 2001]

(1) Amino acids (2) Polypeptide
(3) Glucose (4) Fatty acids

Q.144 Which type of kidney are found in adult amphibian– **[RPMT 2002]**

(1) Holonephric (2) Mesonephric
(3) Pronephric (4) Metanephric

Q.145 Which one of the following body functions is not performed by kidneys–

[RPMT 2002]

(1) Excretion
(2) Osmoregulation
(3) Regulation of blood volume
(4) Destruction of dead blood corpuscles

Q.146 Which of the following are uricotelic animals–

[AIIMS 2002]

(1) Rohu and frog
(2) Lizard and crow
(3) Camel and frog
(4) Earthworm and eagle

Q.147 Marine teleosts, undergoing putrefaction, emit sharp characteristic foul odour, which is due to the production of– **[MP PMT 2002]**

(1) Trimethylamine
(2) Hydrogen sulphide
(3) Ammonia
(4) Lactic Acid

Q.148 Fresh water bony fishes maintain water balance by– **[BHU 2002]**

(1) Excreting a hypotonic urine
(2) Excreting salt across their gills
(3) Drinking small amount of water
(4) Excreting wastes in the form of uric acid

Q.149 Which is mismatched–

[Delhi PMT 2003]

(1) Bowman's capsule-Glomerular filteration
(2) PCT-Absorption of Na^+ and K^+
(3) DCT-Absorption of glucose
(4) None of these

Q.150 Duct of Bellini opens on–

[BVP 2003]

(1) Collecting duct
(2) Ureter
(3) Renal papilla
(4) DCT

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STATE PMT EXAMS EXERCISE

Q.1 Uric acid is the main excretory product in :- **[Bihar 2002]**
(1) Insects (2) Earthworm
(3) Amphibains (4) Mammals

Q.2 Main function of glomerulus is :- **[Bihar 2004]**
(1) Filtration of blood
(2) Reabsorption of H_2O
(3) Reabsorption of Na^+
(4) Concentration of urine

Q.3 If ADH level of blood is less : - **[Bihar 2005]**
(1) Volume of urine increases
(2) Volume of urine decreases
(3) Volume of urine is normal
(4) Volume of urine is unaffected

Q.4 Urea formation takes place through **[MP PMT 2003]**
(1) Nitrogen cycle
(2) Ornithne cycle
(3) Cori cycle
(4) Kreb's cycle

Q.5 Aquatic reptiles are : **[Jharkhand 2003]**
(1) (Ammonotelic
(2) Ureotelic
(3) Ureotelic in water
(4) Ureotelic over land

Q.6 Loop of Henle is associated with : - **[Bihar 2002]**
(1) Uriniferous tubules
(2) Seminiferous tubules
(3) Neurons
(4) Muscle fibres

Q.7 Loop of Henle is associated with : - **[Uttarancal PMT 2004]**
(1) Excretory system
(2) Respiratory system
(3) Reporducitve system
(4) Digestive system

Q.8 The complete reabsorption of glucose takes place in - **[MP PMT 2003]**
(1) Collecting tubule
(2) Distal tubule
(3) Proximal convoluted tubule
(4) Henic loop

Q.9 Duct of Bellini opens on : - **[Bihar 2004]**
(1) Ureter (2) Renal papilla
(3) Duodenum (4) DCT

Q.10 Which of the following is concerned formation of urea in rabbit : - **[UP CPMT 2004]**
(1) Blood (2) Kidney
(3) Spleen (4) Liver

Q.11 Loop of Henle is found in : - **[UP CPMT 2004]**
(1) Lung (2) Liver
(3) Neuron (4) Nephron

Q.12 Absorption of H_2O in DCT is controlled by :- **[UP CPMT 2004]**
(1) ADH
(2) ACTH
(3) LH
(4) Oxytocin

Q.13 Which of the following is metabolic waste of protein metabolism : - **[MP PMT 2002]**
(1) NH_3, urea and CO_2
(2) Urea, oxygen and N_2
(3) Urea, ammonia and alanine
(4) Urea, ammonia and creatinine

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Q.14 A condition in which body's internal environment remains relatively constant within limits is called **[UP CPMT 2004]**
(1) Homeostasis (2) Hemostasis
(3) Cematoma (4) Haemopoiesis

Q.15 The presence of arginase confirms that : **[UP CPMT 2004]**
(1) Urea cycle is operating
(2) Urea cycle may be operating
(3) Arginine is being converted into omithin
(4) Arginine is being converted into citruline

Q.16 The most abundant, harmfual and universal waste product of metabolism is : **[UP CPMT 2004]**
(1) CO_2
(2) Uric acid
(3) H_2O
(4) C_2H_5OH

Q.17 Glomerular filtrate contains : - **[UP CPMT 2005]**
(1) Blood without blood cells and proteins
(2) Plasma without sugar
(3) Blood with proteins but without cells
(4) Blood without urea

Q.18 Urea is directly produced in mammals from : - **[UP CPMT 2005]**
(1) Ammonia released by oxidative deamination
(2) Oxidative deamination of purines
(3) Breakdown of ornithine
(4) Breakdown of arginine

Q.19 Glomerular hydrostatic pressure is present in :- **[UP CPMT 2007]**
(1) Tubule of kidney
(2) Bowman's capsule
(3) Glomerulus or uriniferous tubule
(4) Malpighian tubule

Q.20 Diruresis is condition, which is characterized by **[MP PMT 2004]**
(1) Increase in urine volume
(2) Increased sugar excretion
(3) Decrease in urine volume
(4) Decrease in ionic balance

Q.21 Renin is released from :- **[MP PMT 2002]**
(1) Juxta glomerular apparatus
(2) Cortical nephron
(3) Collecting duct
(4) Pelvis

Q.22 Liquid which collects in the cavity of Bowmans' Capsule is :- **[MP PMT 2004]**
(1) Blood plasma minus blood protiens
(2) Glycogen and water
(3) Urea, glycogen and water
(4) Urea

Q.23 The cavity of Bowman's caspule contain :- **[MP PMT 2001]**
(1) Urea, glycogen and water
(2) Urea and water
(3) Blood plasma except blood protein
(4) Concentrated blood

Q.24 Mammalain kidney resemble contractile vacuole of Amoeba in excretion of : - **[MP PMT 2006]**
(1) Glucose (2) Excess water
(3) Urea (4) Ammonia

Q.25 The hormone secreted by kidney is : - **[MP PMT 2001]**
(1) Gastrin
(2) Secretin
(3) Erythropoietin
(4) Aldosterone

Q.26 ADH acts on the : - **[MP PMT 2004]**
(1) Collecting tubule of kidney
(2) Loop of Henle
(3) Collecting ducts of tests
(4) None of the above

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Q.27 Enzyme 'Renin' is secreted by : - **[MP PMT 2001]**
(1) Cells of stomach
(2) Cells of intestine
(3) The cortical cells of kidney
(4) The cells of juxtaglomerular apparatus of kidney

Q.28 Absorption Na^+ and K^+ ions does not occur in : - **[MP PMT 2004]**
(1) Bowman's capsule
(2) Loop of henle
(3) Distal convoluted tubule
(4) Proximal convoluted tubule

Q.29 Loop of Henle is primarily meant for absorption of : - **[MP PMT 2002]**
(1) Potassium (2) Glucose
(3) Urea (4) Water

Q.30 Glomerular filtrate is : - **[UP CPMT 2004]**
(1) Blood minus blood corpusles and plasma protein
(2) Blood minus corpuscles
(3) Mixture of water, ammonia and corpuscles
(4) Urine

Q.31 Blood vessel leading into Bowman's capsule are called : - **[MP PMT 2001]**
(1) Renal vein (2) Renal artery
(3) Efferent arteriole (4) Afferent arteriole

Q.32 Urea synthesis takes place in :- **[MP PMT 2005]**
(1) Urinary bladder (2) Alimentary canal
(3) Liver (4) Kidney

Q.33 Human urine as compared to human blood is normaly : - **[Bihar 2004]**
(1) Hypotonic (2) Hypertonic
(3) Isotonic (4) All of these

Q.34 Kidney of frog is : - **[Bihar 2001]**
(1) Pronephric (2) Mesonephric
(3) Metanephric (4) None of these

Q.35 Which one of the following is **not** a part of a renal pyramid ? **[AIPMT 2011]**
(1) Loops of Henle
(2) Peritubular capillaries
(3) Convoluted tubules
(4) Collecting ducts

Q.36 Which one of the following correctly explains the function of a specific part of a human nephron ? **[AIPMT 2011]**
(1) Afferent arteriole : carries the blood away from the glomerulus towards renal vein
(2) Podocytes : Create minute spaces (slit pores) for the filtration of blood into the Bowman's capsule
(3) Henle's loop : most reabsorption of the major substances from the glomerular filtrate
(4) Distal convoluted tubule : reabsorption of K^+ ions into the surrounding blood capillaries

Q.37 Uricotelic mode of passing out nitrogenous wastes is found in : **[AIPMT 2011]**
(1) Insects and Amphibians
(2) Reptiles and Birds
(3) Birds and Annelids
(4) Amphibians and Reptiles

Q.38 Which one of the following statements is correct with respect to kidney function regulation ? **[AIPMT 2011]**
(1) During summer when body loses of lot of water by evaporation, the release of ADH is suppressed
(2) When someone drinks lot of water, ADH release is suppressed
(3) Exposure to cold temperature stimulates ADH release
(4) An increase in glomerular blood flow stimulates formation of Angiotensin II

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ANSWER KEY

EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	2	4	1	1	4	3	4	2	2	3	1	1	3	3	2	1	3	2	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	2	4	1	2	1	2	3	3	2	3	4	2	1	2	3	3	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	1	1	1	3	3	3	4	4	3	4	4	2	1	1	4	4	4	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	1	2	1	1	1	2	1	3	3	3	2	2	4	4	1	4	1
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	2	1	2	2	3	4	2	3	4	2	1	4	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	3	1	3	2	1	1	4	2	2	4	4	1	4	1	3	4	3	3	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	2	4	1	3	3	2	1	4	1	3	1	3	3	1	1	1	1	3	1	1
Ques.	141	142	143	144	145	146	147	148	149	150										
Ans.	3	3	2	2	4	2	1	1	3	3										

STATE PMT EXAMS EXERCISE

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	1	1	2	1	1	1	3	2	4	4	1	1	1	3	1	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
Ans.	1	1	3	2	3	1	4	1	4	1	4	3	2	2	3	2	2	2		

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