STRUCTURAL ORGANISATION IN ANIMAL

Animal Tissue

- According to Whittaker classification, all animals are multicellular but in two kingdom classification, all organisms were grouped into Kingdom plantae and animalia, so all animals can be grouped into two categories based on number of cells which are unicellular and multicellular.
- In unicellular organisms, all functions like digestion, respiration and reproduction are performed by a single cell.
- In the complex body of multicellular animals, the same basic functions are carried out by different groups of cells in a well-organized manner.
- The body of a simple organism like *Hydra* is made of different types of cells and the number of cells in each type can be in thousands. The human body is composed of billions of cells to perform various functions.

ANIMAL TISSUE

- In multicellular animals, a group of similar cells along with intercellular substances perform a specific function. Such an organization is called **tissue**.
- Tissue is a group of cells, usually having similar structures, performing similar functions and mostly having similar origin. But in a tissue, cells may be dissimilar in structure and function but they are always similar in origin.
- These tissues are organized in specific proportion and pattern to form an organ like stomach, lung, heart and kidney. When two or more organs perform a common function by their physical and/or chemical interaction, they together form organ system, e.g., digestive system, respiratory system, etc. Cells, tissues, organs and organ systems split up the work in a way that exhibits division of labour and contribute to the survival of the body as a whole.
- Word animal tissue was coined by **Bichat** and plant tissue by **N. Grew.** Study of tissue - **Histology.** Histology word was given by **Mayer.** Father of Histology - **Bichat.** Detail study of tissue is called **Microscopic anatomy.** Founder of microscopic anatomy - **Marcello Malpighi.**
- **Based on origin, structure and function**, **animal tissues** are grouped in **to 4 categories**.

S.No.	Type	Location	Origin	Functions
1.	Epithelial	Free surfaces	Ectoderm, Endoderm and Mesoderm	Covering, protection, absorption, secretion, Reproduction and excretion
2.	Connective	Below the skin, around the organs	Mesoderm	Attachment, support, storage and transport
3.	Muscular	In the body parts involved in movement and locomotion.	Mesoderm (except ciliary body, iris and diaphragm muscles which are ectodermal)	Movement and locomotion
4.	Nervous	Throughout the body organs.	Ectoderm	Generate, conduct and control impulses in the body.

EPITHELIAL TISSUE

- The term epithelium was coined by **Ruysch.**
- Word epithelium is composed of two words.
  Epi – Upon
  Thelia – growth
  A tissue which grows upon another tissue is called Epithelium. It always rest upon underlying connective tissue.
- It commonly refers to an epithelial tissue as epithelium (pl.: epithelia).
- It is only type of tissue in which cells are arranged in form of layers. It forms 10% of the total tissue.
- During course of evolution it was the **first tissue to be evolved**, during embryogenesis it is **first to be formed**. It originates from all three germinal layer.
- Ectodermal – Epidermis - Mesodermal – Mesothelium, Endodermal – Inner lining of gut.
- Maximum damage occurs to this tissue and due to this fact it has **highest power of regeneration**.
- Power of regeneration is absent or least power is found in nervous tissue.
- This tissue has a free surface, which faces either a body fluid or the outside environment and thus provides a covering or a lining for some part of the body.
- Cells are very close to each other, so intercellular matrix is very less or absent. Due to this fact, blood vessels and lymphatic vessels can't penetrate so blood circulation is absent in epithelium. Hence cells depend for their nutrients on underlying connective tissue.
- Between epithelial tissue and underlying connective tissue, a thin non living acellular basement membrane is present which is highly permeable. It is formed partially by **epithelial tissue** and partially by underlying connective tissue, so can be divided in two layers-

  i. Basal Lamina
  It lies just below epithelial layer. It is composed of mucopolysaccharide and glycoprotein which are secreted by epithelial cells. It is thin layer so visible under **electron microscope only**.

  ii. Fibrous or Reticular Lamina
  It is present toward connective tissue layer. It is composed of collagen and reticular fiber in matrix of mucopolysaccharides which is formed by cells of connective tissue. It is thick layer so visible **under compound microscope**.

CELL JUNCTION : In nearly all animal tissues, specialised junctions provide both structural and functional links between its individual cells, epithelium cells modified to form following structures is called Intercellular Junctions.

i. Tight junctions (Zonula occludens) – At some places, plasma membrane of adjacent cells become fused to form tight junction. Stop substances from leaking across a tissue. These structures are mostly found in **columnar epithelium.**

ii. Gap junctions - Facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules. In gap junctions, connexin proteins are present which form connexons (fluid channels), used for transmission of electrical and chemical signals.

iii. Adhering Junction (Macula Adhrens), Zonula adherens

This type of Junction consists of disc – like protein plate with intermediate fibre known as **tonofibrils** composed of **keratin like protein**. These filaments are deeply situated in the cytoplasm of respective cell. These structures provide mechanical support to **stratified epithelium** or performing cementing to keep neighbouring cells together.

iv. Interdigitations

Finger like processes of plasma membrane which enter into cytoplasm of adjacent cell. These structures are mainly found in **transitional** epithelium.

Modifications of Plasma Membrane

Plasma membrane of free end get modified to form 3 types of functional structures.

a. Microvilli

These are minute protoplasmic process which are non motile, non contractile. They help in absorption, secretion, excretion. They increase surface area more than 20 times. They are present in the wall of **Intestine, Gall bladder, Proximal convoluted tubule** etc.

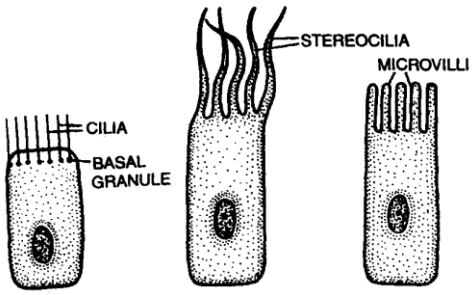
b. Stereocilia

Long cytoplasmic process, non motile, non contractile. Basal granule is absent. Plasma membrane is thick and rigid. Base of stereocilia is broad and apical part is narrow so they are conical in shape. They increase surface area and found in **e.g. Epididymis, Vas deferens.**

c. Cilia / Kinocilia

Long Cylindrical protoplasmic process. Motile and contractile. Originated from basal granule or kinetosome. Diameter of cilia is same from base to apex. In internal structure of cilia, 9 + 2 arrangement of microtubules is present. Their function is to move particles or mucus in a specific direction over the epithelium.

e.g.- Fallopian tube, Bronchioles, Trachea, Uterus, Ependymal epithelium: (Inner lining of ventricles of brain and central canal of spinal cord. Function of cilia is to conduct substances in CSF.)



Epithelial cells showing projections in the form of cilia, stereocilia and microvilli

Type of Epithelial Tissue

On the basis of number of layers of cell, it is of two types

A. Simple epithelium
– Composed of single layer of cells
– Unilayered
– Functions as lining for body cavities, ducts and tubes

On the basis of shape/structural modifications of cells, it is of four types

(1) Simple Squamous epithelium
(2) Simple Cuboidal epithelium
(3) Simple Columnar epithelium
(4) Pseudostratified epithelium

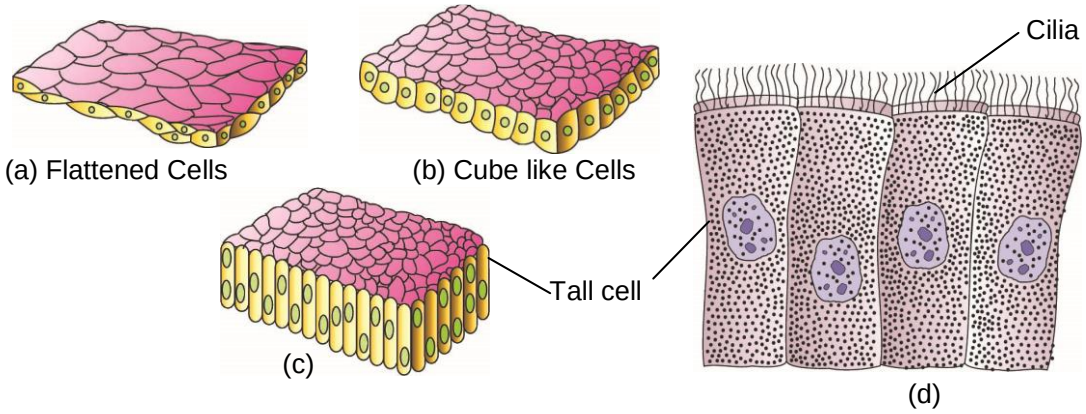
B. Compound epithelium
– Consists of 2 or more cell layers
– Multilayered
– It has protective function as it does in our skin

On the basis of stretching ability, it is of two types

(1) Transitional epithelium
(2) Stratified epithelium

On the basis of shape of the cells of outermost layer it is of three types

(1) Stratified squamous epithelium
(2) Stratified cuboidal epithelium
(3) Stratified columnar epithelium



Simple Epithelium: (a) Squamous (b) Cuboidal (c) Columnar (d) Columnar cells bearing cilia

A. Simple Epithelia

It is composed of a single layer of cells. Being single layered it play role in secretion, absorption and filtration but has no role in protection. It always rest on basement membrane.

On the basis of cell shape it is of following types

(A) Simple Squamous Epithelia

A single thin layer, cells are flat or scale like in shape, with irregular boundaries. Nucleus is flattened and rounded. It is also called **pavement epithelium** due **to its tile like appearance.** Also called **Tesselated epithelium** due to **its wavy appearance.**

Function - Filtration & diffusion

- **Occurrence -**

i **Endothelium – Inner lining of blood vessels and lymph vessels. (Tesselated)**

ii. Inner lining of heart wall (Tesselated)

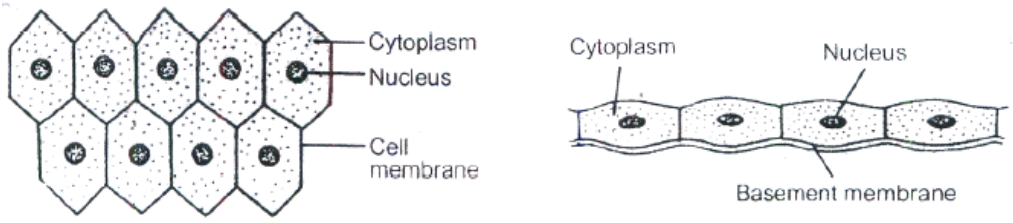
iii. **Terminal bronchioles and Air sacs (alveoli) of lungs. (Type- I Pneumocytes)**

iv. Bowman's capsule (Podocyte)

v. Thin limbs of loop of Henle.

vi. Inner surface of the tympanic membrane (eardrum)

vii. Mesothelium – Covering of coelom is called as mesothelium, (Tesselated). (Visceral & Parietal peritonium, Visceral and perietal pleura, Visceral and Parietal pericardium).



(a) (b)

Fig. Simple squamous epithelium: (a) Surface view (b) Vertical section

(B) Simple Cuboidal Epithelium

- Cells are cube like in shape
- A rounded nucleus is present in the centre of cell
- This epithelium is also called **Germinal epithelium** because in gonads (testis & ovaries) cubodial cells divide to form egg & sperm.
- **Function** - Secretion, excretion and absorption.
- **Occurrence -**

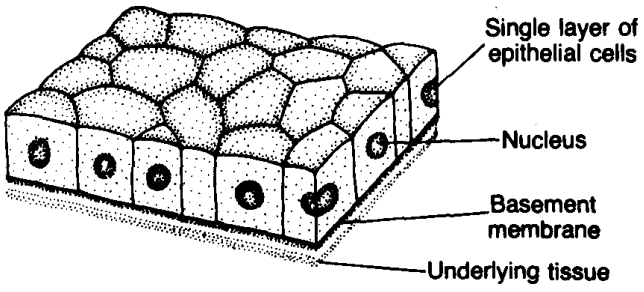
i. Acini of pancreas

ii. Vesicles of thyroid gland

iii. Iris, choroid, ciliary body of eye

iv. Sweat glands

v. ducts of small salivary and pancreatic glands and tubular parts of nephrons



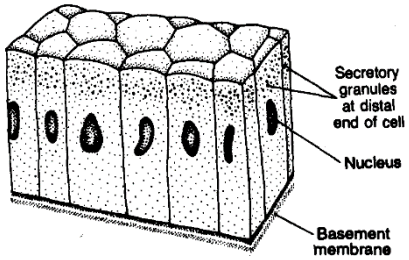
Modifications of simple cuboidal epithelium

(i) When microvilli are present on free end of cuboidal cells then it is called as **Brush bordered cuboidal epithelium. e.g.- cells of PCT of nephron.**

(ii) When cllia present on free end of cuboidal cells then it is called as **ciliated cuboidal epithelium**. **Found in certain part of nephron and in collecting duct.**

(C) Simple Columnar Epithelium

- Cells are pillar like in shape. (Tall and slender)
- Elongated nucleus is present at the base of cell.
- Function - Secretion and absorption
- **Occurrence**
  - i. **Lining of stomach and large intestine**
  - ii Bile Duct
  - iii. Gastric gland, intestinal gland, pancreatic lobule.



Modifications of Simple Columnar epithelium

(1) Brush Bordered Columnar epithelium:
When microvilli are present on free end of columnar epithelium. e.g Gall bladder, small intestine.

(2) Ciliated columnar epithelium:
When cilia are present on free end of columnar cells.
Eg. Fallopian Tube, Ependymal epithelium, Bronchioles.

(3) Sterio ciliated columnar epithelium: When steriocilia are present on free end of columnar cells.
Eg. Epididymis, Vas deferens

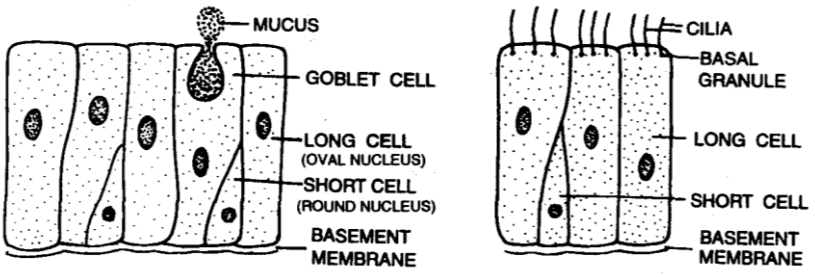
(D) Pseudo stratified Epithelium

In this epithelium, two types of cells are present i.e
(i) Long cells, (ii) Short cells

All these cells are pillar like in shape so it is also a modification of columnar epithelium.
Nucleus in both cells are present on different levels so it appears bilayered because few cells are too short to reach the top surface. But all cells are present on single basement membrane so it is unilayered. Eg. – Middle part of male Urethra, **duct of parotid salivary gland.**

Modification :

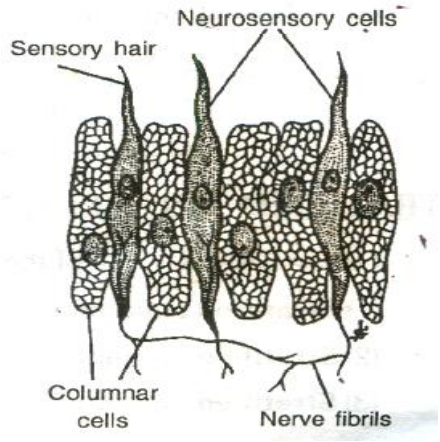
Pseudostratified ciliated glandular epithelium [PSCGE]: In this epithelium, cilia are present at free end of long cells and goblet cells are also present in this epithelium. Eg. Trachea, Bronchioles.
Respiratory epithelium of nasal chambers.



Special Types of Epithlium

(a) Neuro sensory epithelium

In the structure of this epithelium in between piller shaped supporting cells modified sensory cells are present. On the free end of sensory cell sensory hair is present by which they receive sensation. Base of these cells is attached with sensory nerve.



Eg. – Gustatory Epithelium – Covering of taste bud of tongue receive taste sensation.
– Olfactory epithelium – Schneidarian membrance receive smell sensation
– Stato–acoustic –Lining of internal ear.
– In retina of eye receive optic sensation

(b) Myoepithelium – Around mammary and sweat gland (around secretery unit)

(c) Pigmented epithelium (Cuboidal) – In Retina of Eye.

B. Compound Epithelium

Multilayered and limited role in secretion and absorption. To provide protection against chemical & mechanical stress. On the basis of stretching ability it is of 2 types –

(1) Stratified epithelium : – Non- stretchable

(2) Transitional epithelium : – Stretchable

(1) Stratified Epithelium

Basement membrane is present on which basal layer lies. On the basis of shape of the cells of outermost layer it is of three types.

(i) Stratified squamous epithelium –

(ii) Stratified Cuboidal epithelium –

(iii) Stratified columnar epithelium –

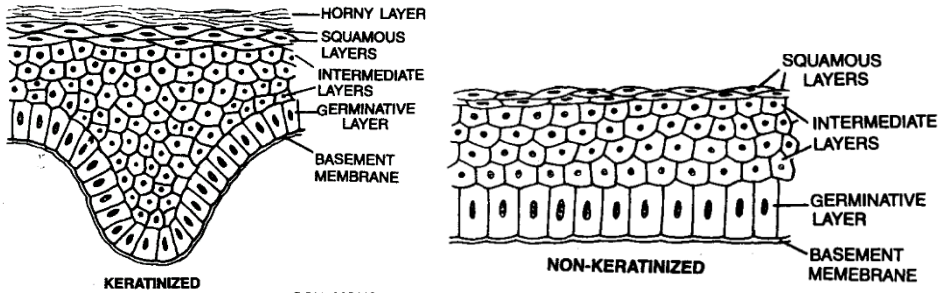
(i) Stratified squamous epithelium - As the name indicates, superficial layer is composed of squamous cells. Based on presence or absence of keratinization it can be further divided in to two types-

(a) Non keratinized Stratified Squamous epithelia - Keratin protein is absent. Cells are nucleated and living. Present on lining of moist surfaces of buccal cavity, tongue, pharynx, upper oesophagus, anal canal, cornea of eye, vagina and cervix.

(b) Keratinized Stratified squamous epithelia-

Keratin Protein is present and cells become non nucleated dead cells.

Eg. – Epidermis of skin, Scale, Horn, Nails, Feathers etc.



(ii) Stratified Cuboidal Epithelia - As the name suggests, superficial cell layer is composed of cuboidal cells. Middle layer– polygonal shaped cells. Outermost layer of cells are cube like & cells are nucleated & living. Present in epidermis of fishes and tailed amphibians. Also line sweat gland ducts and large salivary and pancreatic ducts.

(iii) Stratified Columnar Epithelia-

As suggested by name, superficial cell layer is columnar in shape. On the basis of presence of cilia this epithelium is of 2 types

(a) Ciliated stratified columnar epithelium – Cilia is present. Eg. Buccopharyngeal cavity of Frog, Larynx.

(b) Non ciliated stratified columnar epithelium. Cilia is absent. Eg. Epiglottis, Distal part of male urethra.

(2) Transitional epithelia-

- Basement membrane is absent so it becomes distensible and hence called as plastic epithelia.
- Cells in lowermost layer are cuboidal, in middle layers umbrella shaped/polyhedral and in upper 1-2 layers are oval in relaxed stage, when stretched all cells appear to be squamous.
- Over upper layer, thin film of cuticle is present which makes the tissue impermeable to water.
- Present in ureters, urinary bladder and upper part of urethra hence also called **urothelium**.

Function :- Permits distension.

Glandular Epithelia

A cell or a group of cells which secretes chemical substances are called glands.

All glands are composed of epithelial tissue. Some columnar or cuboidal cells get specialised for secretion known as glandular epithelium.

Glands produce a fluid secretion that is different from blood or any extra cellular fluid in its composition. Such secretions occur along with the synthesis of intracellular macromolecules, such as proteins (in pancreas), lipids (in adrenal glands), complexes of carbohydrate and proteins (in salivary glands) or all three types of macromolecule (in mammary glands).

CLASSIFICATION OF GLANDS

(1) On the basis of mode of pouring of their secretion.

(a) Exocrine gland :- Secretory duct present – secretes mucus, saliva, earwax, oil, milk and enzymes.

(b) Endocrine glands :- Secretory duct absent and secrete hormones. Their products are secreted directly into the fluid bathing the gland.

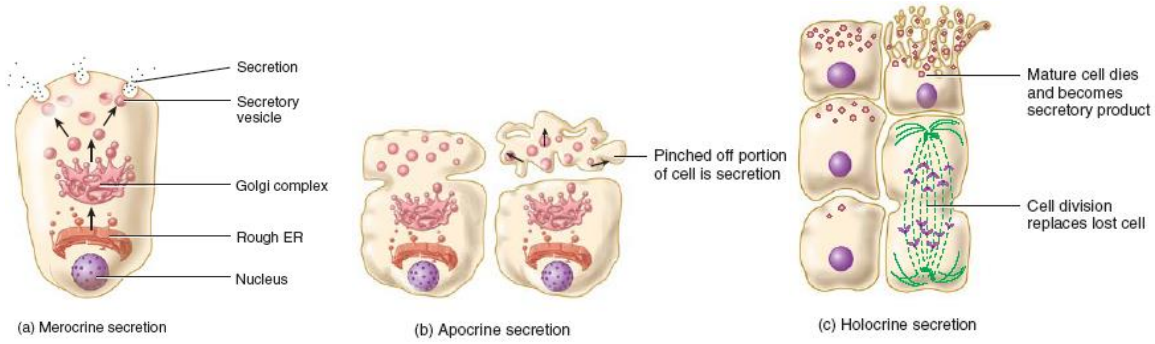
(c) Heterocrine/mixed gland :- Both endocrine & exocrine parts are present. e.g. Pancreas, Gonads etc.

(2) On the basis of nature of secretion :- 3 types of glands are there.

(a) Merocrine gland :- In these glands, secretory cells secrete substances by simple diffusion (Exocytosis). No part of cytoplasm is destroyed in secretion. Secretory matter like water.
Eg. Sweat glands, Goblet cells, Salivary gland, Tear gland, Intestinal glands, Mucous gland.

(b) Apocrine gland :- In this type of glands, secretory products are collected in apical part of secretory cell and apical portion is also shed alongwith secretory matter.
Secretory matter is comparitively concentrate.
- Mammary glands.

(c) Holocrine glands :- The production or secretion is shed with whole cell leading to its destruction. i.e. Whole cell shed as secretion (Secretory matter concentrate)
Example : Sebaceous, meibomian & Zeis gland.



(3) On the basis of secretory matter- It is three types
(a) Serous glands – Secretion-Watery fluid Eg. Sweat glands
(b) Mucous glands – Secretion : Mucous/gelationous Eg. Goblet cell
(c) Mixed glands – Secretion : Watery + Mucous Eg. Pancreas, gastric glands

(4) On the basis of number of cells – It is two types
(a) Unicellular glands (Isolated glandular cell) Eg. Goblet cells, Paneth cells
(b) Multicellular glands (Consisting of cluster of cell) Eg. Salivary glands

Test your Resonance with concept

1. Cells of the epithelial tissue rest on a basement membrane which is made up of
(1) Monosaccharides (2) Mucopolysaccharides
(3) Di saccharides (4) Lipids

2. The cells of a tissue are similar in
(1) Structure (2) Function (3) Origin (4) All of these

3. The intercellular matrix is negligible or absent in which one of the following tissues?
(1) Connective tissue (2) Epithelial tissue (3) Muscular tissue (4) Cardiac tissue

4. Simple cuboidal epithelium is found in
(1) Sweat glands (2) Choroid of eye (3) Thin bronchioles (4) All of these

Answers
1. (2) **2.** (4) **3.** (2) **4.** (2)

CONNECTIVE TISSUE

- It is most abundant and most widely distributed tissue.
- Only connective Tissue constitutes 30% of total body weight. Muscle-50%. Epithelium-10% Nervous-10%.
- It is named connective tissues because of their special function of linking and supporting other tissues/organs of the body. They range from soft connective tissues to specialized types. Which include cartilage, bone, adipose, and blood.
- In all connective tissues **except blood**, the cells secrete fibres of structural proteins called collagen or elastin. The fibres provide strength, elasticity and flexibility to the tissue.
- These cells also secrete modified polysaccharides, which accumulate between cells and fibres and act as **matrix (ground substance)**.

Components of Connective tissue-

Connective tissue is composed of three parts namely cells, fibres and matrix.

(A) Cells of Connective tissue-

Mesodermal embryonic cells called mesenchymal cells give rise to the cells of connective tissue.

(a) Fibroblasts are large, flat cells with branching processes. Maximum in number. Primary function of these cells is secreting the fibers. Fibres are composed of protein and certain components of the ground substance (matrix).

- Fibroblast cells are also considered as undifferentiated cells of connective tissue because they can be modified into Osteoblast & Chondroblast cells to produce bone & cartilage.
  Function : (1) To produce fibres (2) To secrete matrix

(b) Adipocytes, also called fat cells or adipose cells, are connective tissue cells that store triglycerides (fats).

- Fat is collected in the form of fat globule. Fat globule is formed by the fusion of small oil droplets. They are found deep to the skin and around organs such as the heart and kidneys.
- On the basis of number of fat globules, adipocytes are of two types.
  - **(i) Monolocular adipocytes :** In these cells, single large and central fat globule is present. Nucleus and cytoplasm is peripheral and cytoplasm is less in amount. Due to compression of fat globule, nucleus become flattened in shape. These adipocytes **form white fat**.
  - **(ii) Mulitlocular adipocytes :** In these cells, many small fat globules are distributed in the cytoplasm around nucleus. Cytoplasm is more in quantity. Nucleus is rounded & found in the centre. These adipocytes **form brown fat**.

(c) Mast cells are abundant along the blood vessels that supply connective tissue. They produce **histamine (vasodilator)**, **serotonin (5-hydroxy tryptamine, vasoconstrictor)** and **heparin (anticoagulant)** as part of the inflammatory response, the body's reaction to injury or infection.

(d) White blood cells are not found in significant numbers in normal connective tissue. However, in response to certain conditions they migrate from blood into connective tissues. For example, **neutrophils** gather at sites of infection, and **eosinophils** migrate to sites of parasitic invasions and allergic responses.

(e) Macrophages develop from monocytes, a type of white blood cell. Macrophages have an irregular shape with short branching projections and are capable of engulfing bacteria and cellular debris by phagocytosis.

- ❖ Fixed macrophages reside in a particular tissue; examples **Lungs** – Dust cells, **Liver**– Kupffer cells, **Brain** – Microglial cells, **Thymus gland** – Hassel's corpuscle, **Spleen**–reticular cells.
- ❖ Wandering macrophages have the ability to move throughout the tissue and gather at sites of infection or inflammation to carry on phagocytosis.

(f) Plasma, cells are small, amoeboid cells that develop from a type of white blood cell called B lymphocyte. They are also called cart wheel cells as chromatin material is arranged in form of spokes.

- ❖ Plasma cells secrete antibodies, proteins that attack or neutralize foreign substances in the body. Thus, plasma cells are an important part of the body's immune response.
- ❖ Although they are found in many places in the body, most plasma cells reside in connective tissues, especially in the gastrointestinal and respiratory tracts. They are also abundant in the salivary glands, lymph nodes, spleen, and red bone marrow.

  Function: To produce, secrete & transport antibody.

(B) Matrix / Ground substance- It contains water and large organic molecules, many of which are complex combinations of polysaccharides and proteins. The polysaccharides include hyaluronic acid, chondroitin sulfate, dermatan sulfate, and keratan sulfate. Collectively, they are referred to as **glycosaminoglycans** or **GAGs.**

(C) Fibres- Connective tissue fibres are secreted by fibroblast cells. Based on chemistry and other physical properties, fibres are divided in to three categories-

(a) Collagen fibers (white fibres)- They are composed of collagen protein (most abundant protein in animal world). They are white in colour, are unbranched and present in bundles.

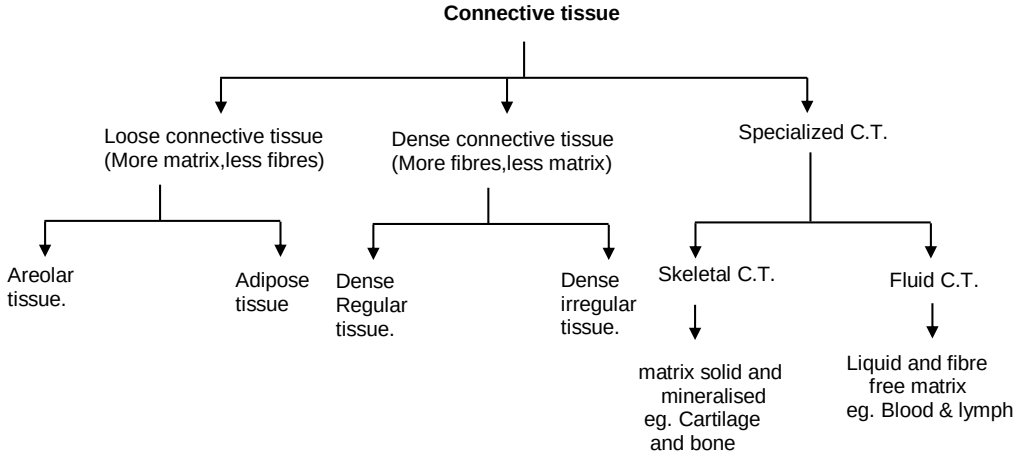
- ❖ Skin of larger mammals is used as leather after a chemical process called tanning due to presence of it. It can be digested by pepsin. Generally present in tendons. Upon boiling, it changes in to gelatin.

(b) Elastic fibers (yellow fibres)- They are composed of elastin protein which is surrounded by a glycoprotein named **fibrillin**, are yellow in colour, branched and present singly. Chemically it is stronger than collagen fibers. It can be digested by trypsin and elastase enzymes.

- ❖ Blood vessels of several, year old mummies are still intact due to presence of it. Generally present in ligaments.

(c) Reticular fibers- They are composed of reticulin protein, are translucent, branched and occur singly. Generally present organs like liver, spleen and lymph nodes.

TYPES OF CONNECTIVE TISSUE



1. Loose connective tissue-

Here cells and fibres are loosely arranged in semifluid ground substance. It is of two types:

(A) Areolar connective tissue-

- It is most widely distributed connective tissue in the body and contain maximum amount of intercellular spaces and ground substance.
- It is present beneath epithelia of many visceral organs, skin and in wall of arteries and veins. It joins skin to muscles, fill space inside organs, form submucosa of tracts of body and found around muscles and nerves too.
- It helps in repair of tissue after injury.
- In the matrix which is made up of modified polysaccharides and glycoproteins, various types of cells and fibres are present-
  - i. Fibroblast cells- most important cell of areolar connective tissue.
  - ii. Macrophages or histiocytes
  - iii. Mast cell
  - iv. Plasma cell
  - v. Adipocytes

All three types of fibres viz. collagen fibre, elastic fibre and reticular fibres are present.

In between cells and fibres, many air spaces are present which are called areole (provide sponginess) and so the name of tissue.

This tissue is highly vascular as numerous blood capillaries and lymphatic capillaries are present.

Location

(i) Under skin as subcutaneous tissue.

(ii) In between muscle, nerves and blood vessels.

(iii) In submucosa of alimentary canal and respiratory tract

(iv) In bone marrow.

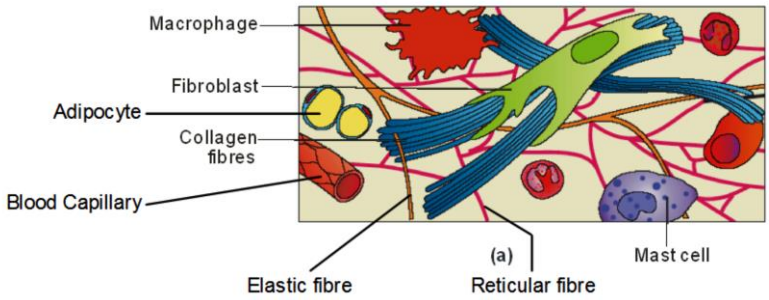


Fig. Loose connective tissue : (a) Areolar tissue

(B) Adipose Tissue-

- It is a modification of areolar connective tissue where instead of fibroblast, adipocytes become major cells.
- It is highly vascular like as areolar tissue.
- It is fat storage connective tissue so if kept in organic solvent, cells become empty. Due to presence of fat it can be stained with sudan dye.
- Any excess of intaken nutrient are converted to fat, which is stored here.
- Being fat reservoir it can act as food reserve during prolonged fasting.
- Excessive accumulation of this tissue is called adiposis.
- It is also believed to secrete a hormone- leptin which regulate appetite and body weight.

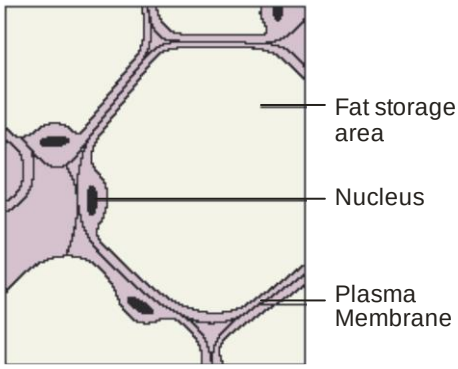
On the basis of adipocytes, 2 type of fats are found in animals.

1. **White fat** 2. **Brown fat**

1. **White fat :-** It is composed of monolocular adipocytes in which single large fat globule, peripheral cytoplasm and peripheral nucleus is present. Due to less amount of cytoplasm, Mitochondria are also less in number. So they produce less energy.
   Eg. **Blubber :-** Thick layer of white fat found under dermis of skin. **Found in whale, seal and elephants.**
   Hump of camel
   Tail of marino sheep
   Yellow bone marrow.

2. **Brown fat :-** It is composed of multilocular adipocytes in which many fat globules are present. Cytoplasm is more in amount. Due to more number of mitochondria, it produces 20 times more energy than white fat. Brown colour of fat is due to presence of cytochrome pigment.
   Eg. Rodents like rat, shrew. They are hibernating animals & during hibernation they obtain energy from stored brown fat.
   Location
   In subcutaneous tissue, around heart, Kidney, eyeball.

Brown fat is present new born babies of human. It can oxidize speedily liberating larger amount of heat so prevent shivering in new born. After some time of birth in human, brown fat is replaced by white fat.



(b)

Fig. Loose connective tissue: (b) Adipose tissue

Resonate the Concept
Loose connective tissue has two more types which are predominantly present in embryos. First is **Mesenchyme** which consists of mesenchymal cells and reticular fibres. It is source of all connective tissues present in body. It is found in developing bones and below skin. Some mesenchymal cells are also present in adults around blood vessels. Other one is **Mucoid Connective Tissue** which is made up of fibroblasts present in a jelly like matrix containing fine collagen fibres. In embryo it is present in umbilical cord while in adults present in Vitreous humor of eye and also in cock's comb.

2. **Dense Connective Tissue** - It consist of fibres and fibroblast cells which are compactly packed in the ground substance. Orientation of fibres can be regular or irregular. It provide strong connections between different structures. On the basis of arrangement of fibres it can be divided in to two types:
   (A) Dense Regular Connective tissue-
   Fibroblast cells are present in definite rows between many parallel bundles of fibres.

Based on abundance of types of fiber it can be divided in to 2 groups-

(a) White Fibrous Connective Tissue-

- ❖ It is very dense, strong and fibrous connective tissue with thick parallel bundles of collagen fibres. Few fibroblasts are present in rows between bundles of collagen fibres.
- ❖ If it is in cylindrical form than called **tendons** which connect muscle to bone. Strongest tendon of body is Tendocalcaneus tendon which connect gastrocnemius muscle of shank with calcaneum bone of ankle.
- ❖ If it is in form of a sheet then occur in dermis of skin, tunica adventitia of large blood vessels, periosteum of bone, perichondrium of cartilage, pericardium of heart, duramater of brain and spinal cord, renal capsule of kidney, sclera of eye, fibrous capsules of penis and between skull bones to make them immovable.

(b) Yellow Elastic Connective Tissue- This tissue is composed of much thicker branched loose network of yellow fibres. Collagen fibres are also present but they are comparatively lesser. Fibroblasts are irregularity scattered. It also contains mast cells, macrophages and often some adipose cells.

- ❖ If it is cylindrical form then called **ligaments** which join bone to bone. If all the ligaments of body are cut then bones will become unfixed. Sprain is caused due to excessive pulling of ligaments. Strongest ligament of body is ilio femoral ligament.
- ❖ If it is in form of sheet then present in wall of blood vessels (blood vessels of mummies are still intact due to presence of it), lungs, bronchioles, true vocal chords, trachea and ligamenta flava (connect adjacent vertebra).
- ❖ Due to having abundant yellow fibres it allow stretching and provide considerable elasticity.

(B) Dense Irregular Connective Tissue- It has fibroblasts and many irregular collagen fibres which are oriented in different directions. This tissue is present in the skin.

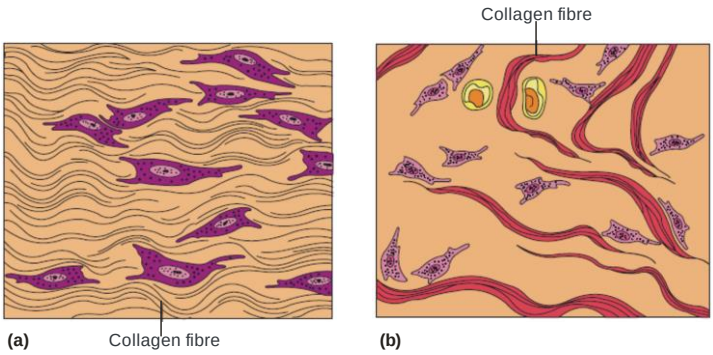


Figure : Dense connective tissue: (a) Dense regular (b) Dense irregular

Test your Resonance with concept

1. When collagen fibres are removed from the areolar tissue, it

(1) becomes hard (2) becomes loose and elastic

(3) becomes hard and inelastic (4) remains unchanged

2. The main function of connective tissue is

(1) Binding together other tissues (2) Supporting various parts of the body

(3) Forming a packing around organs (4) All of these

3. Which of the following is not correct

(1) The brown adipose tissue cell has a single large droplet of fat surrounded by a small amount of cytoplasm, whereas the white adipose tissue cell has many small droplets of fat suspended in a larger amount of cytoplasm
(2) Brown fat cells contain many mitochondria, while white fat cells have comparatively few
(3) Brown fat has a larger capacity for generating heat than white fat
(4) Brown fat is mainly found in new born mammals

4. New born mammals generally do not shiver inspite of lower temperature outside because of
(1) Brown fat which has larger capacity for generating heat
(2) White fat which has larger capacity for generating heat
(3) Chromatophores present in them
(4) Skeletal tissue present in them

5. The connective tissue that connects the skin to the underlying structures is
(1) Areolar tissue (2) Serous membrane (3) Reticular tissue (4) Dense connective tissue

Answers

1. (2) 2. (4) 3. (1) 4. (1) 5. (1)

3. Specialized Connective Tissue-

They are specialized for a particular function and in general structure bear remarkable differences from rest of the connective tissues in terms of structure and function.
Based on function, they are of following two types-

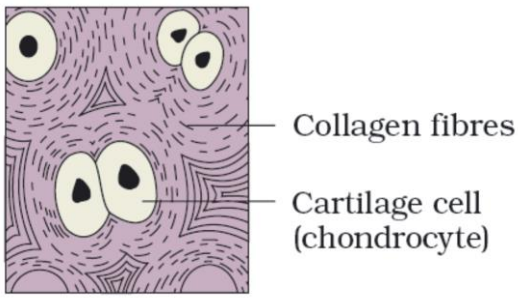
(A) Skeletal Connective Tissue
(B) Vascular Connective tissue

(A) Skeletal Connective Tissue

Matrix is dense & mineralised. Due to deposition of minerals it becomes hard.
Also known as **Supporting Tissue** i.e. provide support to body.
It is two types - (a) Cartilage, (b) Bone

(a) Cartilage :-

- Outer most covering of hyaline cartilage is called perichondrium which is composed of white fibres connective tissue.
- Cartilage producing cells are arranged on periphery of cartilage known as **chondroblast**. These are active cell & divide to form chondrocytes, and synthesize the matrix of cartilage. Mature cells of cartilage is called Chondrocytes. They are found in vacuole like space in matrix called Lacuna. In which 1 - 4 Chondrocytes are present.
- Matrix of cartilage is called chondrin composed of chondromucoprotein having Chondrotin-6-sulphate and mucopolysacchride (Hyaluronic acid). Matrix of cartilage provides rigidity & elasticity to cartilage. (Matrix solid, Pliable and resists compression)
- Blood circulation is absent in the matrix of cartilage but blood supply present in perichondrium.
  Type of Cartilage - There are following types of cartilage
  i. Hyaline Cartilage.
  ii. Fibrous Cartilage - (a) Elastic cartilage (b) White fibrous cartilage
  iii. Calcified Cartilage.



(a)

(i) Hyaline Cartilage- Matrix is almost devoid of fibres and glass like but translucent.

- It is most prevalent cartilage in our body. Most of embryonic endoskeleton is composed of this cartilage, so bones developed from it are called cartilaginous bones and they are most abundant in body.
- It is present at following locations- Articular surfaces at joints of long bones, where it is called articular cartilage, Sterna parts of ribs where it is called costal cartilage. Trachea, bronchi, hyoid apparatus, nasal septum, parts of larynx (Thyroid, Cricoid and Arytenoid).

(ii) Fibrous Cartilage- it has well developed fibres in the matrix. Based on type of fibre present it can be of two types-

- **White Fibrocartilage** which has abundant collagen fibres. It is strongest cartilage. It occurs in intervertebral disc (central part- Nucleose pulposus) and at pubic symphysis.
- **Yellow Elastic Cartilage** which has abundant elastic fibres due to which colour of cartilage becomes pale yellow. It is present in external ear pinna and auditory canal of ear, eustachian tubes, tip of nose, epiglottis and cartilage of santorini present in larynx.

(iii) Calcified Cartilage- initially it is hyaline cartilage but later on due to deposition of inorganic salts it becomes calcified and hence it is hard and inelastic. It is present in suprascapula and pubis of Frog, and vertebrae of Shark.

(b) Bone-

- Study of Bone - Osteology
- Process of bone formation - Ossification
- Hardest Tissue - Bones
- Softest Tissue - Blood.
- Hardest substance - Enamel.
- Outermost covering of bone is periosteum which is composed of white fibrous connective tissue.
- Bone producing cell is called osteoblast. They divide to form osteocyte & synthesize organic part of matrix. Mature cell of bone is called as osteocyte which is found in lacuna. Only one osteocyte is found in lacuna. Bone destroying cells are osteoclast cells.
- **Matrix -** Hard and Non-pliable - It has two parts

  Inorganic Part :- 65-68%

  $Ca_3(PO_4)$ – 80% max. rest 20% $CaCO_3$ (10%), $Mg_3(PO_4)_2$(10%), Fluorides (very less).

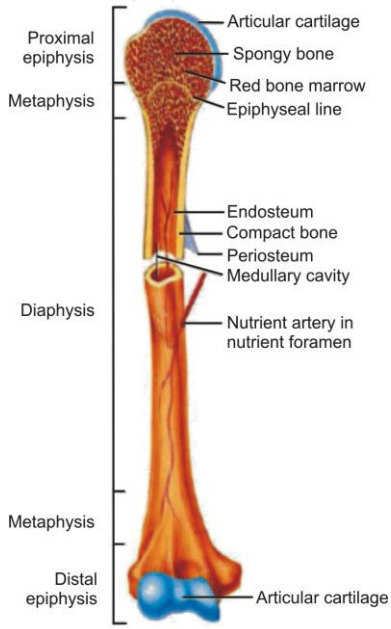
  Organic part :- **32 – 35%** ossein protein in which bundle of collagen fibres suspended in sulphated mucopolysaccharide.

  Sharpay's fibre :- Bundles of collagen fibres are present in outermost layer of bone and called **sharpey's fibres.** They provide extra mechanical strength to bone.

Internal Structure of Mammalian Bone

It has following major structures

1. Periosteum 2. Matrix 3. Endosteum 4. Bone marrow cavity



Partially sectioned humerus (arm bone)

1. PERIOSTEUM

Outermost covering of bone is called **Periosteum.**

It consists of two layers.

Outer layer consist of white fibrous connective tissue in which blood circulation is present.

Inner layer - consists of single layer of osteoblast cells. They divide to form osteocyte and secrete layers of matrix.

2. MATRIX

- It is composed of inorganic & organic compounds.
- In the matrix of bone, two types of canals are present.

1. Haversian canal 2. Volkmann's canal

1. **Haversian canal -** Longitudenal canals which are arranged parallel to long axis of bone. In these canals, one or two blood capillaries and nerve fibres are present.
2. **Volkmann's Canal -** These are transverse/horizontal or oblique canals.

Haversian canals are interconnected by volkmann's canal. Matrix of bone is synthesized in the form of layer. These layers of matrix are called lamellae. On the basis of arrangement three types of lamellae are present in the matrix.

(i) Haversian lamellae
(ii) Interstitial lamellae
(iii) Circumferential lamellae.

(i) HAVERSIAN LAMELLAE

Concentric layers of matrix which are present around Haversian Canal.

Between these lamellae, layer of osteocyte cells are also present.

Haversian canal, Haversian lamellae & osteocyte form **Haversian system or Osteon**.

Presence of haversian system is a typical feature of mammalian compact bones.

Osteocyte are present in the lacuna. Each osteocyte is interconnected with adjacent osteocyete by their cytoplasmic process. Cytoplasmic process of osteocyte are present in the canals of lacuna called as canaliculi.

(ii) INTERSTITIAL LAMELLAE

These layers of matrix are present in the space between two haversian systems.

(iii) CIRCUMFERENTIAL LAMELLAE - Circumferential layer of matrix are of two types.

(a) Outer circumferential lamellae: These are present around all Haversian system. These are peripheral layers of matrix.

(b) Inner circumferential lamellae: Present around bone marrow cavity.

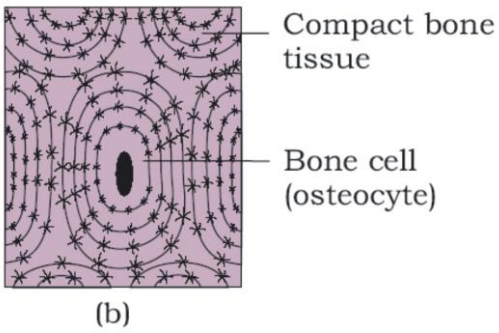
3. ENDOSTEUM - Endosteum consist of two layers.

Towards bone marrow cavity layer lined with reticular fibrous connective tissue.

Towards matrix of bone endosteum lined with layer of osteoblast cells. They divide to form osteocyte & synthesize matrix. So growth of bone is bidirectional (Periphery & central region). While growth of cartilage is unidirectional (Periphery).

4. BONE MARROW CAVITY

In the central region, hollow cavity is present which is filled with yellow bone marrow. It is composed of white fat & its function is collection of fats or storage of fats.



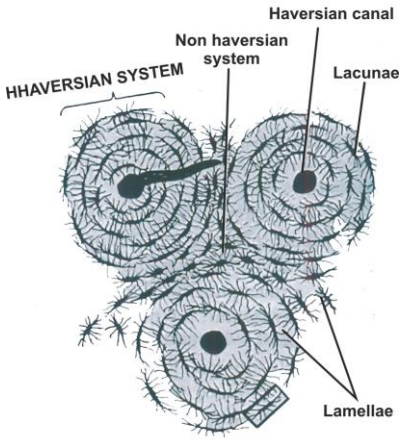


Fig. T.S. of mammalian bone

Resonate the Concept
Bone marrow- long bones such as humerus and femur contain a cavity inner to endosteum called bone marrow cavity. This cavity is filled with bone marrow which is actually myeloid tissue. Bone marrow is of two types- **Red Bone Marrow-** its colour is red due to presence of abundant blood vessels. It is present in the spongy part of the bone. It produces RBC, WBC and blood platelets. During foetal life it is present in entire skeleton. In adults it is present in vertebrae, sternum, ribs, clavicle, scapula, cranial bones and proximal part of humerus and femur. **Yellow Bone Marrow-** it is present in shaft of long bones. It is yellow in colour, has abundant adipose tissue, and deficient in blood supply. It produces blood corpuscles under emergency conditions i.e. changes into red bone marrow.

Types of Bones-

1. **On basis of texture-** based on texture bone can be divided in to two types-
   (a) **Compact or Dense Bone-** It is comparatively hard and compact. It contains yellow bone marrow and has Haversian system. **Eg, Shaft of long bones.**
   (b) **Spongy or Cancellate Bone –** Bones in which haversian systems are absent. In these bones marrow cavity is present in the form of trabeculae filled with RBM. So all spongy bones of body are haemopoietic. **Eg,** Ribs, Pubis, Sternum, Vertebrae, Clavicle, End of long Bones, Scapula

2. **On the basis of development or location of ossification, bones are of four types.**
   (a) **Cartilagenous bones/Replacing/Endochondral bone**
   These bones are developed from cartilage or they are formed by the ossification of cartilage. These bones are also called as replacing bones.
   Eg. Maximum bones of our body like limb bones (fore & hind limb), Ribs.

   (b) **Membranous bones/Dermal bones/Investing bones**
   These bones are devloped from the connective tissue of dermis or formed by ossification in the connective tissue of dermis.
   Eg. Pubis, Sternum, Nasal Bone, Clavicle, Vomer Bone (Present in the posterior part of Nasal chamber) Scapula bone.
   Flat bones of skull- Parietal Bone, Frontal, Lachrymal, Temporal bone.
   Jaw bones.

3. **Sesamoid bones -** These bones are developed by the ossification of tendons at the joints.
   Eg. **Pisciform (wristbone)** of man and rabbit. **Patella (knee bone)** largest sesamoid bone.

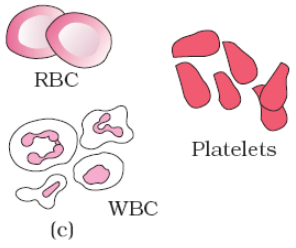
4. **Visceral Bones -** If ossification takes place in the visceral organs then *visceral* bones are formed. These are rare bones, found in few animals. In man these bones are absent.
   Eg. **Os Cardis :** Present in inter ventricular septum of deer's heart.
   Os Palpebrae : In the eyelid of crocodile.
   Os Penis (Baculum) : In the penis of rodents - rat, shrew, bat, whale, tiger
   Os rastralis : In the snout of pig.

(B) VASCULAR CONNECTIVE TISSUE

There are two types of vascular connective tissue: (1) Blood (2) Lymph
Matrix is liquid & fibre free

1. **Blood**
   Study of Blood - Haematology
   Process of blood formation- Haemopoiesis (in bone marrow).

Colour	-	Red
pH	-	7.4 (Slightly alkaline)
By weight	-	7 to 8% of body weight
By volume	-	5 – 6 liter



2. **Lymph :** Lymph is a mobile connective tissue comprising lymph plasma (fluid) and lymph corpuscles (cells).

Test your Resonance with concept

1. In mammals Haversian canals are connected with each other by transverse canals, which are called
(1) Semicircular canals (2) Volkman's canals
(3) Inguinal canals (4) Bidder's canals

2. Major constituent of bone is
(1) Calcium phosphate (2) Magnesium phosphate
(3) Calcium carbonate (4) Sodium chloride

3. Intervertebral disc is made up of
(1) Elastic cartilage (2) Fibrous cartilage
(3) Calcified cartilage (4) Hyaline cartilage

4. Red marrows of the bone produce
(1) Lymphocytes (2) Eosinophils (3) Plasma (4) RBCs

5. The bone cells are
(1) Chondroclasts (2) Osteoclasts (3) Osteoblasts (4) Osteocytes

Answers
1. (2) **2.** (1) **3.** (2) **4.** (4) **5.** (4)

MUSCULAR TISSUE

It consists of elongated cells, known as muscle fibres or myocytes, which can use ATP to generate force to cause body movements, maintain posture and generate heat. It is classified into three types **i.e.** skeletal, cardiac and smooth muscular tissue depending on their specific location and certain structural and functional characteristics.

❖ **Skeletal ,Striated , Striped or Voluntary muscular tissue**

It consists of long cylindrical muscle fibres with blunt ends. They are unbranched, multinucleated (an instance of structural syncytium) and contain many mitochondria or sarcosomes.It is easily fatigueable and is located in somatic muscles of body wall, tongue, upper part of pharynx, peripheral part of thoracoabdominal diaphragm.

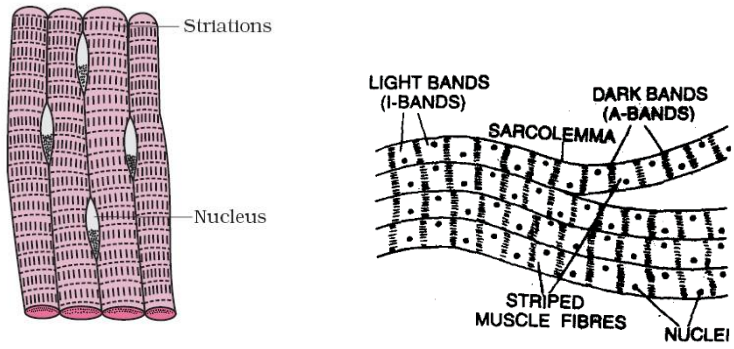


Fig. Structure of skeletal muscle

❖ **Cardiac muscular or myocardial tissue**

It is involuntary, feebly striated and present exclusively within the heart. They are uninucleated, short, cylindrical with truncated ends, branched and in fatiguable.It is characterized by the presence of tight junctions known as intercalated or booster discs at the sites of joining. The booster discs represent low resistance or high conductance zones to facilitate the rapid spread of electric waves of depolarization or nerve impulse between adjacent myocardial fibres.

Myocardium or heart muscle represents an instance of functional syncytium as each one of the different cardiac chambers contracts as independent unit despite being multicellular owing to the presence of intercalated discs and branching.

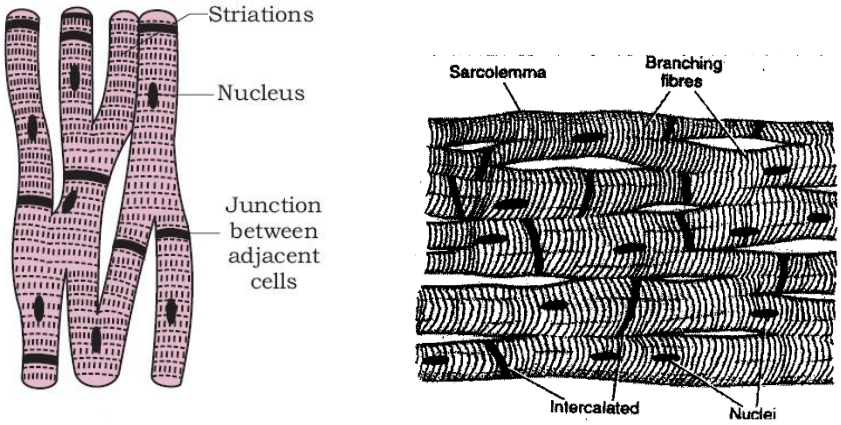


Fig. Structure of cardiac muscle

❖ **Visceral, Smooth, Unstriped or Non striated muscular tissue**

It consists of short, spindle shaped muscle fibres which are swollen in the middle and tapering at the ends. They are unbranched, uninucleated, devoid of striations and involuntary. They are located in different visceral organs like lower part of pharynx, oesophagus, stomach, small and large intestine, gall bladder, central part of thoracoabdominal diaphragm, renal pelvis, ureters, urinary bladder, fallopian tubes or oviducts, uterus, cervix and vagina.

It is responsible for peristalsis in parts of alimentary canal, urinary and reproductive tracts and involuntary contractions of gall bladder, diaphragm, uterus, cervix and vagina.

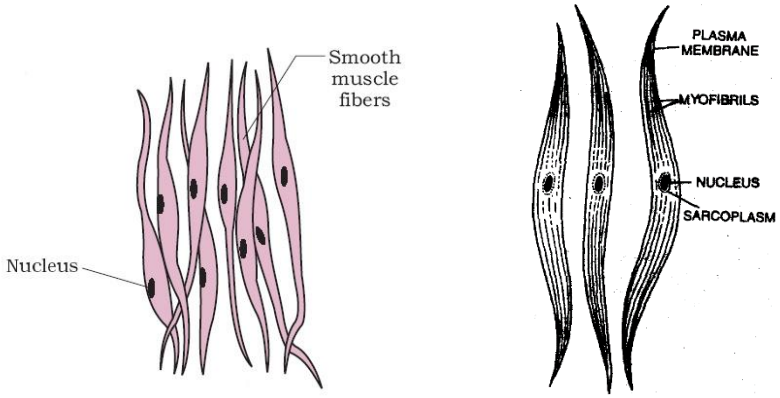


Fig - Structure of smooth muscle

Test your Resonance with concept

1. Which one of the following muscles, gets fatigued very quickly?
(1) Skeletal muscle (2) Smooth muscle (3) Cardiac muscle (4) All of the above

2. Smooth muscles are not
(1) Spindle shaped (2) Under control of autonomic nervous system
(3) Very simple in structure (4) Multinucleated

3. Unstriped muscles are found in
(1) Neck (2) Urinary bladder (3) Arms (4) Fingers

4. Unstriped smooth muscles are found in the
(1) Thigh (2) Arm (3) Iris (4) Tongue

5. Involuntary muscles are
(1) Under the control of will (2) Not under the control of animal's will
(3) Controlled by autonomic nervous system (4) Both (2) and (3)

Answers

1. (1) **2.** (4) **3.** (2) **4.** (3) **5.** (4)

NERVOUS TISSUE

Neural tissue exerts the greatest control over the body's responsiveness to changing conditions. Neurons, the unit of neural system are excitable cells. The neuroglial cell which constitute the rest of the neural system protect and support neurons. Neuroglia make up more than one half the volume of neural tissue in our body. When a neuron is suitably stimulated, an electrical disturbance is generated which swiftly travels along its plasma membrane. Arrival of the disturbance at the neuron's endings, or output zone, triggers events that may cause stimulation or inhibition of adjacent neurons and other cells.

It consists of two types cells: neurons and neuroglia

(i) Neurons -

They are responsible for sensing, thinking, remembering, controlling and coordinating muscular activities and regulating glandular secretions. Don't form layer & remain structurally separate. Can be differentiated from the other cells by perikaryon & dendrites. Usually do not divide as lack centrosome.

It consists of three parts namely cyton, dendrites and axon. Two neurons are joined by synapse which may be electrical or chemical

(ii) Neuroglial cells - Neuroglia supports, nourishes and protects the neurons and maintains homeostasis in the interstitial fluid surrounding them. Around 50% of CNS is made up of these cells.

They are of three types.

(a) Astrocytes/Macrocytes - They are large in size with a number of protoplasmic processes. They form maximum number of glial cells. They help in repair of nerve tissue and form blood brain barrier.

(b) Oligodendrocytes - They are with few protoplasmic processes and form myelin sheath in CNS.

(c) Microglial cells - They are mesodermal in origin. They are smallest in size with few feathery processes and help in phagocytosis.

Functions of Nervous Tissues:

1. Controls all the body activities.
2. Coordinates between various body parts during any body function.

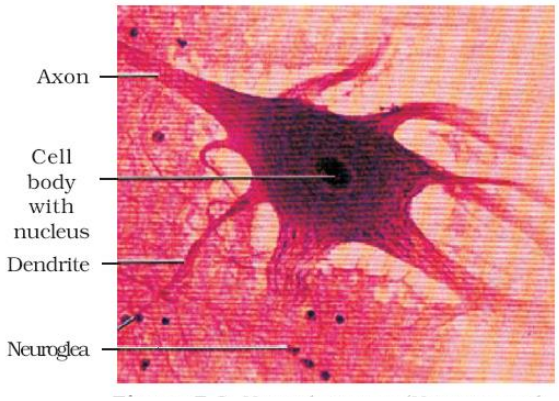


Figure - Neural tissue (Neuron with Neuroglea)

Test your Resonance with concept

1. Synapses store
(1) Stimulating chemicals (2) Inhibitory chemicals
(3) Conducting chemicals (4) All of these

2. The branched ends of nerve cells are called telodendria, which establish the functional contact with other nerve cell. This connection is called
(1) Sinongium (2) Synapse (3) Synapsis (4) Synapta

3. The nerve cells originate from the embryonic
(1) Ectoderm (2) Mesoderm (3) Both of these (4) Endoderm

4. Longest cell in human body may be a
(1) Nerve cell (2) Muscle cell in the leg
(3) Bone cell (4) Muscle cell in the heart

Answer

1. (4) **2.** (2) **3.** (1) **4.** (1)

ORGAN AND ORGAN SYSTEM

The basic tissues mentioned above organise to form organs which in turn associate to form organ systems in the multicellular organisms. Such an organisation is essential for more efficient and better coordinated activities of millions of cells constituting an organism. Each organ in our body is made of one or more type of tissues. For example, our heart consists of all the four types of tissues, i.e., epithelial, connective, muscular and neural. We also notice, after some careful study that the complexity in organ and organ systems displays certain distinguishable trend. This discernable trend is called evolutionary trend. Morphology refers to study of form or externally visible features. In the case of plants or microbes, the term morphology precisely means only this. In case of animals this refers to the external appearance of the organs or parts of the body. The word anatomy conventionally is used for the study of morphology of internal organs in the animals.