Biology 3 Hours

BIOLOGY

The Living World

Building blocks of life and their functions:

Living organism is formed of many types of inorganic as well as organic biomolecules. Inorganic compounds include water, minerals etc. and are always micro-biomolecules (small sized, low molecular weight, readily soluble in water and diffusible) while organic molecules may be micro (e.g. monosugars, amino acids etc.) or macrobiomolecules (large sized, high molecular weight, insoluble or slightly soluble and non-diffusible e.g., proteins, fats, nucleic acids, etc.). These both types of biomolecules play important roles in metabolism:

- Role of Water: Water forms 70-90% of the cellular pool. It forms 65% of human body. It is formed of H and O in the ratio of 2:1. 95% of water is found in free state and 5% in combined form in the cell.
- Role of Oxygen: Oxygen is mainly utilized in aerobic cell respiration of the nutrients inside the mitochondria to produce energy-rich ATP molecules so is essential for life. In the absence of oxygen, only 5% of energy available is released.
- Role of Sodium chloride (common salt): Sodium chloride plays an important role in metabolic functions of body especially when in ionic form.
- Role of Carbohydrates: Carbohydrates are organic compounds formed of C, H and O generally in the ratio of 1:2:1. These are commonly called saccharides (Gk. saccharon = sugar). Most organisms use carbohydrates as an important fuel, breaking these bonds and releasing energy to sustain life.
- Role of Proteins: Proteins are polymeric compounds formed by interlinking of amino acids (monomers) by peptide bonds. Out of about 100 types of amino acids, only 20 types of amino acids are of biological importance. Proteins play a vital role in the formation of structures in living organisms. Like carbohydrate and fat protein can be broken down with the release of energy.
- Role of lipids: Lipids comprise a major group of insoluble hydrocarbons having many functions. These are polymers of alcohols (e.g. glycerol) and fatty acids interlinked by ester bonds. Complex lipids such as true fats are important organic molecules that are used to provide energy.
- Role of Nucleic Acid: These are polymers of nucleotides interlinked by phosphodiester bonds, so called polynucleotides. Each nucleotide is formed of 3 components: a pentose sugar (e.g. ribose in RNA and deoxyribose in DNA), a phosphate group and an inorganic nitrogen-base (a purine or a pyrimidine).

  DNA acts as genetic material in most organisms and controls the synthesis of structural and. functional proteins. RNA also act as genetic material in all plant viruses e.g. TMV and helps in protein synthesis.

Systematics

1. The term 'Systematics' was proposed by Linnaeus in 1735.
2. It includes description of external morphological characters of plants or living organisms. E.g., morphological characters of root, stem, leave, flowers.
3. New systematics or Neo systematics or Biosystematics is a new branch. Its name was given by Julian Huxley (1940).
4. The term taxonomy was coined by A. P. de Candolle.
5. Carolus Linnaeus is called the father of taxonomy.
6. H. Santapau is called the father of Indian taxonomy.
    - Alpha taxonomy- Only morphological characters are used for identification and classification of plants.
    - Beta taxonomy- Involves genetical, anatomical, cytological, palynological, physiological and other characters.
    - Omega taxonomy- Analysis and synthesis of all information and types of data to develop classification system based on phylogenetic relationship.
7. **Cytotaxonomy –** The use of cytological characters of plants in classification or in solving taxonomic problems is called cytotaxonomy.
8. **Chemotexonomy –** The use of chemical compounds present in plants for classification or in solving taxonomic problems is called chemotaxonomy or chemical taxonomy. The basic chemical compounds used in chemotaxonomy are alkaloids, carotenoids, tannins, etc.
9. **Karyotaxonomy –** It is based on the characters of nucleus and chromosomes. Pattern of chromosomal bands is most specific character for classification of organisms.

Nomenclature

1. **Nomenclature** is giving distinct scientific names to various structures including living organisms for their identification.
2. The names are of two types – **vernacular** (common name) and **scientific names.**
3. **Types of Nomenclature -**
    - Polynomials nomenclature
    - Binomial nomenclature
    - Trinomial nomenclature
4. **Carolus Linnaeus** is the founder of binomial system.
5. Linnaeus proposed scientific names in his book "*Species planatarum*".
6. In binomial nomenclature, each scientific name has 2 components – **generic name** (genus) and **specific name**(species). Eg. Solanum tuberosum (potato).

ICBN-"International Code of Botanical Nomenclature"

1. Collection of rules regarding scientific nomenclature of plants.
2. ICBN was first proposed by **Sprague, Hitchcock, Green** (1930).
3. ICBN was first accepted in 1961.

Main rules of ICBN

- Name of any species consists of two names – Generic name and Specific name.
- In plant nomenclature, tautonyms are not valid i.e. generic name and specific name cannot be the same e.g., *Magnifera indica*. But tautonyms are valid for animal nomenclature e.g., *Naja naja* (Indian cobra).
- Length of genus or species should not be less than 3 letters and not more than 12 letters e.g., *Magnifera indica*. Exception: *Riccia pathankotensis*
- First letter of genus should be in capital letters and first letter of specific name should be in small letter.
- Name of scientist (who proposed nomenclature) should be written in roman in short after the specific name e.g., *Magnifera indica* Lin.
- If any scientist has proposed wrong name then his name should be written in bracket and the scientist who corrected the name should be written after the bracket e.g., *Tsuga canadensis* (Lin.) Salisbury.

Type specimen (herbarium sheet) are of different types-

Holotype: Herbarium sheet on which the first description of plant is based.

Isotype: Isotype is any duplicate specimen of the holotype.

Lectotype: In case holotype is lost, second herbarium sheet prepared from the original plant is called lectotype.

Isolectotype: Isolectotype is any duplicate specimen of the lectotype.

Syntype: In case holotype and original plant is lost then many herbarium sheet prepared from many plants of same species is called syntype.

Isosyntype: It is a duplicate specimen of a syntype.

Neotype: In case holotype and original plant is lost then herbarium sheet prepared from other plants of same species is called neotype.

Isoneotype: any duplicate specimen of the neotype.

Paratype: Additional description sheet used in the first description of plant is called paratype. It is prepared from some other plant of same species having some variations.

Taxonomic categories

a. Species b. Genus c. Family

d. Order e. Class f. Phylum g. Kingdom

Biological Classification

Systems of Classification:

- Identification of differences among organisms and placing them into groups that reflect their most significant features and relationship is called **biological classification.**
- Biological classification was first proposed by Aristotle who divided plants into herbs, shrubs and trees. Animals were classified into with RBC's and without RBC's.

Two kingdom classification:

It consists of artificial and natural system of classification.

- Artificial system of classification was proposed by Linnaeus.
- The first natural system of classification was proposed by **Schimper** (1879) followed by **Eichler** (1883).

Five kingdom classification:

(1) Given by R. H. Whittaker (1969).

(2) The five kingdom classification of Whittaker was based on 3 characters:

(a) **Complexity of cell:** Cell is prokaryote or eukaryote, on this basis, kingdom Monera is formed. And all the prokaryotes are grouped into it.

(b) **Complexity of organism:** Organism is unicellular or multicellular, on this basis kingdom Protista was formed, and all the unicellular eukaryotes are grouped into it.

(c) **Nutrition:** Organism is autotrophic or heterotrophic, on this basis kingdom Fungi, Plantae and Animalia were formed.

(3) The five kingdoms classified by Whittaker are:

Kingdom Monera:

- Includes prokaryotes.
- Typically unicellular organisms (but one group is mycelia).
- genetic material is naked circular DNA, not enclosed by nuclear envelop.
- Ribosomes and simple chromatophores are the only subcellular organelles in the cytoplasm. The ribosomes are 70S.
- Gas vacuole may be present.
- The predominant mode of nutrition is absorpitive. But some groups are photosynthetic and chemosynthetic.

- The organisms are non-motile ior move by beating of simple gflagella or by gliding.
- Flagella composed of many interwined chains of a protein **flagellin.**
- Maoneran cells are moicroscopic.
- Most organisms bear a rigid cell wall (peptidoglycan).
- Reproduction is primarily asexual by binary fission or budding. Mitotic apparatus is not formed during cell division.
- Examples: bacteria, actinomycetes, mycoplasma and cyanobacteria.
- Smallest and most abundant organism on Earth.

Bacteria:

- Bacteria are found in various shapes like:
  a) Coccus (spherical)
  b) Bacillus (rod-shaped)
  c) Vibrio (comma shaped)
  d) Spirillum (spiral shaped)

- Bacteria found almost everywhere and can be Photosynthetic autotrophs, Chemosynthetic autotrophs or Heterotrophs.

Archaebacteria:

- Archaebacteria has different cell wall structure due to which they can live in most harsh habitats.
  a) Halophiles (salt-loving), e.g., halobacterium and halococcus
  b) Thermoacidophiles (in hot springs), e.g., sulfobolus and thermoplasma
  c) Methanogen (marshy area),e.g., Methanobacterium, Methanolinea
- Methanogens are also found in the guts of several ruminant animals such as cows and buffalos and they are responsible for the production of methane (biogas) from the dung of these animals.

Eubacteria:

- These are also known as true bacteria.
- They have a rigid cell wall.
- They posses flagellum, if motile.
- They also known as blue green algae or **Cyanobacteria**.
- Cyanobacteria are **photosynthetic autotrophs**.

- These are unicellular, colonial or filamentous algae.
- Colonies are surrounded by **gelatinous sheath**.
- Some of the eubacteria can fix atmospheric nitrogen by specialized cells, e.g. *Anabaena* and *Nostoc*. These special cells are called **heterocyst.**
- **Chemosynthetic autotrophs**: Oxidize various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production. They play a great role in recycling nutrients like nitrogen, phosphorous, iron and sulphur.
- **Heterotrophic bacteria**: The most abundant in nature
  a) Most of them are decomposer
  b) They are helpful in making curd from milk.
  c) They are helpful in Production of antibiotics
  d) Some are pathogen causing diseases like cholera, typhoid, and tetanus.
- Bacteria reproduce mainly by **fission**, also produce **spore** in unfavorable condition.
- Reproduce sexually by transfer of DNA form one bacteria to other, the process called **conjugation**.

Mycoplasma:

- Completely lack a cell wall.
- Smallest living cells known.
- Can survive even without oxygen.
- Pathogenic in animals and plants.

Kingdom Protista:

- All are unicellular and eukaryotic.
- Primarily aquatic, can live in moist places.
- Forms a link with the others dealing with plants, animals and fungi.
- The cell body contains a well defined nucleus and membrane bound organelles.
- Some have cilia or flagella.
- Reproduce asexually and sexually by a process involving cell fusion and zygote formation.

◈ PHOTOSYNTHETIC AUTOTROPHS

Chrysophytes:

- Includes diatoms and **golden algae** (desmids)
- They are found in freshwater as well as in marine environments.
- Mostly planktonic (passive swimmer)
- Cell walls overlap to fit together like a soap box.
- Cell wall contains silica hence indestructible.
- Their accumulation forms '**Diatomaceous Earth'**.
- Used in polishing, filtration of oils and syrups.
- Diatoms are the chief '**producers'** in the oceans.

Dinoflagellates :

- Marine, photosynthetic.
- Cell wall has stiff cellulose plates.
- Appears yellow, green, brown, blue or red depending on the pigments.
- Have two flagella – one longitudinal and other transversely in a furrow between wall plates.
- Red Dinoflagellates (*Gonyaulax*) form **red tides.**

Kingdom Fungi

- Fungi are eukaryotic organisms.
- They are non-vascular.
- They reproduce by means of spores called **conidia** or **sporangiospores** or **zoospores**.
- Depending on the species and conditions both sexual and asexual spores may be produced.
- They are non-motile.
- Exhibit the phenomenon of alteration of generation.
- The vegetative body of the fungi may be unicellular or composed of microscopic threads called **hyphae**. The network of hyphae is known as **mycelium.**
- Cell wall composed of chitin.
- Fungi are heterotrophic organisms.
- Store their food as starch.
- Nutrition in fungi is saprophytic, or parasitic or symbiotic.
- Reproduction in fungi is both by sexual and asexual means. Sexual state is referred to as **teleomorph**, asexual state is referred to as **anamorph**.

Taxonomic class of Fungi	Hypha	Type of Reproduction	Characteristic spore	Origin of Spore	Examples of Fungi
Phycomycetes	Asptate	Asexually Sexually	Sporangio-spore Zygospore or oospore	Sporangio phore Fussion of nuclei	Nuisance fungi including general Absidia, Muclor, and Rhizopus
Ascomycetes	Septate	Asexually Sexually	Blastospore Conidium Ascospore	Budding Conidio-phore Ascus	Allescheria Aspergillus Piedraia Saccharomyces (perfect yeast)
Basidiomycetes	Septate	Sexually	Basidio-spore	Basidium	Mushrooms, smuts and rusts
Deutero-mycetes (fungi imperfecti)	Septate	Asexually	Thallospore Conidium	Thallus (hypha) Conidio-phore	Most saprophytes and pathogens encountered in medical mycology (Imperfect mold and yeast)

◈ LICHENS

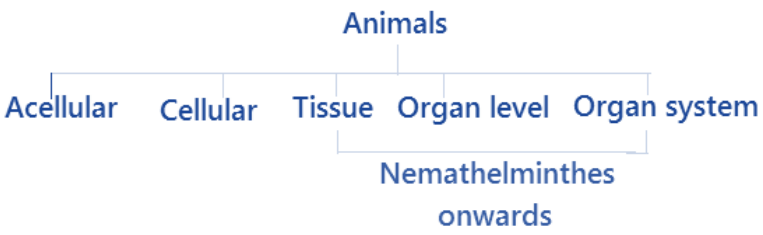
- Forms symbiotic relation with alga and fungus.
- Algal partner: phycobiont, fungal partner:mycobiont.
- Vegetative reproduction by fragmentation.
- Asexual as well as sexual reproduction.
- Three types:
  1. Crustose lichen: crust like growth,Thallus flat irregularly lobed.example:Rhizocarpon, Graphis
  2. Foliose lichen: Thallus like dry forked leaf, flat ,irregularly lobed example:Parmelia , Peltigera
  3. Fruticose lichen: Branched like a bush and attached to the substratum with the help of flattened disc. Example: Usnea , Cladonia

Kingdom Plantae

- Most of the plants are eukaryotic.
- They contain chlorophyll.
- Cells are surrounded by cell wall.
- Cell walls of plant cells are comprised of cellulose.
- They have an ability to grow by cell division. Growth occurs due to the presence of definite growing points or cells. In higher forms, growing areas are called meristems.
- In life cycle of plant cells, the interchanges occur from the embryos and are supported by other tissues and self produ ce.
- Plants have tissue and organ.
- They obtain their energy from sun through photosynthesis.
- Plants reproduce both sexually and asexually. **Alternation of generation** is found in plants.
- They lack motility.

Kingdom Animalia

- Animals are eukaryotic, multicellular and heterotrophic organisms.
- They have multiple cells with mitochondria
- They depend on other organisms for food.
- The size of animals ranges from a few celled organism like the mesozoans to animals weighing many tons like the blue whale.
- The animal cell contains organelles like the nucleus, mitochondria, Golgi complex, endoplasmic reticulum, ribosomes, lysosomes, vacuoles, centrioles, and cytoskeleton.
- They have tissue/organ/organ system.
- Organ systems are skeletal system, muscular system, digestive system, respiratory system, circulatory system, excretory system, reproductive system, immune system and the endocrine system.
- Most animals have the ability to move, they show rapid movement as compared to other organisms.



Plant Kingdom

Kingdom Plantae includes green, brown and red algae, liwerworts, mosses, ferns and seed plants with or without flowers. They have the following characters:-

(1) Multicellular organisms with walled and frequently vacuolate eukaryotic cells.

(2) They contain photosynthetic pigment in plastids.

(3) Principle mode of nutrition is photosynthesis but number of plants has become absorptive.

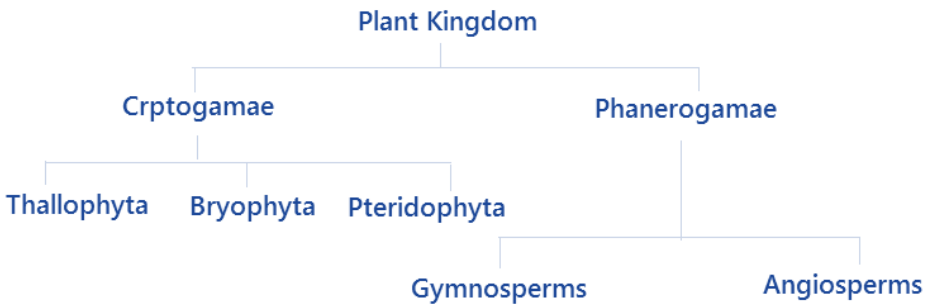
(4) Reproduction is primarily asexual or sexual. The reproductive organs are multicellular.

(5) A multicellular embryo is formed during development from the zygote. Algae lack embryo stage.

Life cycle consists of alternating haploid gametophyte and diploid sporophyte generation. This phenomenon is called alternation of generation.

Thallophyta

Algae



(1) The branch of botany dealing with the study of algae is called as phycology or algology.

(2) It is derived from the Greek word Phykos which means 'alga' or 'sea weed'.

(3) They are simple, autotrophic non-vascular plants having unicelled sex organs and no embryo formation.

(4) According to Fritsch, (1935) the designation alga must include all holophytic organisms.

(5) Specialized habitat

(1) Chlorophyceae

Plants fresh water or marine.

Forms unicelled to parenchymatous.

Chief pigments – Chlorophyll a, b; a, b, g– carotenes, lycopene, lutein, violaxanthin.

Reserve food – Starch and oils.

Zoospore formation occurs.

Male gametes flagellate.

Sexual reproduction – Isogamous, anisogamous or oogamous.

(2) Phaeophyceae

Plants marine

Forms unicelled to parenchymatous

Chief pigments – Chlorophyll a, c; beta–carotene, fucoxanthin, lutein, violaxanthin, diatoxanthin.
Reserve food – Laminarin, mannitol and oils.

Zoospore formation occurs.

Male gametes flagellate.

Sexual reproduction – Isogamous , anisogamous or oogamous.

(3) Rhodophyceae

Plants generally marine.

Forms filamentous to parenchymatous.

Chief pigments – Chlorophyll a, d is present but chlorophyll c is absent; a, b–carotene, lutein, violaxanthin, fucoxanthin, myxoxanthin, g–phycoerythrin, g–phycocyanin and allophycocyanin.
Reserve food – Floridean starch, galactan $–SO_4$ polymers.

No zoospore formation.

Male gametes non-flagellate.

Sexual reproduction by specialized type of oogamy.

Life cycle haplobiontic or diplobiontic.

Bryophyta

(1) Bryophyta (Gk: Bryon = moss; phyton = plants) includes the simplest and primitive land plants.

(2) Due to peculiar type of their habitats, they are regarded as 'the amphibians of the plant kingdom'.

(3) **Habitat:** Bryophytes usually grow in moist and shady places.

(4) **Specialized habitats:** Some bryophytes grow in diverse habitats such as –

(a) Aquatic (e.g., Riccia fluitans, Ricciocarpus natans, Riella), epiphytes (e.g., Dendroceros, Radula protensa and many mosses), saprophytes (e.g., Buxbaumia aphylla, Cryptothallus mirabilis)

(b) Dry habitats such as dry heaths (e.g., Polytrichum juniperinum), deserts (e.g., Tortula desertorum) and dry rocks (e.g., Porella platyphylla).

(5) Sexual reproduction: The male sex organ is called as antheridium and the female as archegonium.

(6) Salient features of classes

(i) **Hepaticopsida:** The latin word Hepatica means liver. Thus the members of hepticopsida are popularly known as liverworts.

(ii) **Anthocerotopsida:** This class is characterized by the following characters –

Gametophyte is thalloid. Thalli are lobed, dorsiventral, and internally homogenous without any differentiation of tissues.

Scales are absent.

Each cell possesses single (some times more) large chloroplast with central pyrenoid.

Antheridia are endogenous in origin, borne singly or in groups inside the closed cavities.

Sporogonium is differentiated into foot, meristematic zone and capsule (the seta is absent).

Capsule has central sterile columella.

(iii) **Bryopsida**: The members of bryopsida are commonly known as mosses. The class is characterised by the following characters –

Gametophyte is differentiated into two stages – prostrate protonema and erect radial leafy shoot.

Leaf-like appendages are spirally arranged on stem – like axis.

Rhizoids are multicellular with oblique septa.

Sex organs develop from superficial cells.

Sporogonium is differentiated into foot, seta and capsule.

Wall of capsule is several layered with stomata on epidermis.

The capsule has central columella.

Pteridophyta

(1) The pteridophytes (Gk. Pteron = feather and phyton = plants ; means plants with feather like fronds or ferns). They are flowerless, seedless, spore producing vascular plants which have successfully invaded the land.

(2) **Habitat:** The plants of pteridophytes are mostly terrestrial. They prefer shady habitats.

(3) They have Sporophytic plant body

(4) **Apical growth:** The pteridophyte generally possesses a single apical cell with three cutting faces in the shoot apex.

(5) Salient features of sub-phyla

(i) Sub-phylum: Psilopsida

(a) These are the oldest known vascular plants; most of them (except Psilotum and Tmesipteris) are fossils.

(b) Plant body is relatively less differentiated.

(c) Roots are absent; instead dichotomously branched rhizome is present.

(d) Aerial axis is either naked or have small spirally arranged leaves.

(e) Sporangia are cauline (i.e., directly borne on the axis or stem); they are lateral or terminal in position. e.g., Psilotum, Tmesipteris.

(ii) Sub-Phylum: Lycopsida

(a) Plant body is differentiated into root, stem and leaves.

(b) Leaves small (i.e., microphyllous) with a single unbranched vein.

(c) Sporangia develop in the axil of the sporophylls.

(d) Sporophylls generally form compact strobili. e.g., Lycopodium, Selaginella, etc.

(iii) Sub-Phylum: Sphenopsida

(a) Stem differentiated into nodes and internodes.

(b) Leaves microphyllous, present in whorls at each node.

(c) Sporangia are borne on the sporangiophores which form compact cones at the apex of the fertile branches. e.g., Equisetum.

(iv) Sub-Phylum: Pteropsida

(a) Plant body well differentiated into root, stem and leaves.

(b) Leaves megaphyllous, pinnately compound.

(c) Sporangia develop on the ventral surface of the sporophylls, usually aggregated into sori. e.g., Dryopteris, Pteris, Pteridium, Polypodium, etc.

Angiosperms

The angiosperms, or flowering plants, constitute the most dominant and ubiquitous vascular plants of present day flora which changed the green and yellow melancholy of the earth's vegetation by the colourful brightness and fragrance of their flower.

(i) Dicotyledons :

They are show following distinguished characteristics.

(a) Tap roots found in the members of this group.

(b) The leaves in members of these class exihibit reticulate (net like) venation.

(c) The flowers are tetramerous or pentamerous having four or five members in the various floral whorls, respectively.

(d) The vascular bundles arranged in a ring, numbering 2–6, open and with cambium.

(e) The seeds of dicotyledons are with two cotyledons as the name indicate.

(ii) Monocotyledons:

They are show following distinguished characteristics:

(a) Adventitious roots found in the members of this group.

(b) The leaves are simple with parallel venation.

(c) The flowers are trimerous having three members in each floral whorl.

(d) The vascular bundles scattered in the ground tissue, many in number, closed and without cambium.

(e) The seeds of monocotyledons are with one cotyledon as the name indicates. e.g., Cereals, bamboos, sugarcane, palms, banana, lilies and orchids.

Gymnosperms

(1) Living gymnosperms are mostly perennials, xerophytic, evergreen, arboreal and woody plants.

(2) They grow as wood trees, bushy shrubs or rarely as climbers (e.g., Gnetales).

(3) None of them are herbs or annuals.

(4) External features:

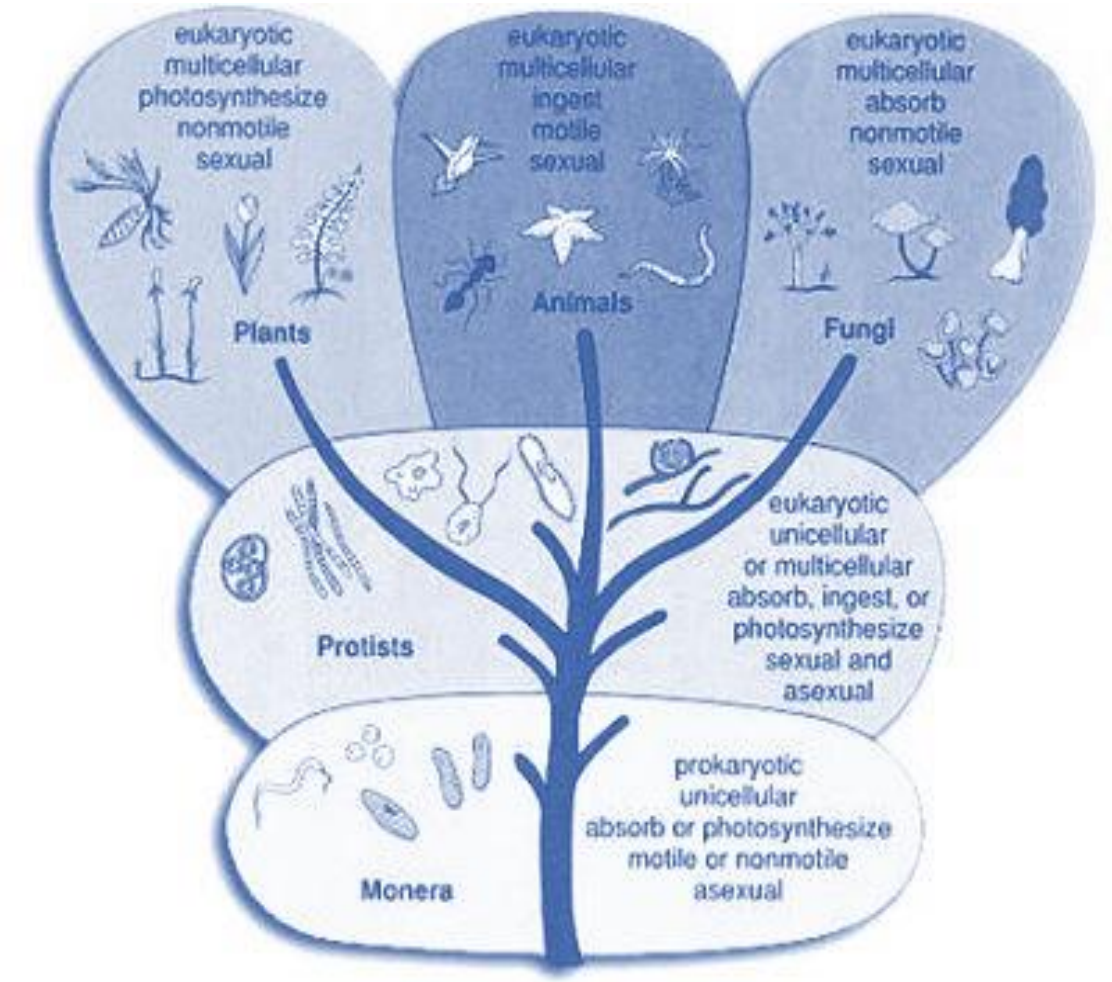
(i) The plant body is sporophyte and differentiated into root, stem and leaves.

(ii) The plant possesses well developed tap root system. In some cases the roots are symbiotically associated with algae (e.g., Coralloid roots of Cycas) or with fungi (e.g., Mycorrhizal roots of Pinus).

(iii) The stem is erect, aerial, solid, woody and branched (unbranched in Cycadales) but almost tuberous in Zamia.

(iv) The leaves may be microphyllous or megaphyllous

Animal Kingdom



(i) Characters of Non Chordata (Invertebrates): The animals which lack a notochord are called invertebrates. e.g. Amoeba, sponges, Hydra, worms, insects, etc., Invertebrates are characterised by the following salient features –

(1) The vertebral column is absent.

(2) The nerve cord is solid in nature.

(3) The nerve cord is present on the ventral side and never on the dorsal side.

(4) When alimentary canal is present, it lies dorsal to the nerve cord.

(5) Invertebrates may be acoelomate or pseudocoelomate or true coelomate.

(6) They have either asymmetry or radial symmetry or bilateral symmetry.

(7) The circulatory system is open type or closed type.

(8) They exhibit all possible type of reproduction.

- Phylum Protozoa and Porifera
- Phylum Cnidaria and Ctenophora
- Phylum Platyhelmithes and Nematoda
- Phylum Mollusca and Echinodermata

(ii) Characters of Chordata (Vertebrates): The animals which possess a notochord are called vertebrates.

(1) Aquatic, aerial or terrestrial.

(2) Body small to large, bilaterally symmetrical and metamerically segmented.

(3) A post anal tail usually projects beyond the anus at some stage and may or may not persist in the adult.

(4) Exoskeleton often present; well developed in most vertebrates.

(5) Body wall triploblastic with 3 germinal layers : ectoderm, mesoderm and endoderm.

(6) Coelomate animals having a true coelom, enterocoelic or schizocoelic in origin.

(7) A skeletal rod, the notochord, present at some stage in life cycle.

(8) A cartilaginous or bony, living and jointed...

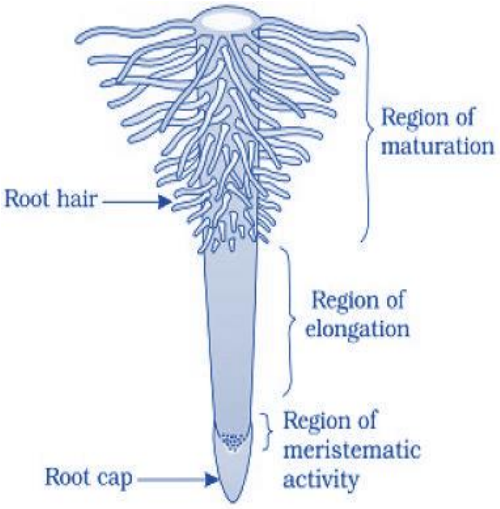
Morphology & Anatomy of flowering Plants

Morphology (Gr. *Morphos* = Form; *logos* = Study) is the branch of science which deals with the study of form and structure. In botany, it generally means the study of external features, forms and relative positions of different organs on plants.

Angiospermic or flowering plants show a great variety of shape, size and form. The size ranges from the minute*Wolffia* and *Lamna* (0.1*cm*) to the tall *Eucalyptus* (up to 100 *metre*) and large sized Banyan (*Ficus bengalensis*).

Parts of a flowering plant:

The Root



The root is usually an underground part of the plant which helps in fixation and absorption of water. The root with its branches is known as the root system.

(1) **Characteristics of the root**

(i) The root is the descending portion of the plant axis and is positively geotropic.

(ii) It is non-green or brown in colour.

(iii) The root is not differentiated into nodes and internodes.

(iv) As per the rule the root does not bear leaves and true buds.

(v) Usually the root tip is protected by a root cap.

(vi) The root bears unicellular root hairs.

(vii) Lateral roots arise from the root which are endogenous in origin (arises from pericycle).

(2) **Types of root system:**

The root system is generally of two types:

(i) **Tap root system:** The tap root system develops from radicle of the germinating seed. It is also called the normal root system. The tap root system is present in **dicotyledonous plants**.

(ii) **Adventitious root system:** The root system that develops from any part of the plant body other than the radicle is called the adventitious root system. It is mostly seen in monocotyledonous plants.

The Stem

(1) The stem develops from the plumule of the germinating seed.

(2) The stem shows the differentiation of nodes and internodes.

(3) The place where the leaf develops on the stem is called the **node**.

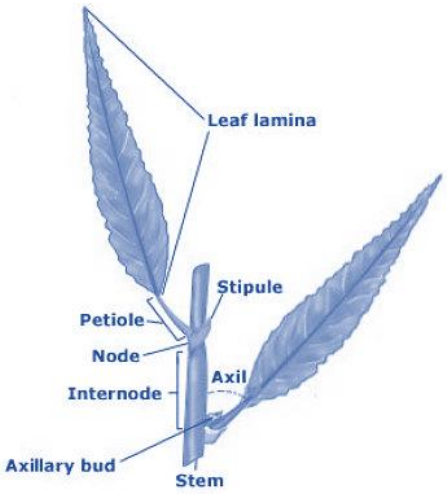
(4) The portion of the stem between two successive nodes is called the **internode**.

(5) **Characteristics of stem**

(i) Stem is an ascending axis of the plant and develops from the plumule and epicotyl of the embryo.
(ii) It is generally erect and grows away from the soil towards light. Therefore, it is negatively geotropic and positively phototropic.
(iii) The growing apex of stem bears a terminal bud for growth in length.
(iv) In flowering plants, stem is differentiated into nodes and internodes.
(v) The lateral organs of stem (*i.e.*, leaves and branches) are exogenous in origin (from cortical region).
(vi) The young stem is green and photosynthetic.
(vii) Hair, if present, are generally multicellular.
(viii) In mature plants, stem and its branches bear flowers and fruits.

The Leaf

The leaf is a green, flat, thin, expanded lateral appendage of stem which is borne at a node and bears a bud in its axil. It is exogenous in origin and develops from the leaf primordium of shoot apex. The green colour of leaf is due to presence of the photosynthetic pigment – chlorophyll which helps plants to synthesize organic food. The green photosynthetic leaves of a plant are collectively called **foliage**. They are borne on stem in acropetal succession.

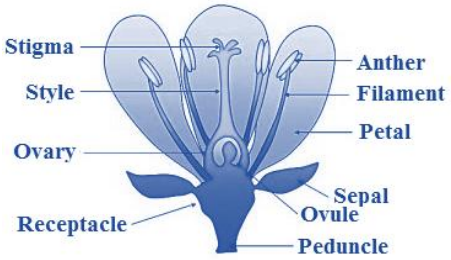


(1) **Characteristics of lea**
(i) The leaf is a lateral dissimilar appendage of the stem.
(ii) A leaf is always borne at the node of stem.
(iii) Generally there is always an axillary bud in the axil of a leaf.
(iv) It is exogenous in origin and develops from the swollen leaf primordium of the growing apex.
(v) The growth of leaf is limited.
(vi) The leaves do not possess any apical bud or a regular growing point.
(vii) A leaf has three main parts – Leaf base, petiole and leaf lamina. In addition, it may possess two lateral outgrowths of the leaf base, called stipules.
(viii) The leaf lamina is traversed by prominent vascular strands, called veins.

Flower

It can be defined as modified dwarf shoot which is meant for sexual reproduction.

(1) Floral **Parts of a typical flower:**
(i) **Calyx:** It is the outermost whorl composed of**sepals**. The calyx may show number of modifications. They are:
Campanulate : Bell shaped, e.g., *Althaea.*
Cupulate : Cup like, e.g., *Gossypium.*
Petaloid : Enlarged and brightly coloured sepals, e.g., *Clerodendron, Mussaenda*



(ii) **Corolla:** It is composed of **petals** and is the second whorl.

The corolla may undergo modifications or possess some special appendages.

(a) Sepaloid : Green or dull coloured sepal. e.g., *Anona*, *Polyalthia* and *Artabotrys.*

(b) Saccate : The corolla tube may form a pouch on one side. e.g., *Antirrhinum*.

(c) Spurred : Sometimes one or two petals or the entire corolla tube grow downwards forming a spur that usually stores nectar. *e.g., Aquilegia vulgaris.*

(d) Corona : Special appendages of different kinds like scales, hairs develop from the corolla. Such appendages are called corona. e.g., *Passiflora, Oleander* and *Nerium*.

(iii) **Androecium:** It is the third whorl composed of **stamens**.

The mode of attachment of a filament to anther by connective is called fixation. It is of following types:

(a) Adnate : Filament attached to the total length of the anther on the back. e.g., *Michelia* (Campa).

(b) Basifixed : Filament is attached to the base of the anther e.g.,...

ANATOMY

A tissue may be defined as, **"a group of similar or dissimilar cells having common origin and performing a specific functions."**

Tissues are mainly divided into three categories:

(A) Meristematic tissues or Meristems

(B) Permanent tissue

(C) Secretory tissue

Meristematic Tissues or Meristems

(1) They contain immature and young cells and are capable of repeated divisions.

(2) Intercellular spaces are not present in meristematic tissue.

(3) They contain a homogeneous thin wall.

(4) They contain large nuclei associated with abundant cytoplasm.

(5) They are metabolically very active but they do not store food material.

(6) Only proto-plastids are present instead of plastids, chloroplast absent.

(7) Dense cytoplasm is present which contains several premature mitochondria.

(8) Vacuoles are absent.

(9) Meristematic cells are isodiametric in shape.

Types of meristems

The meristems may be classified on the basis of their mode of origin, position or function:

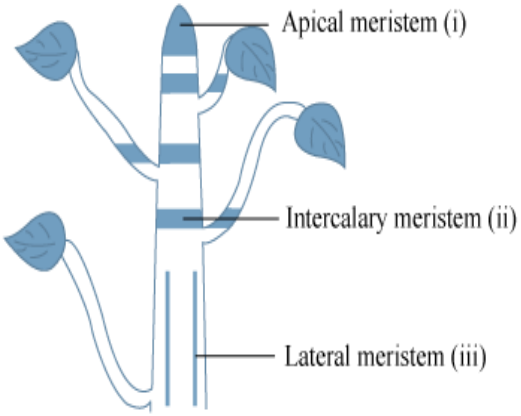
(i) **According to origin and development:** On the basis of origin, meristematic tissues are of three types :

(a) **Promeristem or Primordial meristem:** The promeristem originates from embryo and, therefore, called primordial or embryonic meristem. It is present in the regions where an organ or a part of plant body is initiated.

(b) **Primary meristem:** A primary meristem originates from promeristem and retains its meristematic activity. It is located in the apices of roots, stems and the leaf primordia.

(c) **Secondary Meristem:** They always arise in permanent tissues and have no typical promeristem. Some living permanent cells may regain the meristematic nature.

(ii) **According to position:** On the basis of their position in the plant body meristems are classified into three categories:



(a) **Apical meristem:** This meristem is located at the growing apices of main and lateral shoots and roots. These cells are responsible for linear growth of an organ.

(b) **Intercalary meristem:** These are the portions of apical meristems which are separated from the apex during the growth of axis and formation of permanent tissues. It is present mostly at the base of node (*e.g.*, *Mentha viridis*-Mint), base of internode (*e.g.*, stem of many monocots *viz.*, Wheat, Grasses, Pteridophyts like *Equisetum*) or at the base of the leaf (*e.g., Pinus*).

(c) **Lateral meristem:** These meristems occur laterally in the axis, parallel to the sides of stems and roots. This meristem consists of initials which divide mainly in one plane (periclinal) and result increase in the diameter of an organ.

(iii) **According to function:** Haberlandt in 1890 classified the primary meristem at the apex of stem under the following three types :

(a) **Protoderm:** It is the outermost layer of the apical meristem which develops into the epidermis or epidermal tissue system.

(b) **Procambium:** It occurs inside the protoderm. Some of the cells of young growing region which by their elongation and differentiation give rise to primary vascular tissue constitute the procambium.

(c) **Ground meristem:** It constitutes the major part of the apical meristem develops ground tissues like hypodermis, cortex, endodermis, pericycle, pith and medullary rays.

(iv) **According to plane of cell division:** On the basis of their plane of cell division meristem are classified into three categories :

(a) **Mass meristem:** The cells divide anticlinally in all planes, so mass of cells is formed. *e.g.,* formation of spores, cortex, pith, endosperm.

(b) **Plate meristem:** The cells divide anticlinally in two planes, so plate like area increased. *e.g.,* formation of epidermis and lamina of leaves.

(c) **Rib or File meristem:** The cells divide anticlinally in one plane, so row or column of cells is formed. *e.g,,*formation of lateral root.

Permanent Tissues

Permanent tissues are made up of mature cells which have lost the capacity to divide and have attained a permanent shape, size and function due to division and differentiation in meristematic tissues. The cells of these tissues are either living or dead, thin-walled or thick-walled. Permanent tissues are of three types :

(1) **Simple tissues:** Simple tissues are a group of cells which are all alike in origin, form and function. They are further grouped under three categories :

(i) **Parenchyma:** Parenchyma is most simple and unspecialized tissue which is concerned mainly with the vegetative activities of the plant.

(ii) **Collenchyma:** The term collenchyma was coined by Schleiden (1839). It is the tissue of primary body.

The cells of this tissue contain protoplasm and are living.

The cell walls are thickened at the corners and are made up of cellulose, hemicellulose and pectin.

(iii) **Sclerenchyma:** It was discovered and coined by Mettenius (1805).

The main feature of sclerenchyma are :

It consist of thick-walled dead cells.

The cells vary in shape, size and origin.

Special or secretory tissues

These tissue perform special function in plants, *e.g.*, secretion of resins gum, oil and latex.

These tissues are of two types :

(1) Laticiferous tissues

(2) Glandular tissues

(1) **Laticiferous tissues:** They are made up of thin walled, elongated, branched and multinucleate (coenocytic) structures that contain colourless, milky or yellow coloured juice called latex. These occur irregularly distributed in the mass of parenchymatous cells. latex is contained inside the laticiferous tissue which is of two types:

(i) **Latex cells:**

(a) A laticiferous cell is a very highly branched cell with long slender processes ramifying in all directions in the ground tissue of the organ.

(b) Plants having such tissues are called simple or non-articulated laticifers. *e.g., Calotropis*(Asclepiadaceae) *Nerium*, *Vinca* (Apocyanaceae), *Euphorbia* (Eu phorbiaceae), *Ficus* (Moraceae).

(ii) **Latex vessels:**

(a) They are formed due to fusion of cells and form network like structure in all directions.

(b) Plants having such tissues are called compound or *articulated laticifers*. *e.g., Argemone, Papaver*(Papaveraceae), *Sonchus* (Compositae), *Hevea, Manihot* (Euphorbiaceae).

(2) **Glandular tissue:** This is a highly specialized tissue consisting of glands, discharging diverse functions, including secretory and excretory. Glands may be external or internal.

(i) **External glands:** They are generally occur on the epidermis of stem and leaves as glandular hair in *Plumbago*and *Boerhaavia*.

(ii) **Internal glands:** These are present internally and are of several types. *e.g.,* oil glands in *Citrus* and *Eucalyptus*, resinous ducts in *Pinus*.

The Tissue System

A collection of tissues performing the same general function is known as a “Tissue System''. According to Sachs (1975) there are three major tissue systems in plants as follows:

(1) Epidermal tissue system

(2) Ground or fundamental tissue system

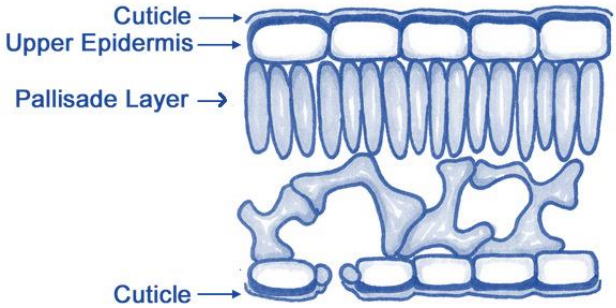
(3) Vascular tissue system

(1) **Epidermal tissue system:** The tissues of this system originate from the outermost layer of apical meristem.

(i) **Epidermis:** Epidermis is composed of single layer cells.

(ii) **Cuticle and Wax:** In aerial parts, epidermis is covered by cuticle. The epidermal cells secrete a waxy substance called cutin, which forms a layer of variable thickness (the cuticle) within and on the outer surface of its all walls. it helps in reducing the loss of water by evaporation.

Cross section of a typical dicot leaf:



(iii) **Stomata:** Stomata are minute apertures in the epidermis. Each aperture is bounded by two kidney shaped cells, called guard cells. Stomata are absent in roots.

Depending upon distribution of stomata, the leaves are :

(a) **Apple-mulberry type:** *e.g. Oxalis, Mulberry, Apple*.

(b) **Potato type:** *e.g.* Bifacial (dorsiventral leaves of pea, bean, tomato).

(c) **Oat type:** *e.g.* Suberect (isobillateral) leaves of most grasses and cereals (monocotyledens).

(d) **Nymphea type:** *e.g.* Floating leaves of *Nelumbo, Nymphia,* water lily.

(e) **Potamogeton type:** *e.g.* Submerged plants like *Hydrilla, Vallisneria, Potamogeton*.

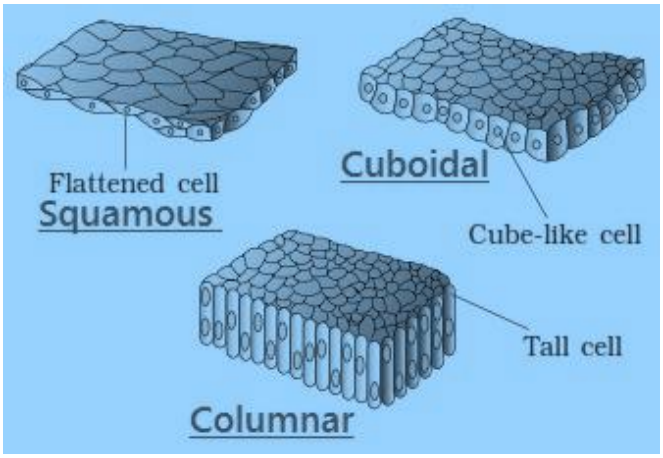
(iv) **Trichomes:** These are epidermal outgrowths present temporarily or permanently on almost all plant parts.

(v) **Root hairs:** They are enlargements of special epiblema cells called **trichoblasts** and occurs in a particular zone of young.

Structural Organization in Animals

Epithelial Tissues

- An epithelium is a tissue composed of one or more layers of cells that cover the body surface and lines its various cavities.
- It serves for protection, secretion and excretion..
- Epithelial tissue evolved first in animal kingdom.
- It originates from all the three primary germ layers. *e.g.* Epidermis arises from ectoderm, Coelomic epithelium from the mesoderm and epithelial lining of alimentary canal from the endoderm.
- **Types of Epithelium**



Glands

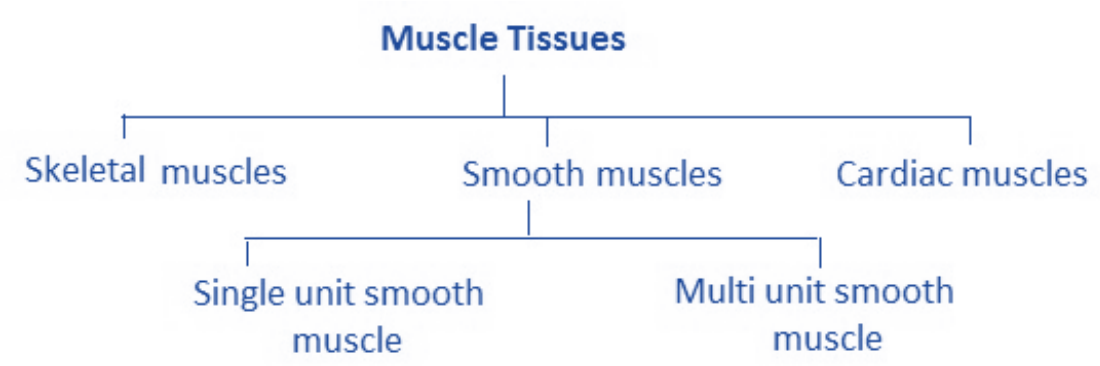
- Multicellular exocrine glands are classified by structure, using the shape of their ducts and the complexity (branching) of their ducts system as distinguishing characteristics.
- Shape include tubular and alveolar (Sac like).
- Simple exocrine glands *e.g.* intestinal glands, mammalian sweat glands, cutaneous glands of frog etc. have only one duct leading to surface.
- Compound exocrine glands have two or more ducts *e.g.* liver, salivary glands etc.

- **Structural classification of exocrine glands:**

Type	Example
Simple tubular	Intestinal glands, crypts of Lieberkuhn in ileum.
Simple coiled tubular	Sweat glands in man
Simple branched tubular	Gastric (stomach) gland, and Uterine gland.
Simple alveolar	Mucous gland in skin of frog, Poison gland of toad and seminal vesicle.
Simple branched alveolar	Sebaceous glands
Compound tubular	Brunner's gland, bulbourethral gland and liver.
Compound alveolar	Sublingual and submandibular parotid salivary gland
Compound tubulo alveolar	Parotid salivary glands, Mammary gland and Pancreas.

Muscle Tissues

- Muscle cells are highly contractile (contracting to 1/3 or 1/2 the resting length).
- Muscle cells lose capacity to divide, multiply and regenerate to a great extent. Study of muscle is called myology.
- About 40% to 50% of our body mass is of muscles.
- The muscle cells are always elongated, slender and spindle-shaped, fibre-like cells, These are, therefore called muscle fibres.
- These possess large numbers of myofibrils formed of actin and myosin.

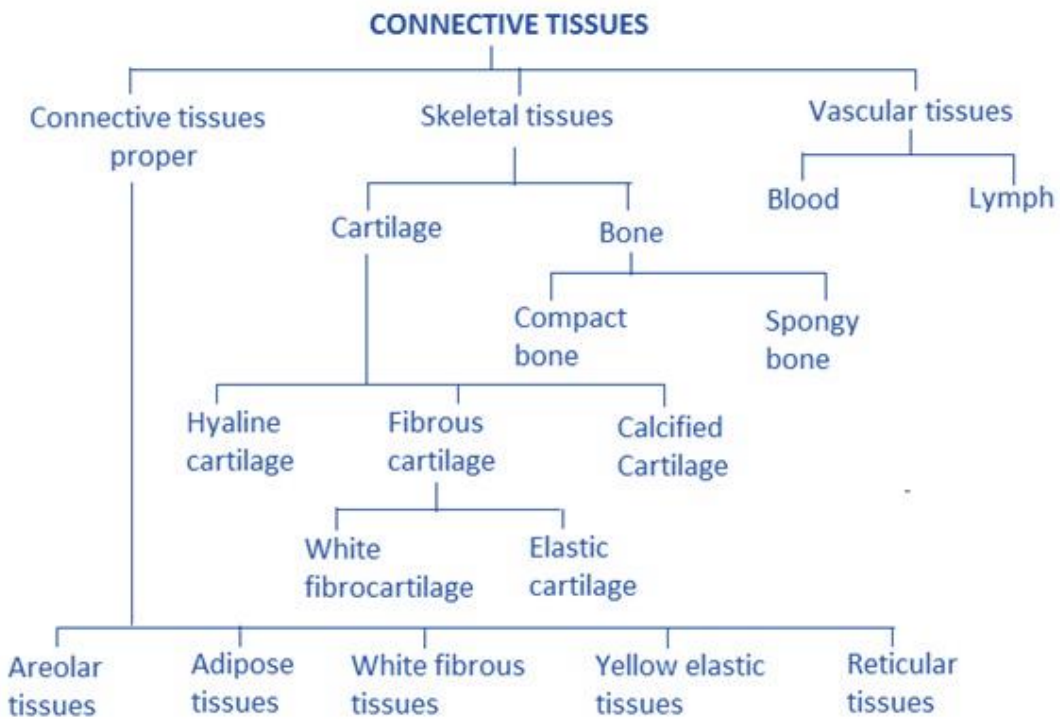


(f) **Difference between three types muscle fibres**

S.No.	Feature	Striated or Striped or Skeletal or Voluntary muscle fibres	Non-striated or Unstriped or Smooth or Visceral or Involuntary muscle fibres	Cardiac muscle fibres
1.	Shape	Long cylindrical	Fusiform (thick in middle tapering at ends) (0.02 nm to 0.2 nm long)	Network of fibres
2.	Stripes	Dark A bands and light I bands present	Absent	Present
3.	Nucleus	Many (syncytial) at periphery	Single at the centre of each cell	Many nuclei between successive end plates central position
4.	Unit	Sarcomeres, cylindrical long myofibrils placed end to end forming cylindrical myofibrils	Fusiform cells with inconspicuous borders	Oblique cross-connecting fibres make this muscle an interconnected bundle of myofibrils
5.	Attachment	To bones	To soft organs or viscera	Not attached to other organs except major blood vessels which are isolated and covered by pericardium
6.	Sarcolemma	Distinct	Absent	Absent
7.	Sarcoplasmic Reticulum	Well developed	Less extensive	Poorly formed
8.	Blood supply	Rich	Poor	Rich
9.	Contraction	Quick, fatigue fast	Slow, sustained contraction	Rhythmic, contractions originate in heart (pace maker immune to fatigue)
10.	Location	Generally peripheral, tongue, proximal part of oesophagus	Central, in hollow visceral organs, iris of the eye, dermis of the skin	Only in heart
11.	Intercalated discs	Absent	Absent	Present
12.	T-tubule system	Well developed	Lacking	Well developed
13.	Innervated nerves	Motor nerves from central nervous system (neurogenic)	Nerves from autonomic nervous system (neurogenic)	Nerves from central and autonomic nervous system (myogenic)
14.	Fibres	Unbranched	Unbranched	Fibres join by short oblique bridges
15.	Action	Voluntary	Involuntary	Involuntary

Connective Tissues

- It connects and supports all the other tissues, the intercellular element predominating.
- The cellular element is usually scanty. In function this tissue may be mechanical, nutritive and defensive.
- It is a tissue made up of matrix (abundant intercellular substance or ground substance) and living cells that connects and support different tissues.
- Connective tissue was called mesenchyme by Hertwig (1893).
- Types of connective tissues



(1) **On the basis of their texture:**

The bones are divided into two categories spongy or cancellous or tubecular bones and compact or periosteal bones

Bone	Cartilage
1. Matrix is composed of a tough, inflexible material, the ossein.	**1.** Matrix is composed of a firm, but flexible material, the chondrin.
2. Matrix is always impregnated with calcium salts.	**2.** Matrix may be free or impregenated with calcium salts.
3. Bone cells lie in lucunae singly.	**3.** Cartilage cells lie in lacunae singly or in groups of two or four.
4. Osteocytes are irregular and give off branching processes in the developing bone.	**4.** Chondroblasts are oval and devoid of processes.
5. Lacunae give off canaliculi.	**5.** Lacunae lack canaliculi.
6. There are outer and inner layers of special bone forming cells, the osteoblasts, that produce new osteocytes, which secrete new lamellae of matrix.	**6.** There are no special cartilage-forming cells. Cartilage grows by division of all chondroblasts.
7. Matrix occurs largely in concentric lamellae.	**7.** Matrix occurs in a homogenous mass.
8. Bone is highly vascular.	**8.** Cartilage in nonvascular.
9. Bone may have bone marrow at the centre.	**9.** No such tissue is present.

(6) **Number of RBC:** The number of RBCs is counted by instrument haemocytometer.

S.No.	Organism	Number of RBCs
1.	Male	5 – 5.4 million / cubic mm of blood
2.	Female	4.5 – 5 million / cubic mm of blood
3.	Infants	65 – 70 lacs/ cubic mm of blood
4.	Embryo	85 lacs/ cubic mm of blood
5.	Rabbit	70 lacs / cubic mm of blood
6.	Frog	4 lacs / cubic mm of blood

(7) **Life span of RBC:**

S.No.	Organism	Life span of RBCs
1.	Mammals and Human	120 days or 4 months
2.	Rabbit	80 days

Cell: The Unit of Life

(1) **Cytology:** (G.k. kyios = cell ; logas = study) is the branch of biology which comprises the study of cell structure and function.

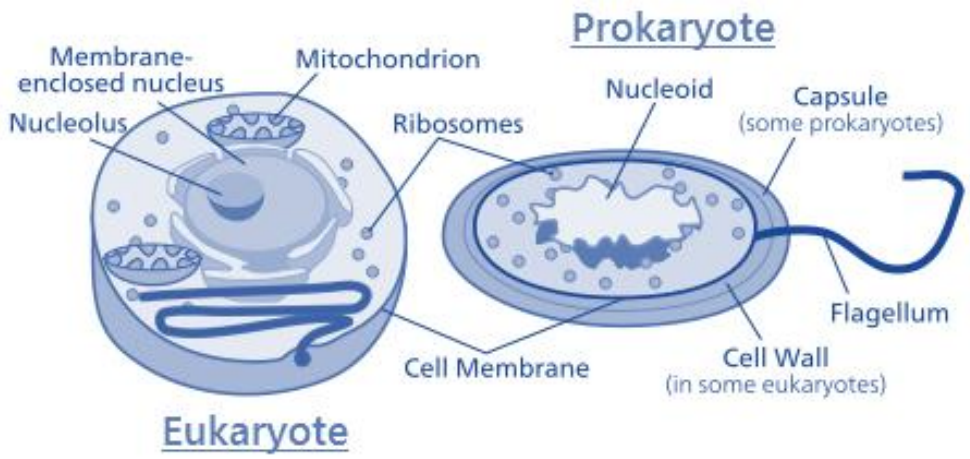
(2) Cell is the structural and functional unit of all living beings.

(3) There are two types of cells: plant cell and animal cell.

Plant cell	Animal cell
Cell wall present.	Cell wall absent.
Nucleus usually lies near periphery due to vacuole.	Nucleus present near the centre.
Centrosome is usually absent from higher plant cells, except lower motile cells.	Usually centrosome is present that helps in formation of spindle fibres.
Plastids are present, except fungi.	Plastids are absent.
Mitochondria is generally spherical or oval in shape.	Generally tubular in shape.
Single large central vacuole is present.	Many vacuoles occur, which are smaller in size.
Number of mitochondria from 200 – 2000.	Number of mitochondria is approximately 1600 – 16000 in liver cells.
Cytoplasm during cell division usually divides by cell plate method.	Cytoplasm divides by furrowing or cleavage method.
Plant cells are capable of forming all the amino acids coenzymes and vitamins.	Animal cells cannot form all the amino acids, coenzymes and vitamins.
There is no contractile vacuole.	Contractile vacuole may occur to pump excess water.
Sodium chloride is toxic to plant cells.	Tissue fluid containing sodium chloride bathes the animal cells.
Plant cells are generally well over 100 micrometer long.	Generally much smaller than 100 micrometer
Spindle formed during cell division is anastral.	Spindle formed during cell division are amphiastral.
Lysosomes present in less number.	Lysosomes present in more number.
Chromosomes are larger in size.	Chromosomes are smaller in size.

Prokaryotic cell	Eukaryotic cell
It is a single membrane system.	It is a double membrane system.
Cell wall surrounds the plasma membrane.	Cell wall surrounds the plasma membrane in some protists, most fungi and all plant cell. Animal cell lack it.
Cell wall composed of peptidoglycans. Strengthening material is mureir.	It is composed of polysaccharide. Strengthening material is chitin in fungi & cellulose in others plants.
Cell membrane bears respiratory enzymes.	It lacks respiratory enzymes.
Cytoplasm lacks cell organelles e.g., Mitochondria, ER, Golgi body etc.	Cytoplasm contains various cell organelles.
Ribosomes are 70 S type.	Ribosomes are 80 S type.
There are no streaming movements of cytoplasm.	Cytoplasm show streaming movements.
Endocytosis and exocytosis do not occur.	Endocytosis and exocytosis occur in animal cells.
Mitotic spindle is not formed in cell division.	Mitotic spindle is formed in cell division.
The mRNA does not need processing.	The mRNA needs processing.
Nuclear material is not enclosed by nuclear envelope and lies directly in cytoplasm. It is called nucleoid.	It is enveloped by nuclear envelope. Nucleus is distinct from cytoplasm.
DNA is circular and not associated with histone proteins.	Nuclear DNA is linear and associated with histone proteins extranuclear DNA is circular and protein free.
Replication of DNA occurs continuously throughout cell cycle.	Replication of DNA occurs during S- Phase of cell cycle only.
These have small size (0.5 to 10 micrometer) and have much less DNA.	These are relatively large (10 – 15 micrometer) and have much more DNA.
Sexual reproduction absent but parasexuality present.	Sexual reproduction is present.
Plasmids and pili occur in many prokaryotes **Example – E. coli**	There are no plasmids and pili in eukaryotic cells Example – Spirogyra, Chlorella
Cell division mostly amitotic.	Cell division is typically mitotic.
Plasma invaginates and from finger like process. Mesosome which take part in respiration	Absent

(4) Difference between Prokaryotic and eukaryotic cells



Primary cell wall	Secondary cell wall
Primary wall is laid inner to middle lamella	Secondary wall is laid inner to primary wall.
It is formed in a growing cell.	It is formed when the cells have stopped growing.
It is capable of extension.	Extensibility is absent except in collenchyma cells.
It is single layered.	It is three or more layered.
Cellulose content is comparatively low (5 – 20%).	Cellulose content is comparatively high (20 – 90%).
Cellulose microfibrils are shorter, wavy and loosely arranged.	They are longer, closely arranged straight and parallel.
Protein content up to 5%.	Protein content up to 1%.
Hemicellulose content is high up to 50%.	It is 25% of the total.
Lipid content up to 5 – 10%.	Lipid is absent.
Primary wall is comparatively thin 1 – 5 micrometer	It is comparatively thick 5 – 10 micrometer

(5) Difference between primary cell wall and secondary cell wall

(6) Difference between extrinsic protein and intrinsic protein

Extrinsic Protein	Intrinsic Protein
These are associated with surface only.	These lie throughout phospholipid matrix and project on both surfaces, also called transmembrane or tunnel protein.
They form about 30% of the total membrane protein.	They form about 70% of total membrane proteins.
Example – Spectrin in red blood cells & ATPase in mitochondria.	Example – Rhodopsin in retinal rod cells.

Cell Wall

(1) **Discovery:** It was first discovered by Robert Hooke in 1665.

(2) Cell wall is the outer most, rigid, protective, non living and supportive layer found in all the plant ells, bacteria, cyanobacteria and some protists.

(3) It is not found in animal cells.

Plasma Memberane

(1) **Definition:** Every living cell is externally covered by a thin transparent electron microscopic, elastic regenerative and selective permeable membrane called plasma membrane.

Protoplasm

(1) **Definition:** Protoplasm is a complex, granular, elastic, viscous and colourless substance. It is selectively or differentially permeable.

(2) It is considered as “Polyphasic colloidal system”.

Cytoplasm

The substance occurs around the nucleus and inside the plasma...

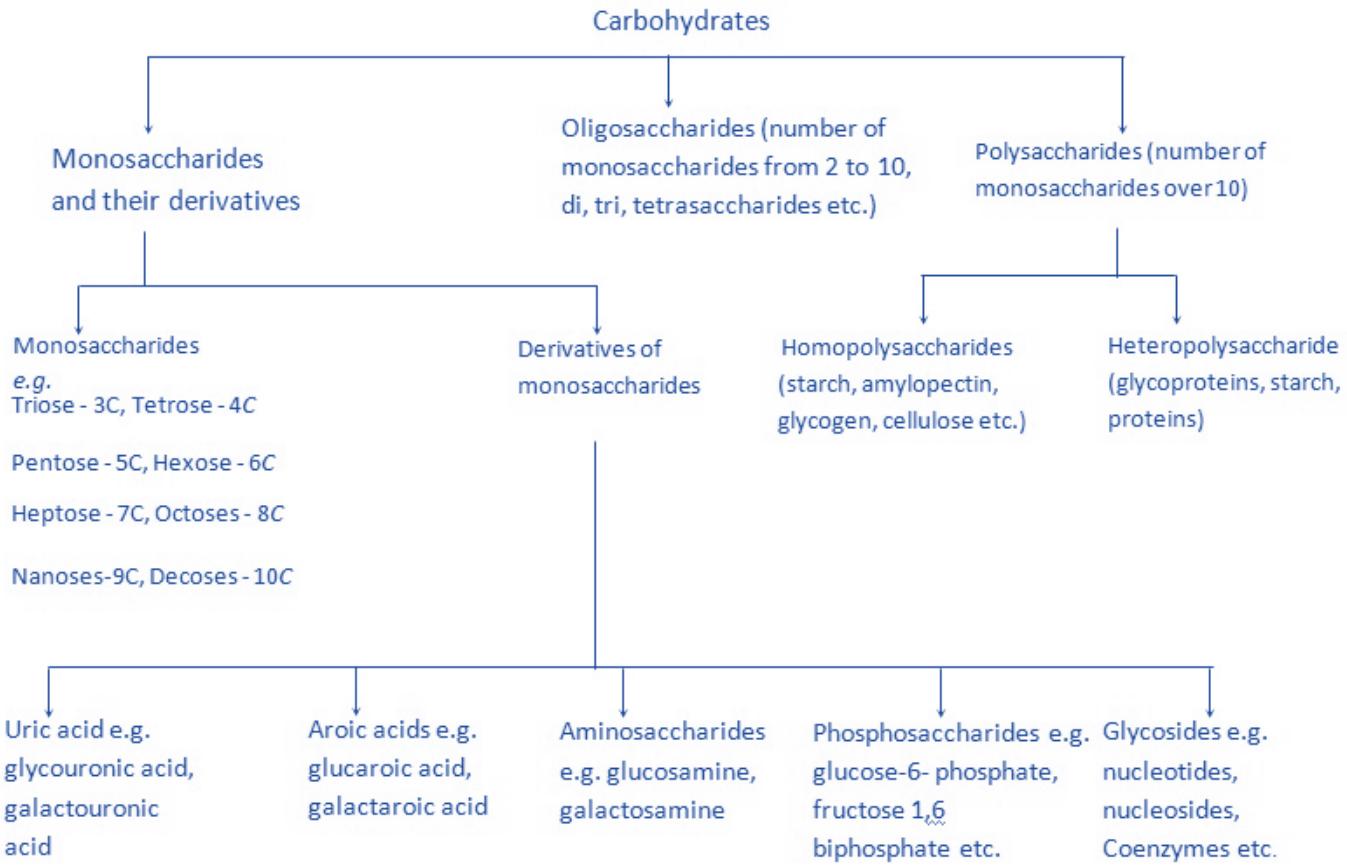
Biomolecules

Carbohydrates:

(1) e.g. sugars, glycogen (animal starch), plant starch and cellulose.

(2) **Source of carbohydrate:** Mainly photosynthesis. It exists only in 1% but constitutes 80% of the dry weight of plants.

(3) **Composition:** It consists of carbon, hydrogen and oxygen in the ratio C_nH_2N. It is also called saccharide and sugars are their basic components.



(4) **Properties of monosaccharide**

(a) Monosaccharides are colourless, sweet tasting, solids.

(b) Due to asymmetric carbon, they exist in different isomeric forms. They can rotate polarized light hence they are dextrorotatory and leavorotatory.

(c) D-glucose after reduction gives rise to a mixture of polyhydroxy alcohol, sorbitol or mannitol.

(d) The sugars with a free aldehyde or ketone group reduce Cu^{++} to Cu^{+} (cupric to cuprous)

(e) Sugars show oxidation, esterification and fermentation.

(f) The aldehyde or ketone group of a simple sugar can join an alcoholic group of another organic compound bond C-O-C the process involves loss of water and is called condensation (H-O-H) or H+OH → H_2O.

Lipids

(1) Term lipid was coined by Bloor.

(2) These are esters of fatty acids and alcohol.

(3) They are hydrophobic insoluble in water but soluble in benzene, ether and chloroform.

(4) Lipids are classified into three groups:–

(A) **Simple lipids:** These are the esters of fatty acids and glycerol. Again they are typed as:–

(a) **Fats and Oils:** (Natural lipids or true fats). These are triglycerides of fatty acid and glycerol. Fats which are liquid at room temperature are called oils. Oils with polyunsaturated fatty acids are called polyunsaturated e.g. sunflower oil, lower blood cholesterol.

(b) **Fatty acids:** Obtained by hydrolysis of fats. Formic acid is simplest fatty acid (HCOOH). These are of 2 types:–

(i) Saturated fatty acids: The fatty acids which do not have double bond in between carbon atoms.e.g. butyric acid, palmitic acid,hexanoic acid, etc. They have high melting points, solid at room temperature and increase blood cholesterol.

(ii) Unsaturated fatty acids: The fatty acids which have double bonds in carbon atoms. e.g. 8 hexadecanoic acid, 9 octadecanoic acid etc. They have lower melting points mostly found in plant fats, liquid at room temperature and lower the blood cholesterol.

(c) **Waxes:** These are simple lipids composed of one molecule of long chain fatty acid and long chain monohydric alcohol. Waxes have high melting point, insoluble in water, resistant to atmospheric oxidation, chemically inert and not digested by enzymes. They reduce rate of transpiration by making plant tissue water proof and work as excellent lubricant.

(B) **Compound lipids:** They contain some additional or element. Group with fatty acid and alcohol on the basis of group they may be of following types:

(a) **Phospholipids:** These contain phosphoric acid. It helps in transport, metabolism, blood clotting and permeability of cell membrane. It is a bipolar molecule i.e. phosphate containing end is hydrophilic whereas fatty acid molecules represent hydrophobic (non-polar tail).

(b) **Glycolipids:** These contain nitrogen and carbohydrate beside fatty acids. Generally found in white matter of nervous system. *e.g.* sesocine frenocin.

(c) **Chromolipids :** It includes pigmented lipids *e.g.* carotene.

(d) **Aminolipids :** Also known as sulpholipids. It contains sulphur and amino acids with fatty acid and glycerol. Cutin and suberin are also compound lipids resistant to water and also provide mechanical support in plants.

(i) **Derived lipids:** These are obtained by hydrolysis of simple and compound lipids.

(5) **Functions of lipids**

(a) Oxidation of lipids yields comparatively more energy in the cell than protein and carbohydrates. 1gm of lipids accounts for 39.1 KJ.

(b) The oil seeds such as groundnut, mustard, coconut store fats to provide nourishment to embryo during germination.

(c) They function as structural constituent i.e. all the membrane systems of the cell are made up of lipoproteins.

(d) Amphipathic lipids are emulsifier.

(e) It works as heat insulator.

(f) Used in synthesis of hormones.

(g) Fats provide solubility to vitamins A, D, E, and K.

Amino Acids

(1) Amino acids are normal components of cell proteins (called amino acid).

(2) They are 20 in number specified in genetic code and universal in viruses, prokaryotes and eukaryotes.

(3) **Structure and Composition :** Amino acids are basic units of protein and made up of C, H, O, N and sometimes S. Amino acids are organic acids with a carboxyl group (–COOH) and one amino group($-NH_2$) on the a -carbon atom. Carboxyl group attributes acidic properties and amino group gives basic ones. In solution, they serve as buffers and help to maintain pH. General formula is $R-CHNH_2.COOH$.

(4) **Classification**

Based on R-group of amino acids

(a) **Simple amino acids:** These have no functional group in the side chain. e.g. glycine, alanine , leucine, valine etc.

(b) **Hydroxy amino acids:** They have alcohol group in side chain. e.g. threonine, serine, etc.

(c) **Sulphur containing amino acids:** They have sulphur atom in side chain. e.g. methionine, cystenine.

(d) **Basic amino acids:** They have basic group ($-NH_2$) in side chain. e.g. lysine, arginine.

(e) **Acidic amino acids:** They have carboxyl group in side chain. e.g. aspartic acid, glutamic acid.

(f) **Acid amide amino acids:** These are the derivatives of acidic amino acids. In this group, one of the carboxyl group has been converted to amide ($-CONH_2$). e.g. asparagine, glutamine.

(g) **Heterocyclic amino acids:** These are the amino acids in which the side chain includes a ring involving at least one atom other than carbon. e.g. tryptophan, histidine.

(h) **Aromatic amino acids:** They have aromatic group (benzene ring) in the side chain. e.g. phenylalanine, tyrosine, etc.

Nucleotides:

(1) Structurally a nucleotide can be regarded as a phosphoester of a nucleoside.

(2) A combination of nitrogens base and a sugar is called nucleoside and combination of a base, a sugar and phosphate group is known as nucleotide.

Types of nitrogen base	Nucleoside	Nucleotide
Adenine	Adenosine	Adenylic acid
Guanine	Guanosine	Guanylic acid
Cytosine	Cytidine	Cytidilic acid
Thymine	Thymidine	Thymidylic acid
Uracil	Uridine	Uridylic acid

(3) **Functions of nucleotides:** Following are the major functions of nucleotides.

(a) **Formation of nucleic acids:** Different nucleotides polymerize together to form DNA and RNA.

(b) **Formation of energy carrier:** They help in formation of ATP,AMP, ADP, GDP, GTP, TDP,TTP, UDP, etc. which on breaking release energy.

(c) **Formation of Coenzymes:** Coenzymes like NAD, NADP, FMN, FAD, CoA, etc are formed. Coenzymes are non-proteinaceous substance necessory for the activity of the enzymes.

Proteins

(1) The word protein was coined by Berzelius in 1838 and was used by G. J. Mulder first time 1840.

(2) 15% of protoplasm is made up of protein. Average proteins contain 16% nitrogen, 50–55% carbon, oxygen 20–24%, hydrogen 7% and sulphur 0.3 – 0.5%. Iron, phosphorous, copper, calcium, and iodine are also present in small quantity.

(3) **Structure of proteins:** It is due to different rearrangement of amino acids. When carboxyl group of one amino acid binded with amino group (– NH_2) of another amino acid the bond is called peptide bond. A peptide may be dipeptide, tripeptide and polypeptide. The simplest protein is Insulin. According to Sanger (1953) insulin consists of 51 amino acids. A protein can have up to four level of conformation.

(i) **Primary structure:** The primary structure is the covalent connections of a protein. It refers to linear sequence, number and nature of amino acids bonded together with peptide bonds only. e.g. ribonuclease, insulin, haemoglobin, etc.

(ii) **Secondary structure:** The folding of a linear polypeptide chain into specific coiled structure (α - helix) is called secondary structure and if it is with intermolecular hydrogen bonds the structure is known as ß - pleated sheet. α - helical structure is found in protein of fur, keratin of hair claws, and feathers. ß - pleated structure is found in silk fibres.

(iii) **Tertiary structure:** The arrangement and interconnection of proteins into specific loops and bends is called tertiary structure of proteins. It is stabilized by hydrogen bond, ionic bond, hydrophobic bond and disulphide bonds. It is found in myoglobin (globular proteins).

(iv) **Quaternary structure:** It is shown by protein containing more than one peptide chain. The protein consists of identical units. It is known as homologous quaternary structure e.g. lactic dehydrogenase. If the units are dissimilar, it is called as heterogeneous quaternary structure e.g. hemoglobin which consists of two α - chains and two ß - chains.

Nucleic Acid

(1) **Definition:** Nucleic acids are the polymers of nucleotide made up of carbon, hydrogen, oxygen, nitrogen and phosphorus and which controls the basic functions of the cell.

(2) These were first reported by Friedrich Miescher (1871) from the nucleus of pus cell.

(3) Altmann called it first time as nucleic acid.

(4) They are found in nucleus. They help in transfer of genetic information.

(5) **Types of nucleic acids :** On the basis of nucleotides i.e. sugars, phosphates and nitrogenous bases, nucleic acids are of two types which are further subdivided. These are DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid).

(A) DNA (Deoxyribonucleic acids)

(i) **Types of DNA:** It may be linear or circular in eukaryotes and prokaryotes respectively.

(a) **Palindromic DNA:** The DNA helical bears nucleotide in a serial arrangement but opposite in two strands.

-T-T-A-A-C-G-T-T-A-A….

-A-A-T-T-G-C-A-A-T-T….

(b) **Repetitive DNA:** This type of arrangement is found near centromere of chromosome and is inert in RNA synthesis. The sequence of nitrogenous bases is repeated several times.

(c) **Satellite DNA:** It may have base pairs up to 11 – 60bp and are repetitive in nature. They are used in DNA matching or finger printing (Jefferey). In eukaryotes, DNA is deutrorotatory and sugars have pyranose configuration.

(B) RNA or Ribonucleic acid: RNA is second type of nucleic acid which is found in nucleus as well as in cytoplasm*i.e.* mitochondria, plastids, ribosomes etc. They carry the genetic information in some viruses. They are widely distributed in the cell.

Enzymes

- Enzymes (Gk. *en* = in; *zyme* = yeast) are proteinaceous substances which are capable of catalysing chemical reactions of biological origins without themselves undergoing any change.
- Enzymes are biocatalysts.
- An enzyme may be defined as "a protein that enhances the rate of biochemical reactions but does not affect the nature of final product."
- Maximum enzymes (70%) in the cell are found in mitochondrion. The study of the composition and function of the enzyme is known as **enzymology**.

Classification of Enzymes

Inorganic part of enzyme acts as prosthetic group in few enzyme they are called activator. These activators are generally...

CLASSIFICATION OF ENZYMES

Group of Enzyme	Reaction Catalysed	Examples
1. Oxidoreductases	Transfer of hydrogen and oxygen atoms or electrons from one substrate to another.	Dehydrogenases Oxidases
2. Transferases	Transfer of a specific group (a phosphate or methyl etc.) from one substrate to another.	Transaminase Kinases
3. Hydrolases	Hydrolysis of a substrate.	Estrases Digestive enzymes
4. Isomerases	Change of the molecular form of the substrate.	Phospho hexo isomerase, Fumarase
5. Lyases	Nonhydrolytic removal of a group or addition of a group to a substrate.	Decarboxylases Aldolases
6. Ligases (Synthetases)	Joining of two molecules by the formation of new bonds.	Citric acid synthetase

Cell Cycle and Cell Division

1. **Introduction:** It is the process by which a mature cell divides and forms two nearly equal daughter cells which resemble the parental cell in a number of characters.
2. A cell divides when it has grown to a certain maximum size which disturb the karyoplasmic index (KI)/Nucleoplasmic ratio (NP)/Kernplasm connection.
3. Two processes take place during cell reproduction.

- **Cell growth:** (Period of synthesis and duplication of various components of cell).

- **Cell division:** (Mature cell divides into two cells).

Cell cycle: Howard and Pelc (1953) first time described it. The sequence of events which occur during cell growth and cell division are collectively called cell cycle. Cell cycle completes in two steps:

- **Interphase**
- **M-phase/Dividing phase**

(i) Interphase : It is the period between the end of one cell division to the beginning of next cell division. It is also called resting phase or not dividing phase. But, it is actually highly metabolic active phase, in which cell prepares itself for next cell division. In case of human beings it will take approx 25 hours. Interphase is completed in to three successive stages.

(a) G_1 phase/Post mitotic/Pre-DNA synthetic phase/Gap I^{st}

(b) S-phase/Synthetic phase

(c) G_2-phase/Pre mitotic/Post synthetic phase/gap-II^{nd}

(ii) M-phase/Dividing phase/Mitotic phase

(a) Nuclear division i.e. karyokinesis occurs in 4 phases – prophase, metaphase, anaphase and telophase. It takes 5-10% (shortest phase) time of whole division.

(b) Cytokinesis : Division of cytoplasm into 2 equal parts. In animal cell, it takes place by cell furrow method and in plant cells by cell plate method.

4. **Duration of cell cycle:** It depends on the type of cell and external factors such as temperature, food and oxygen. Time period for G_1, S, G_2 and M-phase is species specific under specific environmental conditions. e.g. 20 minutes for bacterial cell, 8-10 hours for intestional epithelial cell, and onion root tip cells may take 20 hours.
5. **Regulation of cell cycle:** Stage of regulation of cell cycle is G_1 phase during which a cell may follow one of the three options.
   - It may start a new cycle, enter the S-phase and finally divide.
   - It may be arrested at a specific point of G_1 phase.
   - It may stop division and enter G_0 quiscent stage. But when conditions change, cell in G_0 phase can resume the growth and reenter the G_1 phase.
6. Cell division is of three types, Amitosis, Mitosis and Meiosis.
7. Difference between cell Mitosis and Meiosis

S.No	Characters	Mitosis	Meiosis
I. General			
(1)	Site of occurrence	Somatic cells and during the multiplicative phase of gametogenesis in germ cells.	Reproductive germ cells of gonads.
(2)	Period of occurrence	Throughout life.	During sexual reproduction.
(3)	Nature of cells	Haploid or diploid.	Always diploid.
(4)	Number of divisions	Parental cell divides once.	Parent cell divides twice.
(5)	Number of daughter cells	Two.	Four.
(6)	Nature of daughter cells	Genetically similar to parental cell. Amount of DNA and chromosome number is same as in parental cell.	Genetically different from parental cell. Amount of DNA and chromosome number is half to that of parent cell.
II. Prophase			
(7)	Duration	Shorter (of a few hours) and simple.	Prophase-I is very long (may be in days or months or years) and complex.
(8)	Subphases	Formed of 3 subphases : early-prophase, mid-prophase and late-prophase.	Prophase-I is formed of 5 subphases: leptotene, zygotene, pachytene, diplotene and diakinesis.
(9)	Bouquet stage	Absent.	Present in leptotene stage.
(10)	Synapsis	Absent.	Pairing of homologous chromosomes in zygotene stage.
(11)	Chiasma formation and crossing over.	Absent.	Occurs during pachytene stage of prophase-I.
(12)	Disappearance of nucleolus and nuclear membrane	Comparatively in earlier part.	Comparatively in later part of prophase-I.
(13)	Nature of coiling	Plectonemic.	Paranemic.
III. Metaphase			
(14)	Metaphase plates	Only one equatorial plate	Two plates in metaphase-I but one plate in metaphase-II.
(15)	Position of centromeres	Lie at the equator. Arms are generally directed towards the	Lie equidistant from equator and towards poles in metaphase-I while lie at the

		poles.	equator in metaphase-II.
(16)	Number of chromosomal fibres	Two chromosomal fibre join at centromere.	Single in metaphase-I while two in metaphase-II.
IV. Anaphase			
(17)	Nature of separating chromosomes	Daughter chromosomes (chromatids with independent centromeres) separate.	Homologous chromosomes separate in anaphase-I while chromatids separate in anaphase in anaphase-II.
(18)	Splitting of centromeres and development of inter-zonal fibres	Occurs in anaphase.	No splitting of centromeres. Inter-zonal fibres are developed in metaphase-I.
V. Telophase			
(19)	Occurrence	Always occurs	Telophase-I may be absent but telophase-II is always present.
VI. Cytokinesis			
(20)	Occurrence	Always occurs	Cytokinesis-I may be absent but cytokinesis-II is always present.
(21)	Nature of daughter cells	2N amount of DNA than 4N amount of DNA in parental cell.	1 N amount of DNA than 4 N amount of DNA in parental cell.
(22)	Fate of daughter cells	Divide again after interphase.	Do not divide and act as gametes.

Plant Body Systems

Transport in Plants

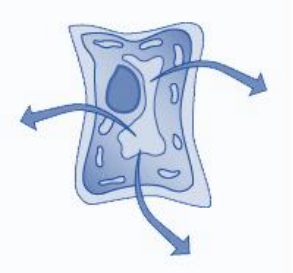
(1) Types of osmosis

Depending upon the movement of water into or outward of the cell, osmosis is of two types.

(a) **Endosmosis:** The osmotic inflow of water into a cell, when it is placed in a solution, whose solute concentration is less than the cell sap, is called endosmosis *e.g.,* swelling of raisins, when they are placed in water.

(b) **Exosmosis:** The osmotic outflow of water from a cell, when it is placed in a solution, whose solute concentration is more than the cell sap, is called exosmosis. *e.g.,*shrinkage of grapes when they are placed in strong sugar solution.

(2) Osmotic concentrations (Types of solutions)



A solution can be termed as hypotonic, hypertonic and isotonic depending upon its osmotic concentration, with respect to another solution or cell sap.

(a) **Hypotonic solution** (*hypo* = less than). A solution, whose osmotic concentration (solute potential) is less than that of another solution or cell sap is called hypotonic solution. If a cell is placed in such a solution, water start moving into the cell by the process of endosmosis, and cell become turgid.

(b) **Hypertonic solution** (*hper* = more than). A solution, whose osmotic concentration (solute potential) is more than that of another solution or cell sap is called hypertonic solution. If a cell is placed in such a solution, water comes out of the cell by the process of exosmosis and cell become flaccid. If potato tuber is placed in concentrated salt solution it would become shrink due to loss of water from its cell.

(c) **Isotonic solution** (*iso* = the same). A solution, whose osmotic concentration (solute potential) is equal to that of another solution or cell sap, is called isotonic solution. If a cell is placed in isotonic solution, there is no net change of water between the cell and the solution and the shape of cell remain unchanged. The normal saline (0.85% solution of *NaCl*) and 0.4 *m* to 0.5 *m* solution of sucrose are isotonic to the cell sap.

(3) Significance of osmosis in plants

(a) The phenomenon of osmosis is important in the absorption of water by plants.

(b) Cell to cell movement of water occurs throughout the plant body due to osmosis.

(c) The rigidity of plant organs (*i.e.,* shape and form of organism) is maintained through osmosis.

(d) Leaves become turgid and expand due to their OP.

(e) Growing points of root remain turgid because of osmosis and are thus, able to penetrate the soil particles.

(f) The resistance of plants to drought and frost is brought about by osmotic pressure of their cells.

(g) Movement of plants and plant parts, for example, movement of leaflets of Indian telegraph plant, bursting of many fruits and sporangia, etc. occur due to osmosis.

(h) Opening and closing of stomata is affected by osmosis.

(4) Turgor pressure (TP)

The plant cell, when placed in pure water, swells but does not burst. Because of negative osmotic potential of the vacuolar solution (cell sap), water will move into the cell and will cause the plasmalemma be pressed against the cell wall.

(5) Wall pressure (WP)

Due to turgor pressure, the protoplast of a plant cell will press the cell wall to the outside. The cell wall being elastic, presses back the protoplast with a pressure equal in magnitude but opposite in direction. This pressure is called **wall pressure**. Wall pressure (WP) may, therefore, be defined as '*the pressure exerted by the cell wall over the protoplast to counter the turgor pressure*.

(6) Plasmolysis (Gr. Plasma = something formed; lysis = loosing)

If a living plant cell is placed in a highly concentrated solution (*i.e.* hypertonic solution), water comes out of the cell due to exosmosis, through the plasmamembrane. The loss of water from the cell sap causes shrinkage of the protoplast away from the cell wall in the form of a round mass in the centre. "*The shrinkage of the protoplast of a living cell from its cell wall due to exosmosis under the influence of a hypertonic solution is called plasmolysis*".

(7) **Water potential (*y*)**

The movement of water in plants cannot be accurately explained in terms of difference in concentration or in any other linear expression. The best way to express spontaneous movement of water from one region to another is in terms of the difference of free energy of water between two regions. Free energy is the thermodynamic parameter that determines the direction in which physical and chemical changes must occur. The potential energy of water is called water potential. *e.g.,* water is stored behind a dam.

(8) Differences between diffusion pressure deficit and water potential

S.No.	Diffusion Pressure Deficit (DPD)	Water Potential (*y*)
(1)	The DPD was originally described by the term suction force (*Saugkraft*) by Renner. Other synonyms of the term are suction pressure (SP), enter tendency (E) and osmotic equivalent (E).	Water potential is the chemical potential of water which is equivalent to DPD with negative sign. The term water potential was coined by Slatyer and Taylor (1960).
(2)	The diffusion pressure deficit is abbreviated as DPD. The term was coined by Meyer (1938).	The symbol for water potential is a Greek letter*psi*, which is designated as *y*.

(9) Differences between active and passive absorption of water

S.No.	Active absorption	Passive absorption
(1)	Force for absorption of water is generated in the cells of root itself.	Force for absorption of water is created in the mesophyll cells.
(2)	Osmotic and non-osmotic forces are involved in water absorption.	Water is absorbed due to transpiration pull.
(3)	Water is absorbed according to DPD changes.	Water is absorbed due to tension created in xylem sap by transpiration pull.
(4)	Water moves through symplast.	Water moves mainly through apoplast.
(5)	Rate of absorption is not affected significantly by temperature and humidity.	Its rate is significantly affected by all those factors which influence the rate of transpiration.
(6)	Metabolic inhibitors if applied in root cells decrease the rate of water absorption.	No effect of metabolic inhibitors if applied in root cells.
(7)	Occurs in slow transpiring plants which are well watered.	Occurs in rapidly transpiring plants.
(8)	Rate of absorption is slow.	Very fast rate of water absorption.

(10) Differences between transpiration and evaporation

S.No.	Transpiration	Evaporation
(1)	It is a physiological process and occurs in plants.	It is a physical process and occurs on any free surface.
(2)	The water moves through the epidermis with its cuticle or through the stomata.	Any liquid can evaporate. The living epidermis and stomata are not involved.
(3)	Living cells are involved.	It can occur from both living and non-living surfaces.
(4)	Various forces (such as vapour pressure, diffusion pressure, osmotic pressure, etc) are involved.	Not much forces are involved.
(5)	It provides the surface of leaf and young stem wet and protects from sun burning.	It causes dryness of the free surface.

(11)**Types of stomata**

On the basis of orientation of subsidiary cells around the guard cells, **Metcalfe** and **Chalk** classified stomata into following types :

(i) **Anomocytic :** The guard cells are surrounded by a limited number of unspecialised subsidiary cells which appear similar to other epidermal cells. *e.g.*, in Ranunculaceae family.

(ii) **Anisocytic :** The guard cells are surrounded by three subsidiary cells, two of which are large and one is very small. *e.g.,* in Solanaceae and Cruciferae families.

(iii) **Paracytic :** The guard cells are surrounded by only two subsidiary cells lying parallel to the guard cells *e.g.*, Magnoliaceae family.

(iv) **Diacytic :** The guard cells are surrounded by only two subsidiary cells lying at right angles to the longitudinal axis of the guard cells. *e.g.*, Acanthaceae and Labiatae families.

(v) **Actinocytic :** The guard cells are surrounded by four or more subsidiary cells and which are elongated radially to stomata.

(12)Differences between transpiration and guttation

MineralNutrition

(1) **Macronutrients (Macroelements or major elements):** Nutrients which are required by plants in larger amounts (Generally present in the plant tissues in concentrations of 1 to 10 *mg per* gram of dry matter).

(2) The macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium, magnesium.

(3) **Micronutrients (Microelements or minor elements or trace elements):** Nutrients which are required by plants in very small amounts, *i.e.,* in traces (equal to or less than 0.1 *mg* per gram dry matter).

(4) The micronutrients include iron, manganese, copper, molybdenum, zinc, boron and chlorine. Recent research has shown that some elements, such as cobalt, vanadium and nickel, may be essential for certain plants.

(5) The usual concentration of essential elements in higher plants according to D.W. Rains (1976) based on the data of Stout are as follows:

Major Role of Nutrients

Various elements perform the following major role in the plants:

(1) **Construction of the plant body:** The elements particularly C, H and O construct the plant body by entering into the constitution of cell wall and protoplasm. They are, therefore, referred to as **frame work elements**. Besides, these (C, H and O) N, P and S also enter in the constitution of protoplasm. They are described as**protoplasmic elements**.

(2) **Maintenance of osmotic pressure:** Various minerals present in the cell sap in organic or inorganic form maintain the osmotic pressure of the cell.

(3) **Maintenance of permeability of cytomembranes:** The minerals, particularly Ca^{++}, K^{+} and Na^{+} maintainthe permeability of cytomembranes.

(4) **Influence the pH of the cell sap:** Different cations and anions influence on the *pH* of the cell sap.

(5) **Catalysis of biochemical reaction:** Several elements particularly *Fe, Ca, Mg, Mn, Zn, Cu, Cl* act as metallic catalyst in biochemical reactions.

(6) **Toxic effects:** Minerals like *Cu, As,* etc. impart toxic effect on the protoplasm under specific conditions.

(7) **Balancing function:** Some minerals or their salts act against the harmful effect of the other nutrients, thus balancing each other.

Specific Role of Macronutrients

The role of different elements is described below:

(1) **Carbon, hydrogen and oxygen:** These three elements though cannot be categorized as mineral elements, are indispensible for plant growth. These are also called **'framework elements'**.

(2) **Nitrogen:** Nitrogen is an essential constituent of proteins, nucleic acids, vitamins and many other organic molecules as chlorophyll. Nitrogen is also present in various hormones, coenzymes and ATP etc.

  (i) **Deficiency symptoms:** The symptoms of nitrogen deficiency are as follows:

    (a) Impaired growth

    (b) Yellowing of leaves due to loss of chlorophyll, *i.e.*, **chlorosis**.

    (c) Development of anthocyanin pigmentation in veins, sometimes in petioles and stems.

    (d) Delayed or complete suppression of flowering and fruiting.

(3) **Phosphorus**

(a) Phosphorous is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates.

(i) **Deficiency symptoms**

(a) Leaves become dark green or purplish.

(b) Sometimes development of anthocyanin pigmentation occurs in veins which may become necrotic (**Necrosis** is defined as localised death of cells).

(c) Premature fall of leaves.

(4) **Sulphur**

(i) **Functions**

(a) Sulphur is a constituent of amino-acids like cystine, cysteine and methionine; vitamins like biotin and thiamine, and coenzyme A.

(ii) **Deficiency symptoms**

(b) Leaf tips and margins roll downwards and inwards *e.g.*, tobacco, tea and tomato.

(c) Premature leaf fall.

(d) Delayed flowering and fruiting.

(5) **Potassium**

(i) **Functions**

(a) It differs from all other macronutrients in **not being a constituent** of any metabolically important compound.

(b) It is the **only monovalent cation** essential for the plants.

(c) It acts as an activator of several enzymes including DNA polymerase.

(ii) **Deficiency symptoms**

(a) **Mottled chlorosis** followed by the development of necrotic areas at the tips and margins of the leaves.

(b) K^+ deficiency inhibits proteins synthesis and photosynthesis. At the same time, it increases the rate of respiration.

(c) The internodes become shorter and root system is adversely affected.

(6) **Calcium**

(i) **Functions**

(a) It is necessary for formation of middle lamella of plants where it occurs as calcium pectate.

(b) It is necessary for the growth of apical meristem and root hair formation.

(c) It acts as activator of several enzymes, *e.g.*, ATPase, succinic dehydrogenase, adenylate kinase, etc.

(ii) **Deficiency symptoms**

(a) Ultimate death of meristems which are found in shoot, leaf and root tips.

(b) Chlorosis along the margins of young leaves, later on they become necrotic.

(c) Distortion in leaf shape.

(7) **Magnesium**

(i) **Functions**

(a) It is an important constituent of **chlorophyll**.

(b) It is present in the **middle lamella** in the form of magnesium pectate.

(c) It plays an important role in the metabolism of carbohydrates, lipids and phosphorus.

(ii) Deficiency symptoms

(a) **Interveinal** chlorosis followed by anthocyanin pigmentation, eventually necrotic spots appears on the leaves. As magnesium is easily transported within the plant body, the deficiency symptoms first appear in the mature leaves followed by the younger leaves at a later stage.

(b) Stems become hard and woody, and turn yellowish green.

(c) Depression of internal **phloem** and extensive development of **chlorenchyma**.

Specific Role of Micronutrients

(1) **Iron**

(i) **Functions**

(a) Iron is a structural component of ferredoxin, flavoproteins, iron prophyrin proteins (Cytochromes, peroxidases, catalases, etc.)

(b) It plays important roles in energy conversion reactions of photosynthesis (phosphorylation) and respiration.

(c) It acts as activator of nitrate reductase and aconitase.

(ii) **Deficiency symptoms**

(a) Chlorosis particularly in younger leaves, the mature leaves remain unaffected.

(b) It inhibits chloroplast formation due to inhibition of protein synthesis.

(c) Stalks remain short and slender.

(2) **Manganese**

(i) **Functions**

(a) It acts as activator of enzymes of...

Photosynthesis in Higher Plants

Chloroplast-The site of photosynthesis:

The most active photosynthetic tissue in higher plants is the mesophyll of leaves. Mesophyll cells have many chloroplasts. Chloroplast is present in all the green parts of plants and leaves. There may be over half a million chloroplasts per square millimetre of leaf surface. In higher plants, the chloroplasts are discoid or lens-shaped. They are usually 4-10*mm* in diameter and 1-3*mm* in thickness.

Chloroplast pigments:

Pigments are the organic molecules that absorb light of specific wavelengths in the visible region due to presence of conjugated double bonds in their structures. The chloroplast pigments are fat soluble and are located in the lipid part of the thylakoid membranes.

(i) **Chlorophylls:** The chlorophylls, the green pigments in chloroplast are of seven types *i.e.*, chlorophyll *a, b, c, d, e*, bacteriochlorophyll and bacterioviridin

(ii) **Carotenoids :** The carotenoids are unsaturated polyhydrocarbons being composed of eight isoprene (C_5H_8) units. They are made up of two six-membered rings having a hydrocarbon chain in between. They are sometimes called lipochromes due to their fat soluble nature.

Difference between Photosystem I and Photosystem II

S.No.	Photosystem I	Photosystem II
(1)	PS I lies on the outer surface of the thylakoids	PS II lies on the inner surface of the thylakoid.
(2)	In this system molecular oxygen is not evolved.	As the result of photolysis of water molecular oxygen is evolved.
(3)	Its reaction center is P700.	Its reaction center is P680.
(4)	NADPH is formed in this reaction.	NADPH is not formed in this reaction.
(5)	It participate both in cyclic and noncyclic photophosphorylation.	It participates only in noncyclic photophosphorylation.
(6)	It receives electrons from photosystem II.	It receives electrons from photolytic dissociation of water.
(7)	It is not related with photolysis of water.	It is related with photolysis of water.

Difference between C_3 Plants and C_4 Plants

S.No.	Characters	C_3 plants	C_4 plants
(1)	CO_2 acceptor	The CO_2 acceptor is Ribulose 1, 5 diphosphate.	The CO_2 acceptor is phosphoenol-pyruvate.
(2)	First stable product	The first stable product is phosphoglyceric acid.	Oxaloacetate is the first stable product.
(3)	Type of chloroplast	All cells participating in photosynthesis have one type of chloroplast.	The chloroplast of parenchymatous bundle sheath is different from that of mesophyll cells. Leaves have 'Kranz' type of anatomy. The bundle sheath chloroplasts lack grana. Mesophyll cells have normal chloroplasts.
(4)	Cycles	Only reductive pentose phosphate cycle is found.	Both C_4-dicarboxylic acid and reductive pentose phosphate cycles are found.
(5)	Optimum temperature	The optimum temperature for the process is 10-25°C.	In C_4 plants, it is 30-45°C.
(6)	Oxygen inhibition	Oxygen present in air (=21% O_2) markedly inhibit the photosynthetic process as compared to an external atmosphere containing no oxygen.	The process of photosynthesis is not inhibited in air as compared to an external atmosphere containing no oxygen.
(7)	PS I and PS II	In each chloroplast, photosystems I and II are present. Thus, the Calvin cycle occurs.	In the chloroplasts of bundle sheath cells, the photosystem II is absent. Therefore, these are dependent to mesophyll chloroplast for the supply of NADPH + H^+
(8)	Enzymes	The Calvin cycle enzymes are present in mesophyll chloroplast.	Calvin cycle enzymes are absent in mesophyll chloroplasts. The cycle occurs only in the chloroplasts of sheath cells.
(9)	Compensation point	The CO_2 compensation point is 50-150ppm.	CO_2 compensation point is 0-10ppm.
(10)	Photorespiration	Photorespiration is present and easily detectable.	Photorespiration is present only to a slight degree and difficult to detect.
(11)	Net rate	Net rate of photosynthesis in full sunlight (10,000-12,000 ft.c) is 15-35mg. of CO_2 per dm^2 of leaf area per h.	It is 40-80mg. of CO_2 per dm^2 of leaf area per h. That is photosynthetic rate is quite high. The plants are efficient.
(12)	Saturation intensity	The saturation intensity reached in the range of 100-4000 ft.c.	It is difficult to reach saturation even in full sunlight.

Respiration in Plants

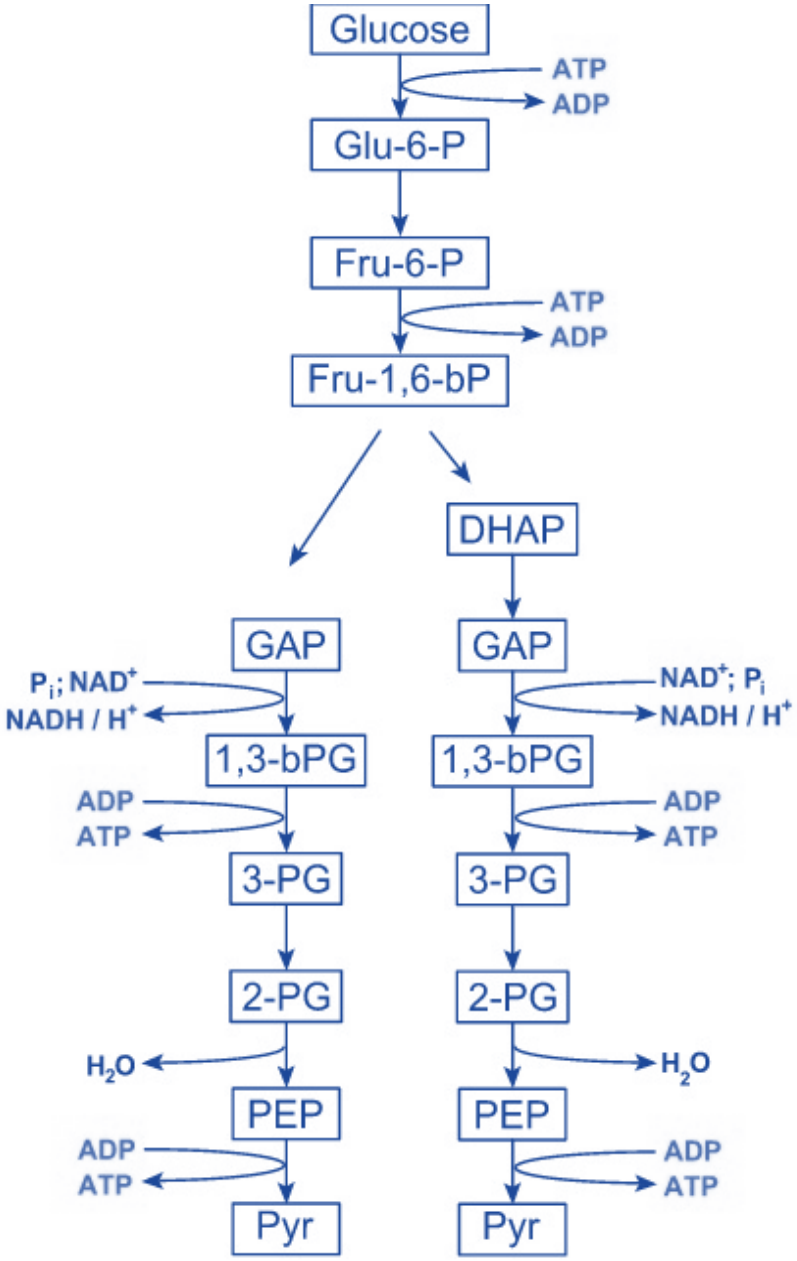
Differences between Photosynthesis and Respiration

Photosynthesis	Respiration
Occurs only in chlorophyll containing cells of plants.	Occurs in all plant and animal cells.
Takes place only in the presence of light.	Takes place continually both in light and in the dark.
During photosynthesis, radiant energy is converted into potential energy.	During respiration, potential energy is converted into kinetic energy.
Sugars, water and oxygen are products.	CO_2 and H_2O are products.
Synthesizes foods.	Oxidizeds foods.
CO_2 and H_2O are raw materials.	O_2 and food molecules are raw materials.
Photosynthesis is an endothermal process.	Respiration is an exothermal process.
Stores energy.	Releases energy.
It includes the process of hydrolysis, carboxylation etc.	It includes the process of the dehydrolysis, decarboxylation, etc.
Results in an increase in weight.	Results in a decrease in weight.
It is an anabolic process.	It is a catabolic process.
Require cytochrome.	Also require cytochrome.

(viii)	**Intermediates**	A number of intermediates are produced.	No intermediate is produced.

Glycolysis cycle

Enzymes of glycolysis and their co-factors

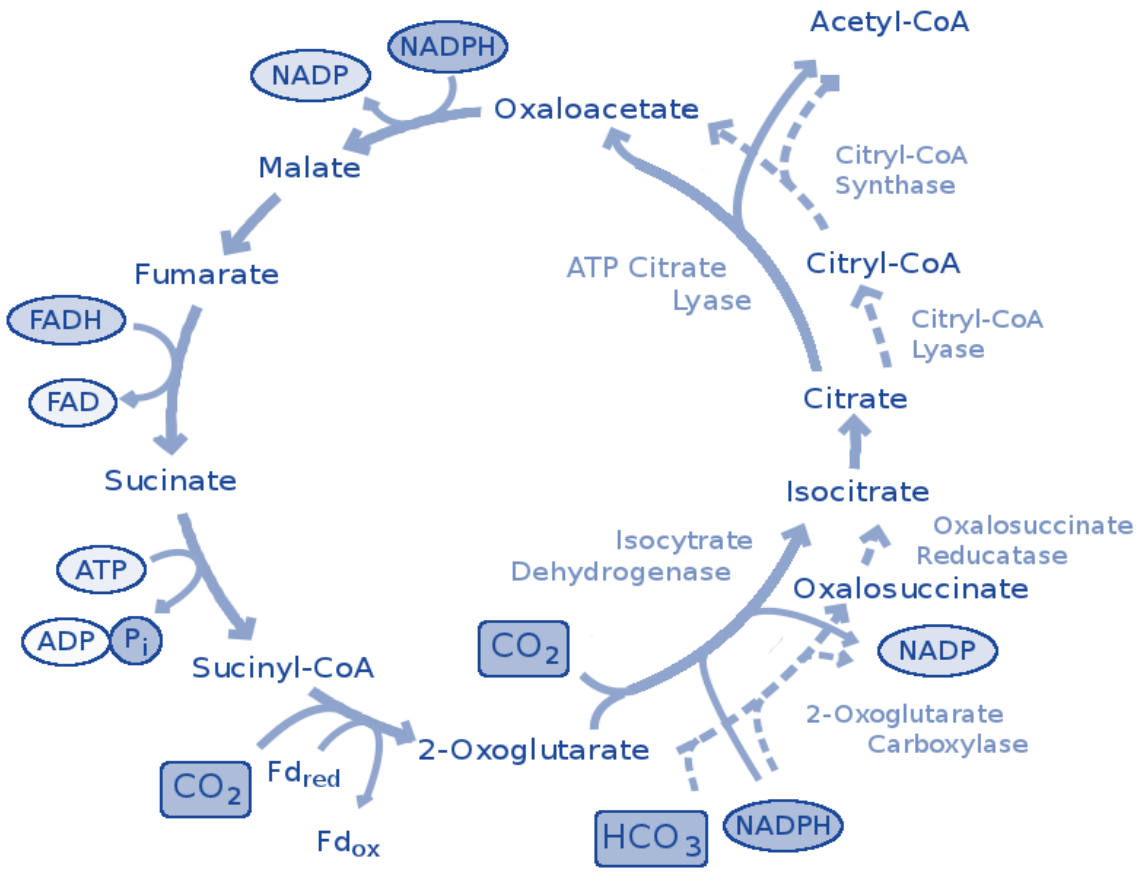


S. No.	Enzyme	Coenzyme (s) and cofactor	Activator (s)	Inhibitor (s)	Kind of reaction catalyzed
(i)	Hexokinase	Mg^{2+}	ATP^{4-}, Pi	Glucose 6-phopshate	Phosphoryl transfer
(ii)	Phosphogluco-isomerase	Mg^{2-}	-	2-dioxyglucose 6-phosphate	Isomerization
(iii)	Phosphofructo-kinase	Mg^{2+}	Fructose 2, 6-diphosphate, AMP, ADP, cAMP, K^{+}	ATP^{4-}, citrate	Phosphoryl transfer
(iv)	Aldolase	Zn^{2+} (in microbes)	-	Chelating agents	Aldol cleavage
(v)	Phosphotriose isomerase	Mg^{2+}	-	-	Isomerization
(vi)	Glyceraldehyde 3-phosphate dehydrogenase	NAD	-	Iodoacetate	Phosphorylation coupled to oxidation
(vii)	Phosphoglycerate kinase	Mg^{2+}	-	-	Phosphoryl transfer
(viii)	Phosphoglycerate mutase	Mg^{2+} 2,3-diphos phoglycerate	-	-	Phosphoryl shift
(ix)	Enolase	Mg^{2+}, Mn^{2+}, Zn^{2+}, Cd^{2+}	-	Fluoride+ phosphate	Dehydration
(x)	Pyruvate kinase	Mg^{2+}, K^{+}	-	Acetyl CoA, analine, Ca^{2+}	Phosphoryl transfer

Total input and output materials in glycolysis

Total Inputs	Total Outputs
1 molecule of glucose (6 *C*)	2 molecules of pyruvate (2×3 *C*)
2 ATP	4 ATP
4 ADP	2 ADP
2 × NAD	2× NADH + $2H^{+}$
2 Pi	$2\times H_2O$

Kreb's Cycle


Acetyl-CoA
NADPH
NADP
Oxaloacetate
Malate
Citryl-CoA Synthase
Fumarate
ATP Citrate Lyase
Citryl-CoA
FADH
Citryl-CoA Lyase
FAD
Citrate
Sucinate
Isocitrate
Oxalosuccinate Reducatase
Isocytrate Dehydrogenase
ATP
Oxalosuccinate
ADP
P_i
CO_2
NADP
Sucinyl-CoA
2-Oxoglutarate Carboxylase
CO_2
Fd_{red}
2-Oxoglutarate
HCO_3
NADPH
Fd_{ox}

Enzymes of Kreb's cycle

Step	Enzyme	(Location in mitochondria)	Coenzyme(s) and cofactor (s)	Inhibitor(s)	Type of reaction catalyzed
(a)	Citrate synthetase	Matrix space	CoA	Monofluoro-acetyl- CoA	Condensation
(b)	Aconitase	Inner membrane	Fe^{2+}	Fluoroacetate	Isomerization
(c)	Isocitrate dehydrogenase	Matrix space	NAD^+, $NADP^+$, Mg^{2+}, Mn^{2+}	ATP	Oxidative decarboxylation
(d)	alpha-ketoglutarate dehydrogenase complex	Matrix space	TPP,LA,FAD,CoA, NAD^+	Arsenite,Succinyl-CoA, NADH	Oxidative decarboxylation
(e)	Succinyl-CoA synthetase	Matrix space	CoA	-	Substrate level phosphorylation
(f)	Succinate dehydrogenase	Inner membrane	FAD	Melonate, Oxaloacetate	Oxidation
(g)	Fumarase	Matrix space	None	-	Hydration
(h)	Malate dehydrogenase	Matrix space	NAD^+	NADH	Oxidation

Products formed during aerobic respiration by Glycolysis and Kreb's cycle

ATP formation in Glycolysis			
	Steps	**Product of reactions**	**In terms of ATP**
ATP formation by substrate phosphorylation	1, 3-diphosphoglyceric acid (2 moles) ® 3 phosphoglyceric acid (2 moles) Phosphoenolpyruvic acid (2 moles) ® Pyruvic acid (2 moles)	2 ATP 2 ATP	2 ATP 2 ATP
		Total	4 ATP
ATP formation by oxidative phosphorylation or ETC	1, 3 - disphosphoglyceraldehyde (2 moles) 1, 3 – diphosphoglyceric acid (2 moles)	2 $NADH_2$	6 ATP
	Total ATP formed	4 + 6 ATP =	10 ATP
ATP consumed in	Glucose (1 mole) ® Glucose 6 phosphate (1	– 1 ATP	– 1 ATP

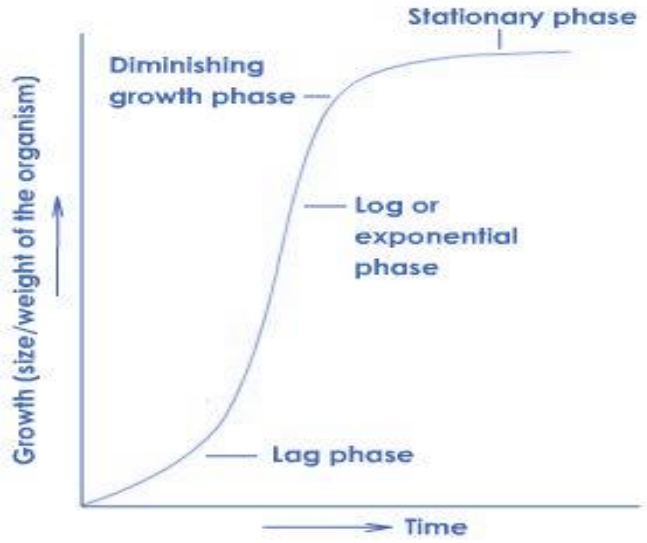
Glycolysis	mole) Fructose 6 phosphate (1 mole) ® Fructose 1, 6-diphosphate (1 mole)	– 1 ATP	– 1 ATP
		Total	2 ATP
	Net gain of ATP = total ATP formed – Total ATP consumed	**10 ATP – 2ATP**	**8 ATP**
ATP formation in Kreb's cycle			
ATP formation by substrate phosphorylation	Succinyl CoA (2 mols) ® Succinic acid (2 mols)	2 GTP	2 ATP
		Total	2 ATP
ATP formation by oxidative phosphorylation or ETC	Pyruvic acid (2 mols) ® Acetyl CoA (2 mols) Isocitric acid (2 mols) ® Oxalosuccinic acid (2 mols) a-Ketoglutaric acid (2 mols) ® Succinyl CoA (2 mols) Succinic acid (2 mols) ® Fumaric acid (2 mols) Malic acid (2 mols) ® Oxaloacetic acid (2 mols)	2 $NADH_2$ 2 $NADH_2$ 2 $NADH_2$ 2 $FADH_2$ 2 $NADH_2$	6 ATP 6 ATP 6 ATP 4 ATP 6 ATP
		Total	28 ATP
	Net gain in Kreb's cycle (substrate phosphorylation + oxidative phosphorylation)	2ATP + 28 ATP	30 ATP
Net gain of ATP in glycolysis and Kreb's cycle	Net gain of ATP in glycolysis + Net gain of ATP in Kreb's cycle	8 ATP + 30 ATP	38 ATP
Over all ATP production by oxidative phosphorylation or ETC	ATP formed by oxidative phosphorylation in glycolysis + ATP formed by oxidative phosphorylation or ETC.	6 ATP + 28 ATP	34 ATP

Aerobic, Anaerobic Respiration and Fermentation

Aerobic Respiration	Anaerobic Respiration	Fermentation
Molecular oxygen is the ultimate electron acceptor for biological oxidation. The ETS serves to transfer electrons from oxidisable donor to molecular oxygen. The early enzymatic steps involve dehydrogenation whereas the final steps are mediated by a group of enzyme called cytochromes. Ultimately the electrons are transferred to oxygen which is reduced to water. During aerobic respiration ATP is generated by coupled reaction	The ultimate electron acceptor is an inorganic compound other than oxygen. The compounds accepting the hydrogen (electrons) are nitrates, sulphates, carbonates orCO_2. Anaerobic respiration produces ATP through phosphorylation reaction involving electron transfer systems. (mechanism not known)	The final electron acceptors are organic compounds. Both electron donors (oxidizable substrate) and electron acceptors (oxidizing agent) are organic compounds and usually both substrates arise from same organic molecules during metabolism. Thus part of the nutrient molecule is oxidised and part reduced and the metabolism results in intramolecular electron rearrangement. ATP is generated by substrate level phosphorylation. This reaction differs from oxidative phosphorylation because oxygen itself is not required for ATP generation.

Plant Growth and Development

(1) The analysis of growth curve shows that it can be differentiated into three phases:



(i) Lag phase: It represents initial stages of growth. The rate of growth is very slow in lag phase. More time is needed for little growth in this phase.

(ii) Log phase (Exponential phase): The growth rate becomes maximum and more rapid**.** Physiological activities of cells are at their maximum. The log phase is also referred to as **grand period of growth**.

(iii) Final steady state (Stationary phase) or Adult phase: When the nutrients become limiting, growth slows down, so physiological activities of cells also slows down. This phase is indicated by the maturity of growth system. The rate of growth can be measured by an increase in size or area of an organ of plant like leaf, flower, fruit etc. The rate of growth is called efficiency index.

(2) P**hytohormones:-**

(i) Growth hormones also called **phytohormones**

(ii) Term given by Thimann (1948),

(iii) It can be defined as 'the organic substances which are synthesized in minute quantities in one part of the plant body and transported to another part where they influence specific physiological processes'.

Growth Hormones and Growth Regulators

(1) Auxins:

(i) Auxins (Gk. *auxein* = to grow) are weakly acidic growth hormones having an unsaturated ring structure and capable of promoting cell elongation, especially of shoots (more pronounced in decapitated shoots and shoot segments) at a concentration of less than 100 *ppm* which is inhibitory to the roots. Among the growth regulators, auxins were the first to be discovered.

(ii) Types of auxins: There are two major categories of auxins natural auxins and synthetic auxins:

(a) Natural auxins: These are naturally occurring auxins in plants and therefore, regarded as **phytohormones**. Indole 3-acetic acid (IAA) is the best known and universal auxin. It is found in all plants and fungi.

(b) Synthetic auxins: These are synthetic compounds which cause various physiological responses common to IAA. Some of the important synthetic auxins are 2, 4-D (2, 4-dichlorophenoxy acetic acid) is the weedicide. IBA is both natural and synthetic auxin.

(iii) Functions of auxins: Auxins control several kinds of plant growth processes. These are as follows:

(a) Cell elongation: Auxins promote elongations and growth of stems and roots and enlargement of many fruits by stimulating elongation of cells in all directions.

(b) Apical dominance: In many plants, the apical bud grows and the lower axillary buds are suppressed. Removal of apical bud results in the growth of lower buds. The auxin (IAA) of the terminal bud inhibits the growth of lateral buds. This phenomenon is known as apical dominance.

(c) Weed control: Weeds are undesirable in a field with a crop. By the spray of 2, 4-D, broad-leaved weeds can be destroyed but 2, 4-D does not affect mature monocotyledonous plants.

(d) Root differentiation

(e) Control of lodging

(f) Parthenocarpy: Parthenocarpy can be induced by application of IAA in a paste form to the stigma of a flower or by spraying the flowers with a dilute solution of IAA.

(2) Gibberellins:

(i) Gibberellins are weakly acidic hormones having gibbane ring structure which cause cell elongation of intact plants in general and increased internodal length of genetically dwarfed plants (i.e., corn, pea) in particular.

(ii) Functions of gibberellin

(a) Stem elongation: The gibberellins induce elongation of the internodes.

(b) Leaf expansion: In many plants leaves become broader and elongated when treated with gibberellic acid.

(c) Reversal of dwarfism: One of the most striking effects of gibberellins is the elongation of genetic dwarf (mutant) varieties of plants like corn and pea.

(d) Bolting and Flowering: Gibberellins induce stem elongation in 'rosette plants' e.g., cabbage, henbane, etc. Such plants show retarded internodal growth and profuse leaf development. In these plants just prior to the reproductive phase, the internodes elongate enormously causing a marked increase in stem height. This is called bolting.

(e) Enzyme formation: One of the most dramatic effects of GA is its induction of hydrolytic enzymes in the aleurone layer of endosperm of germinating barley seeds and cereal grains. GA stimulates the production of digestive enzymes like proteases, a-amylases, lipases which help to mobilise stored nutrients.

(f) Breaking of dormancy: Gibberellins overcome the natural dormancy of buds, tubers, seeds, etc. and allow then to grow. In this function, gibberellins act antagonistically to abscisic acid (ABA).

(g) Parthenocarpy: Gibberellins have been considered to be more effective than auxins for inducing parthenocarpy in fruits like apple, tomato and pear. GA application has also resulted in the production of large fruits and bunch length in seedless grapes.

(h) Sex expression: Gibberellins control sex expression in certain plants. In general, gibberellin promotes the formation of male flowers either in place of female flowers in monoecious plants such as cucurbits or in genetically female plants like *Cannabis, Cucumis*.

(3) Cytokinins (Phytokinins):

(i) Cytokinins are plant growth hormones which are basic in nature, either aminopurine or phenyl urea derivatives that promote cell division (cytokinesis) either alone or in conjugation with auxin.

(ii) Functions of cytokinins

(a) Cell division: Cytokinins are essential for cytokinesis and thus promote cell division. In presence of auxin, cytokinins stimulate cell division even in non-meristematic tissues.

(b) Cell enlargement and Differentiation: Under some conditions cytokinins enhance the expansion of leaf cells in leaf discs and cotyledons. These cells considered to be mature and under normal conditions do not expand.

(c) Delay in senescence: Cytokinin delay the senescence (ageing) of leaves and other organs by controlling protein synthesis and mobilization of resources (Disappearance of chlorophyll). It is called Richmond Lang effect.

(d) Counteraction of apical dominance: Auxins and cytokinins act antagonistically in the control of apical dominance. Auxins are responsible for stimulating growth of apical bud.

(e) Breaking of dormancy: Cytokinins breaks seeds dormancy of various types and thus help in their germination.

(f) Accumulation and Translocation of solutes

(4) Ethylene:

(i) Ethylene is a gaseous hormone which stimulates transverse growth but retards the longitudinal one.

(ii) Functions of ethylene

- **Fruit growth and Ripening:** Ethylene promotes fruit growth and its ripening. The harmone is used in the artificial ripening of climacteric fruits (e.g., Apple, Banana,

Human Body Systems

Digestion and Absorption

(i) Process of conversion of complex food substances to simple absorbable forms is called digestion.

(ii) Intracellular: When the process of digestion occurs within the cell in the food vacuole.

Examples:

Protozoa, Porifera, Coelenterata and free living Platyhelminthes

(iii) Extracellular: When the process of digestion occurs outside the cell, **Examples:** Coelenterates and phylum Platyhelminthes to phylum Chordata.

(iv) Digestion in vertebrates occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly grouped in two groups –

(1) Digestive tract or alimentary canal

(2) Digestive glands

On the basis of the embryonic origin, the alimentary canal of vertebrates can be divided into three parts–

(1) Fore gut / Stomodaeum: Ectodermal. It includes buccal cavity / oral cavity, pharynx, oesophagus, stomach and small part of duodenum.

(2) Mid gut/Mesodaeum: Endodermal. It includes small intestine, and large intestine.

(3) Hind gut/Proctodaeum: Ectodermal. It includes anal canal and anus.

Human Digestive System

The human digestive system is a complex series of organs and glands that processes food. It converts ingested food so that it can be assimilated by the organism. The human digestive system consists of following parts:-

Mouth

Mouth is also known as the oral cavity or buccal cavity. It is the first portion of the alimentary canal. Food and saliva are received by mouth. Mouth has inner lining of mucous membrane epithelium.

Digestive Glands: -

(A) Salivary glands:-

(i) These are the exocrine glands that produce saliva.

(ii) These are the glands with ducts which also secrete amylase.

(iii) Amylase is an enzyme that breaks down starch into maltose.

(iv) **Three types of salivary glands are: -**

1) Parotid gland
2) Submandibular gland
3) Sublingual gland

(B) Gastric glands:-

(i) The gastric glands (fundic gland) secrete acids and digestive enzymes.

(ii) Secretion of gastric gland is called gastric juice.

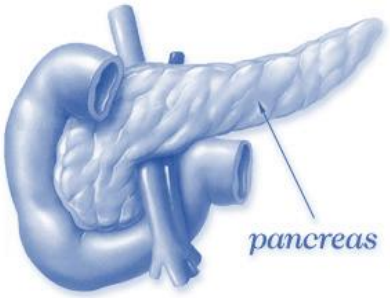
(iii) There are approximately 35 million gastric glands present in human stomach.

(C) Intestinal glands:-

(i) Intestinal glands in maamals is a collective name for **crypts of Liberkuhn** (secretes alkaline enzymatic juice) and **Brunner's glands** (secrete mucous).

(ii) Intestinal glands secrete **intestinal juice** or **sucus entericus.**

(D) Pancreas:-



(i) Pancreas has two different kind of tissue- exocrine and endocrine.

(ii) Pancreatic secretion is stimulated by **cholecystokinin** and **secret in** both.

(iii) Complete digestive juice is pancreatic juice as it contains amylolytic, lipolytic and proteolytic enzymes.

(iv) It produces several important hormones like insulin, glucagon, somatostatin and pancreatic polypeptide.

(E) Liver:-

(i) Liver is the **largest digestive gland of the body,** weighing about 1.2 to 1.5 Kg in an adult human.

(ii) It is situated in the abdominal cavity, just below the diaphragm and has two lobes (small left and large right lobe).

(iii) The liver has a wide range of functions to perform in the body:

a) It detoxifies various metabolites

b) It helps in protein synthesis.

c) Various biochemical necessary for digestion are produced by liver.

Pharynx: -

It is the opening of oral and nasal cavities. **It is classified as: -**

1) Nasopharynx
2) Oropharynx
3) Laryngopharynx

Oesophagus: -

Oesophagus connects pharynx with stomach.

Opening of oesophagus is regulated by **gastro-oesophageal sphincter.**

Stomach: –

It is a J-shaped, muscular, hollow and dilated part of the digestive system. It is located between the oesophagus and the small intestine. It has 1 liter capacity. It secretes protein-digesting enzymes (proteases) and strong acids which aid in food digestion.

The stomach has three parts:

Cardiac: The part of the stomach into which oesophagus opens.
Fundus: It is the air filled portion of stomach.
Pyloric: The portion of the stomach that opens into the small intestine

Breathing and exchange of gases

Pulmonary Volumes and Capacities

There are following respiratory volumes and capacity:

(i) **Tidal volume (TV)**: It is volume of air normally inspired or expired in one breath (i.e. inspiration and expiration) without any extra effort. It is about 500 ml in normal healthy adult. In infants it is 15 ml and in fetus it is 0 ml.

(ii) **Inspiratory reserve volume (IRV) :** By taking a very deep breath, you can inspire a good deal more than 500 ml. This additional inhaled air, called IRV is about 3000 ml.

(iii) **Expiratory reserve volume (ERV) :** If you inhale normally & then exhale as forcibly as possible, you should be able to push out 1200 ml of air in addition to 500ml. of T.V. The extra 1200 ml is called ERV.

(iv) **Residual volume (RV):** Even after expiratory reserve volume is expelled, considerable air remains in the lung, this volume, which cannot be measured by spirometry, and it is called residual volume is about 1200 ml.

(v) **Dead space**: Portion of tracheobronchial tree where gaseous exchange does not occur is called dead space. It is also called conductive zone. Dead space is 150 ml.

(vi) **Functional residual capacity (FRC):** It is the amount of air that remains in the lungs after a normal expiration. It is about 2300 ml.

FRC = ERV + RV

= 1100 + 1200 = 2300 ml.

(vii) **Vital capacity (VC):** This is the maximum amount of air that can be expired forcefully from his lungs after first filling these with a maximum deep inspiration. It is about 4600 ml.

VC = IRV + TV + ERV

= 3000+500+1100 = 4600 ml.

(viii) **Total lung capacity (TLC):** TLC is the sum of vital capacity (VC) and residual volume (RV). It is about 5800ml.

TLC = VC + RV

= 4600 + 1200 = 5800 ml.

(ix) **Inspiratory capacity (IC):** It is the total amount of air a person can inspire by maximum distension of his lungs.

I.C. = TV + IRV

= 500 + 3000 = 3500 ml.

Process of Respiration

The process of respiration is completed in 4 steps:

(i) Breathing or ventilation

(ii) Exchange of gases or External respiration

(iii) Transport of gases

(iv) Cellular respiration

(i) Ventilation or breathing:

Breathing is movement of thorax, expansion (inflation) and deflation of lungs and flow of air into the lungs and from the lungs. It is extracellular, energy consuming and physical process. Sum of inspiration and expiration is called respiratory movement. There are two steps of breathing:

(a) **Inspiration:** Intake of fresh air in lungs from outside. It is an active process. Blood pressure increases during later part of respiration.

(b) **Expiration:** Out flow of the air from the lungs is called expiration. When expiration occurs, the inspiratory muscles relax. As the external intercostal relax, ribs move inferiorly and as the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

(c) **Mechanism of ventilation/breathing:**

(ii) **Exchange of gases:**

(a) **Exchange of gases in lungs:** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2. Comes to alveoli from pulmonary capillary.

(b) **Release of CO_2 by the blood:** The PCO_2 (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the PCO_2 of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.

(c) **Exchange of gases in tissues:** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs via tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has PO_2 higher than that in the tissue cells and PCO_2 lower than that in the tissue cells.

(iii) **Transport of gases:** Blood carries O_2 from respiratory organs to the tissue cells for oxidation and CO_2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O_2 and CO_2 properly.

Difference between breathing and respiration

Breathing (Ventilation)	Respiration
It is a physical process.	It is a biochemical process.
It is simply an intake of fresh air and removal of foul air.	It involves exchange of gases and oxidation of food.
No energy is released rather used.	Energy is released that is stored in ATP.
It occurs outside the cells, hence it is an extra-cellular process.	It occurs inside the cells, hence it is an intra-cellular process.
No enzymes are involved in the process.	A large number of enzymes are involved in the process.
Breathing mechanism varies in different animals.	Respiratory mechanism is similar in all animals.
It is confined to certain organs only.	It occurs in all living cells of the body.

Composition of three samples of air

For the control of respiration following respiratory centres are found in hind brain

Type of centre	Location	Function
Inspiratory centre	Medulla oblongata	Inspiration (2 second active condition)
Respiratory centre	Medulla oblongata	Expiration (3 second inactive condition)
Apneustic centre	Pons	Slow and deep inspiration
Pneumotaxic centre	Pons	Control other centres and produce normal quite breathing
Gasping centre	Pons	Sudden and shallow respiration

Oxygen content: Total volume of O_2 in 100 *ml*. of whole blood *i.e.* volume of O_2 in physical solution form and oxyhaemoglobin form. It is equal to 19.7 + 0.3 = 20 *ml* of oxygen.

Oxygen capacity: Maximal amount of O_2 that can be held by the blood at 760 *mm Hg* pressure and 37^0C. Oxygen capacity is about 20 *ml*/100 *ml.*

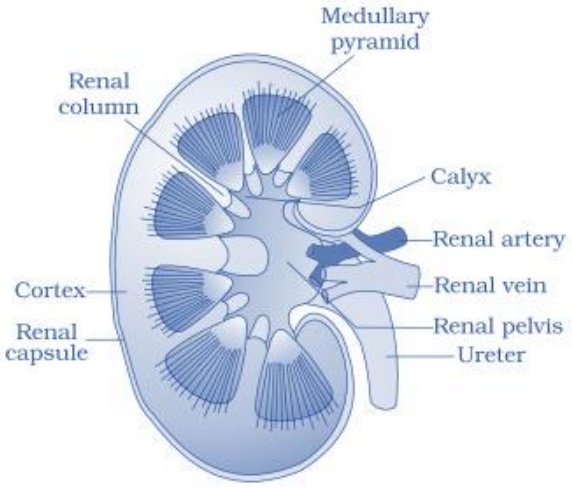
Excretory products and their Elimination

Excretion is the process by which waste products of metabolism and other non-useful materials are eliminated from an organism

Excretory system of man

Mammalian (human) urinary system consists of a pair of kidneys, a pair of ureter, a urinary bladder and a urethra.

(i) Kidneys : The kidneys are dark-red, bean-shaped organs about 11 *cm* long, 5 *cm* wide and 3 *cm* thick, each weight about 150 *gm* in an adult male and about 135 *gm* in adult female.



Differences between cortical and Juxtamedullary nephrons

Cortical Nephrons	Juxtamedullary Nephron
1. Form 80% of total nephrons.	1. Form only 20% of total nephrons.
2. Are small in size.	2. Are large in size.
3. Lie mainly in the renal cortex.	3. Have Bowman's capsules in the cortex near its junction with the medulla.
4. Henle's loops are very short and extend only a little into the medulla	4. Henle's loop are very long and extend deep into the medulla.
5. Control plasma volume when water supply is normal.	5. Control plasma volume when water supply is short.

(ii) **Ureters:** From the hilum of each kidney emerges a whitish tube the ureter. The ureters are about 28 *cm* long. Their wall consists of transitional epithelium surrounded by a layer of muscle fibres. Openings of the two ureters in the bladder are separate, but closely placed. These are oblique, so that the urine cannot regurgitate into the ureters when the bladder contracts. Peristalsis of ureters also cheeks regurgitation of urine.

(iii) **Urinary bladder and Urethra:** The urinary bladder is pear-shaped which is made up of smooth and involuntary muscles. The muscles are also known as detrusor muscles (muscles that has the action of expelling a substance). The lower part or neck of the bladder leads into the urethra.

Differences between male and female urethra

Male urethra	Female urethra
1. It is about 20 cm long.	1. It is just 3 – 5 cm long.
2. It has 3 regions : prostatic urethra (3–4 cm), membranous (1 cm) and penial (15 cm)	2. It is not differentiated into regions.
3. It opens out at the tip of the penis by urinogenital aperture.	3. It opens into the vulva by urinary aperture.
4. It carries urine as well as semen to the exterior.	4. It carries only urine to the exterior.
5. It has 2 sphincters.	5. It has a single sphincter.

Physiology of Excretion

Major nitrogenous excretory substance in frog, rabbit and human is urea, i.e. these are ureotelic animals. The excretory physiology in these animals may be considered under two phases, viz urea synthesis and formation and excretion of urine.

(i) **Synthesis of urea in liver:** Urea is formed in liver by two processes.

(a) Deamination

(b) Ornithine cycle

(ii) **Urine formation:** Urine formation occurs in the kidneys. It involves three processes glomerular filtration, reabsorption and tubular secretion.

(iii) **Mechanism of urine concentration (Counter current mechanism of urine concentration) :** Mammals form hypertonic urine. The urine is made hypertonic with the help of counter current multiplier system. This process takes place in the Henle's loop and vasa recta and it involves mainly Na^+ and Cl^-. In P.C.T. urine is isotonic. The descending limb of loop of Henle is permeable to water. Its surrounding tissue fluid is hypertonic. Hence, the water moves out and the Na^+ and Cl^- move in the descending limb by passive transport. Therefore, the filtrate in the descending limb finally becomes hypertonic.

Summary of events occurring in a nephron

Materials transferred	Nephron region	Process involved	Mechanism
1. Glucose, Amino acids, Vitamins, Hormones, Na^+, K^+, Mg^{2+}, Ca^{+2}, H_2O, Urea, Uric Acid, Creatinine, Ketone Bodies.	Bowman's capsule	Glomerular filtration	Ultrafiltration
2. Glucose, Amino Acids, Hormones, Vitamins, Na^+, K^+, Mg^{2+}, Ca^{+2}	Proximal convoluted tubule	Reabsorption	Active transport
3. Cl^-	Proximal convoluted tubule	Reabsorption	Passive transport
4. Water	Proximal convoluted tubule	Reabsorption	Osmosis
5. Urea	Proximal convoluted tubule	Reabsorption	Diffusion
6. H_2O	Narrow region of descending limb of Henle's loop	Reabsorption	Omosis
7. Na^+,K^+,Mg^{+2},Ca^{+2},Cl^-	Narrow region of ascending limb of Henle's loop	Reabsorption	Diffusion

8.Inorganic ions as above	Wide part of ascending limb of Henle's loop	Reabsorption	Active transport
9.H_2O	Distal convoluted tubule, collecting tubule, collecting duct	Reabsorption with ADH Help	Osmosis
10. Na^+	Distal convoluted tubule, collecting tubule, collecting duct	Reabsorption with aldosterone help reabsorption secretion	Active transport
11. Urea	Last part of collecting duct	Reabsorption with aldosterone help reabsorption secretion	Diffusion
12. Creatinine, Hippuric Acid, Foreign substances	Proximal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
13. K^+, H^+	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
14. NH_3	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Diffusion
15. Urea	Ascending limb of Henle's loop (Thin part)	Reabsorption with aldosterone help reabsorption secretion	Diffusion

Differences between Rennin and Renin

S.No.	Rennin	Renin
1.	It is secreted by peptic (zymogen) cells of gastric glands into the stomach.	It is secreted by specialised cells in the afferent arterioles of the kidney cortex.
2.	Its secretion is stimulated by food.	Its secretion is stimulated by a reduction of Na^+level in tissue fluid
3.	It is secreted as an inactive form prorennin which is activated to rennin by *HCl*.	It is secreted as renin.
4.	It is a proteolytic enzyme.	It is a hormone that acts as an enzyme
5.	It helps in the digestion of milk protein casein.	It converts the protein angiotensinogen into angiotensin.

Renin

(i) Waste products of protein metabolism

(a) **Amino acids:** These are end products of protein digestion absorbed into the blood from small intestine. Certain invertebrates, like some molluscs (*eg Unio, Limnae, etc.*) and some echinoderms (*eg* Asterias) excrete excess amino acids as such. This is called aminotelic excretion or aminotelism.

(b) **Ammonia:** In most animals, excess amino acids are deaminated, i.e. degraded into their keto and ammonia groups. The keto groups are used in catabolism for producing ATP, whereas ammonia is excreted as such or in other forms.

(c) **Urea:** This is less toxic and less soluble in water than ammonia. Hence, it can stay for some time in the body.

(d) **Uric acid:** Animals living in dry (arid) conditions, such as land gastropods, most insects, land reptiles (snakes and lizards), birds *etc* have to conserve water in their bodies.

(f) **Guanine:** Spiders typically excrete their ammonia in the form of guanine. Some guanine is also formed in amphibians, reptiles, birds and earthworms. It is insoluble in water. Hence, no water is required for its excretion.

Differences between ammonotelism, ureotelism and uricotelism

S.No.	Ammonotelism	Ureotelism	Uricotelism
1.	Means excretion of nitrogenous waste mainly as ammonia.	Means excretion of nitrogenous waste mainly as urea.	Means excretion of nitrogenous waste mainly as uric acid.
2.	Uses very little energy in forming ammonia.	Uses more energy in producing urea.	Uses far more energy in producing uric acid.
3.	Its product is very toxic.	Its product is less toxic.	Its product is least toxic.
4.	Causes considerable loss of body's water.	Causes less loss of body's water.	Causes least loss of body's water
5.	Occurs in aquatic animals.	Occurs in aquatic as well as land animals.	Occurs in land animals.
6.	Examples: *Amoeba, Scypha, Hydra, Earthworm, Unio, Prawn, Salamander, Tadpole or frog, bonyfish*.	Examples: Earthworm, Cartilaginous fishes, frog, turtles, alligators, mammals (man).	Examples: Insects, land crustaceans, land snails, land reptiles birds.
7.	Animals excreting NH_3 are called ammoniotelic.	Animals excreting urea are termed uroetelic.	Animals excreting uric acid are called uricotelic.

Body movements and Locomotion

Types of Bones and their Description

Name	No.	Description
Frontal	1	Forms the forehead (anterior or front part of the top of cranium) and some upper parts (roofs) of eye orbits or sockets and nasal cavities. A newborn infant displays a faint suture in midline of frontal, indication that adult frontal is actually formed of two completely fused frontal.
Parietals	2	Articulated to and situated just behind frontal. Form the main parts of bulging top and sides of cranium.
Occipital	1	Articulated to and situated just behind parietals. Forms posterior (back) and lower (base) parts of cranium. Foramen magnum is a large perforation in this bone. On each side of the foramen, the occipital bears a prominent elevation called occipital condyle. The condyles articulate the skull with first vertebra (atlas). Thus, human skull is dicondylic.

Temporals	2	Form lower parts of right and left sides of cranium, as well as, the floor of cranial cavity. These house structures of internal and middle ears and form a part of external auditory meatuses. The middle ear of each side encloses the three small ear ossicles – malleus, incus and stapes.
Sphenoid	1	A typically butterfly-shaped bone that forms the middle and anterior parts of base of cranium in front of occipital in the middle and temporals on the sides. It articulates with all skull bones, keeping these firmly together. It also forms parts of lateral walls and floors of eye orbits.
Ethmoid	1	A small, irregular bone in front of sphenoid and behind nasal bones. It fashions the front (anterior) extremity and closer of cranial cavity. It also contributes to the architecture of eye orbits and proximal parts of nasal chambers.
Nasals	2	Small, oblong bones in middle of upper part of face, forming proximal part of the bridge of our nose. The remaining, lower part of our nose is formed of cartilage.
Inferior nasal conchae (Turbinales)	2	Two highly coiled, scroll-like processes of ethmoid bone, called conchae project into each nasal cavity from lateral wall of the proximal bony part of concerned nasal chamber. One ethmoidal concha is superior (uppermost). The other one is called middle concha, because it is followed by a thin, separate scroll-like bone which is named inferior nasal concha or turbinate.
Vomer	1	A thin, elongated, platelike bone, forming a part of the septum which separates the two nasal cavities.
Lacrimals	2	Small and thin, finger-shaped bones, each located in front part of the medial (inner) side of corresponding eye orbit. these form a part of the passages of corresponding tear ducts.
Zygomatics (Malars)	2	Cheek-bones; form the prominences of our cheeks and parts of the floor and side walls of eye orbits.
Palatines	2	L-shaped bones that form the back (posterior) part of our hard palate (roof of mouth). Also contribute to the framework of nasal cavities and floor of eye orbits.
Maxillae	2	Large, upper jaw bones that form the major part of our face and upper jaw. Comprise entire front (anterior) part of our hard palate. Also contribute to the architecture of eye orbits and nose. Bear the teeth of upper jaw.
Mandible	1	Largest bone of our face, and strongest of all bones of the body. Forms entire lower jaw and bears all lower jaw teeth. Articulated with temporal bones of skull.

Difference between Thoracic and Lumbar vertebra

S.No.	Characters	Thoracic vertebra	Lumbar vertebra
1.	Neural spine	Long undivided and downward directed.	Short, flat and upward directed.
2.	Facet for ribs	Present on transverse process and centrum.	Absent.
3.	Transverse process	Club-shaped.	Thin and elongated.

Difference between Male and Female pelvis

S.No.	Characters	Male pelvis	Female pelvis
1.	Nature of bones of pelvic girdles	Heavier and longer	Lighter and smaller
2.	Sacrum	Less concave	More concave anteriorly
3.	Pelvis	Shallow, narrow and round	Deep, wide and funnel-shaped

Muscle Contraction

From excitation to contraction to relaxation, following occurs within a skeletal muscle:

(1) An electrical signal (action potential) travels down a nerve cell. This in turn causes to release a chemical message (neurotransmitter). This chemical message is released into a small gap between the nerve cell and muscle cell. This gap is called synapse.

(2) The neurotransmitter then crosses the gap. It binds to a protein (receptor) on the muscle-cell membrane which causes an action potential in the muscle cell.

(3) The action potential spreads along the muscle cell.

(4) The action potential enters the cell through T-tubule.

(5) The action potential opens gate in the muscle's calcium store.

(6) Calcium ions flow into the cytoplasm.

(7) Calcium ions bind to troponin-tropomyosin molecules. These are located in the grooves of the actin filaments.

(8) The sites on actin where myosin can form crossbridges are covered by the rod-like tropomyosin molecule.

(9) On binding calcium ions, troponin changes shape. It then slides tropomyosin out of the groove, exposing the actin-myosin binding sites.

(10) Myosin interacts with actin by cycling crossbridges. The muscle thereby creates force, and shortens.

(11) After the action potential has passed, the calcium gates close automatically.

(12)Calcium pumps remove calcium from the cytoplasm. These pumps are located on the sarcoplasmic reticulum.

(13)As the calcium gets pumped back into the sarcoplasmic reticulum, calcium ions come off the troponin.

(14)The troponin returns to its normal shape.

(15)Troponin allows tropomyosin to cover the actin-myosin binding sites on the actin filament.

(16)As no binding sites are available now, hence no crossbridges can form, and the muscle relaxes.

Note:-

(1) The activities of muscle contraction and relaxation require energy.

(2) Muscles use energy in the form of ATP. The energy from ATP is used to reset the myosin crossbridge head and release the actin filament.

(3) In order to make ATP, the muscles do the following:

(a) Breaks down creatine phosphate.

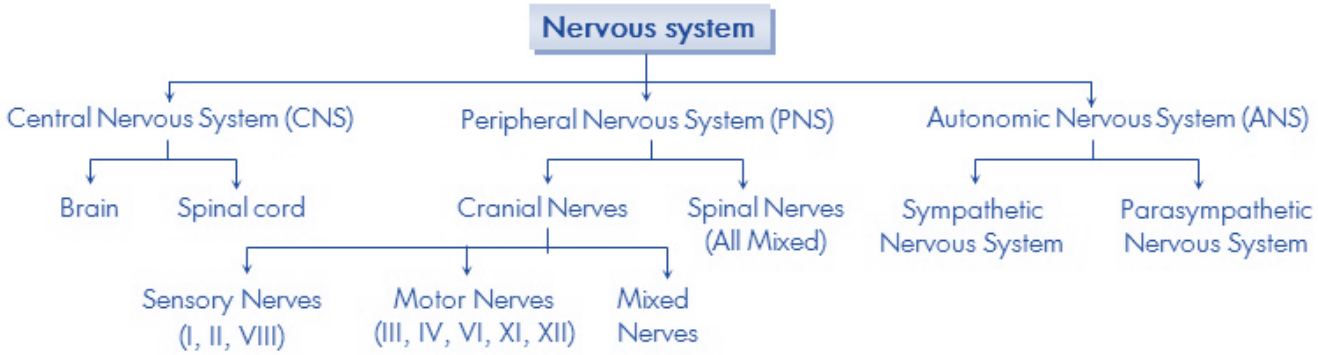
(b) Add phosphate to ADP to create ATP.

(c) Carry out anaerobic respiration, by which glucose is broken down to lactic acid and ATP is formed.

(d) Carry out aerobic respiration. Due to which glucose, glycogen, fats and amino acids are broken down in the presence of oxygen to produce ATP.

Neural Control and Cordination

Parts of nervous system



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Central nervous system:

(1) Central nervous system is made up of brain and spinal cord. CNS is covered by 3 meninges and its wall has two type of matter.

(2) Types of matter: CNS of vertebrates is formed of two types of matter –

(a) Grey matter: It is formed of cell-bodies and non-medullated nerve fibres.

(b) White matter: It is formed of only medullated nerve fibres which appear white due to presence of medullary sheath.

Brain (Encephalon): It is soft, whitish, large sized and slightly flattened structure present inside cranial cavity of cranium of the skull. In man, it is about 1200-1400 *gm* in weight and has about 10,000 million neurons. Brain is made up of 3 parts

(1) **Fore brain (Prosencephalon)**

(i) Olfactory lobe – Rhinencephalon

(ii) Cerebrum – Telencephalon

(iii) Diencephalon – Diencephalon

(2) **Mid brain (Mesencephalon)**

(i) Optic lobes – Mesencephalon

(3) **Hind brain (Rhambencephalon)**

(i) Cerebellum – Metencephalon

(ii) Medulla oblongata – Myelencephalon

Important areas in the human brain

Area	Location	Function
Premotor area	Frontal lobe	The highest centre for involuntary movements of muscles and ANS.
Motor area	Frontal lobe	Controls voluntary movements of the muscle
Broca's area	Frontal lobe	Motor speech area
Somesthetic area	Parietal lobe	Perception of general sensation like pain, touch and temperature
Auditory area	Temporal lobe	Hearing
Olfactory area	Temporal lobe	Sense of smell
Wernicke's area	Temporal lobe	Understanding speech written and spoken
Gustatory area	Parietal lobe	Sense of taste
Visual area	Occipital lobe	Sensation of light

Differences between Cerebrum and Cerebellum

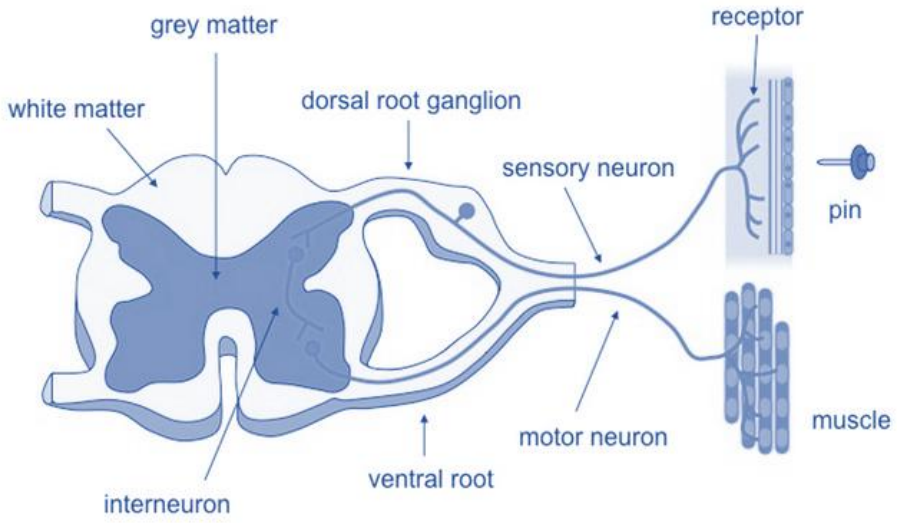
Cerebrum	Cerebellum
(1) It is the largest part of the brain, forming four-fifths of its weight.	(1) It is the second largest part of the brain, forming one-eighth of its mass.
(2) It covers the rest of the brain.	(2) It covers the medulla oblongata only.
(3) It is a part of the forebrain.	(3) It is a part of the hindbrain.
(4) It consists of 2 cerebral hemispheres each comprising 4 lobes : frontal, occipital, parietal, temporal.	(4) It consists of two cerebellar hemispheres and a median vermis.
(5) It encloses 2 lateral ventricles.	(5) It is solid.
(6) White matter does not form arbor vitae.	(6) White matter form arbor vitae.
(7) It initiates voluntary movements, and is a seat of will, intelligence, memory *etc*.	(7) It maintains posture and equilibrium.

Subdivisions, parts and associated structures of a vertebrate brain

Divisions	Subdivisions	Parts	Cavity	Associated strcutures
(I) Prosencephalon (Forebrain)	(1) Telencephalon	Rhinencephalon	I Ventricle (*Rhinocoel*)	Olfactory bulbs Olfactory tracts Olfactory lobes Palaeocortex on pallium
		Cerebral hemispheres	II or Lateral Ventricles	Corpora striata or basal ganglia Corpus callosum Neocortex on pallium Paraphysis
	(2) Diencephalon	Epithalamus (roof)		Habenulae Pineal apparatus Parapineal or parietal
		Thalamus (sides)		

		Hypothalamus (floor)		Hypothalamic nuclei Optic chiasma Median eminence Infundibular stalk Pituitary Saccus vasculosus Mamillary bodies Anterior choroid plexus
(II) Mesencephalon (Midbrain)	–	Crura cerebri (floor)	*Iter* or *cerebral aqueduct*	Cerebral peduncles
(III) Rhombencephalon (Hind brain)	(1) Metencephalon	Cerebellum		Trapezoid body Pons
	(2) Myelencephalon	Medulla oblongata	IV Ventricle (*Metacoel*)	Restiform bodies Pyramids

Reflex action



(1) The reflex actions are involuntary actions because these are not under the conscious control of the brain.

(2) The spinal cord and brain stem are responsible for most of the reflex movements.

(3) A few examples of the reflex actions are withdrawal of hand or leg if pricked by a pin, secretion of saliva as soon as one thinks of delicious food or mere its sight causes salivation, if the body

part is touched with acid or hot object it is automatically, without thinking and planning is withdrawn, cycling, motor driving etc.

(4) Component of reflex action: The whole of the reflex are includes six parts –

- **(a) Receptor organs:** Receptors are windows of the body or guards of the body. These are situated on all, important organs, for example – eyes, nose, ear, tongue, integument etc. These perceive the stimuli from outside the body.
- **(b) Sensory neurons:** These are also termed afferent neurons. These carry the stimuli from receptors to spinal cord. These neurons are situated in the ganglion on the dorsal side of spinal cord.
- **(c) Nerve centre:** Spinal cord is termed as nerve centre. Synaptic connections are formed in it.
- **(d) Association neurons:** These are also called intermediate neurons or interstitial neurons. These are found in spinal cord. They transfer the impulses from sensory neurons to motor neurons.
- **(e) Motor neurons:** These are situated in the ventral horn of spinal cord. These carry the impulses to effector organs.
- **(f) Effector organs:** These are the organs, which react and behave in response to various stimuli, for example – muscles and glands.

(5) Type of reflexes: The reflexes are of following types –

- **(a)** Monosynaptic reflex
- **(b)** Polysynaptic Spinal Reflex
- **(c)** Polysynaptic Spinal/Brain Reflexes
- **(d)** Unconditioned or Simple reflex
- **(e)** Conditioned or Acquired reflex

Cranial nerves of mammal at a glance

Olfactory – sensory
Optic-sensory

Occulomotor (smallest nerve)-motor

Trochlear(pathetic)-motor

Trigeminal(dentists nerve) –mixed (a) Opthalmic-sensory (b)maxillary-sensory (c) mandibular-mixed

Abducens(shortest nerve)-motor

Facial-mixed

Auditory(vestibulocochlear)-sensory

Glossopharyngeal-mixed

Vagus(longest nerve)-mixed

Spinal accessory nerve-motor

Hypoglossal-motor

Properties of hormones

(a) These are secreted by endocrine gland (biogenic in origin).

(b) Their secretions is released directly into blood (except local hormones *e.g.* gastrin).

(c) These are carried to distantly locate specific organs, called target organ.

(d) These have specific physiological action (excitatory or inhibatory). These co-ordinate different physical, mental and metabolic activities and maintain homeostasis.

(e) The hormones have low molecular weight *e.g.* ADH has a molecular weight of 600–2000 daltons.

(f) These act in very low concentration *e.g.* around 10^{-10} molar.

(g) Hormones are non antigenic.

(h) These are mostly short-lived. So have a no camulative effect.

(i) Some hormones are quick acting *e.g.* adrenalin, while some acting slowly *e.g.* ostrogen of ovary.

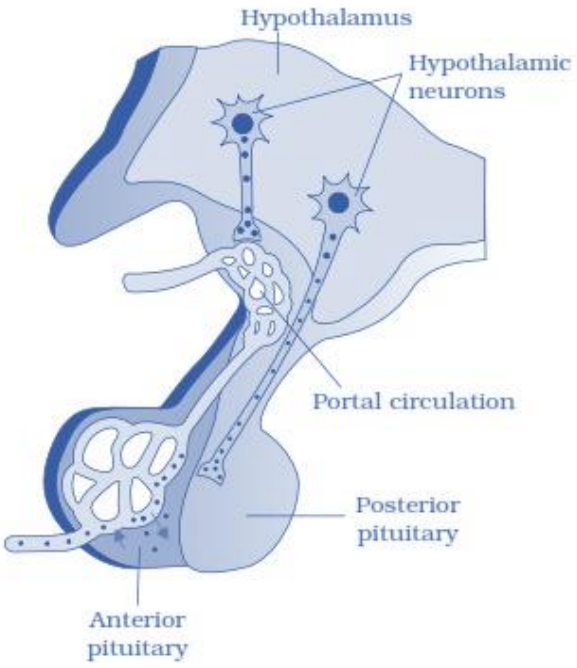
(j) Some hormones secreted in inactive form called Prohormone *e.g.* Pro-insulin.

(k) Hormones are specific. They are carriers of specific information to their specific target organ. Only those target cell respond to a particular hormone for which they have receptors.

Pituitary Gland (Hypophysis)

(1) Pituitory is known as hypophysis cerebri, its name pituitary was given by vesalius.

(2) Muller's gland of amphioxus and subneural gland of hardmania is homologous to pituitary of vertebrates.



Parts and component

(1) **Adenohypophysis (Anterior lobe)**

(i) Pars distalis

(ii) Pars tuberalis

(iii) Pars intermedia

(2) **Neurohypophysis (Posterior lobe)**

(i) Pars nervosa

(ii) Infundibulum

Hypothalamus

(i) **Position and Structure:** Hypothalamus is the floor of diencephalon. It is formed of masses of grey matter, called hypothalmic nuclei, containing neurosecretory cells. It is connected with anterior pituitary lobe by blood capillaries of hypophyseal portal system and with the posterior pituitary lobe by axons of its neurons, both passing through the pituitary stalk.

(ii) **Hormones of hypothalamus:** Neurosecretory cells of hypothalamus secrete neurohormones called releasing factors (RF) or inhibiting factors (IF). These neurohormones are carried by hypophyseal portal system to adenohypophysis (primary target organ) and stimulate or inhibit the release of trophic hormones from adenohypophysis. These neurohormones are proteinous in nature and formed of 3 – 20 amino acids.

Neurohormones of Adenohypophysis

Neurohormones	Physiological effects
(1) TSH-RF	
(Thyroid Stimulating Hormone – Releasing Factor)	Increased ACTH secretion from adenohypophysis.
(2) ACTH-RF	
(Adrenocorticotrophic Hormone-Releasing Factor)	Increased ACTH secretion from adenohypophysis.
(3) STH-RF	
(Somatotrophic Hormone-Releasing Factor)	Increased STH secretion from adenohypophysis
(4) SOMATOSTATIN (GROWTH INHIBITING HORMONE)	Decreased STH secretion from adenohypophysis.
(5) GTH-RF	
(Gonadotrophic Hormone-Releasing Factor)	
(i) FSH-RF	
(Follicular Stimulating Hormone-Releasing Factor)	Increased FSH secretion from adenohypophysis.
(ii) LH-RH (In female)	
(Luteinising Hormone – Releasing Factor)	Increased LH secretion from adenohypophysis.
or ICSH-RF (In male)	
(Interstitial Cells stimulating Hormone-Releasing Factor)	
(6) Prolactin-Releasing hormone (P-RH)	Increased secretion of prolactin or leutotrophic hormone.
(7) Prolactin-Inhibiting hormone (P-IH)	Increased secretion of prolactin or leutotrophic

	hormone.
(8) MSH-RF	
(Melanophore Stimulating Hormone-Releasing Factor)	Increased MSH secretion from intermediate pituitary lobe.
(9) MIF	
(Melanophore Inhibiting Factor)	Decreased MSH secretion from intermediate pituitary lobe.

List of hormones their chemical nature and functions

Name of endocrine gland	Name of hormone and its chemical nature	Functions
(1) Neurosecretory cells of Hypothalamus (Supraoptic Nucleus and Paraventricular Nucleus)	(1) Oxytocin and vasopressin nanopeptide.	(1) Milk ejection and parturition (oxytocic effect). (2) Vasoconstriction and antidiuretic (vasotocin) effects.
	(2) Gonadotropin releasing hormones	Stimulates FSH and LH sysnthesis.
	(3) Other releasing hormones *e.g.*TSHRH, MSHRH, ACTHRH, GHRH etc. Proteinaceous	Stimulate TSH, MSH, ACTH GH secretions from pituitary.
(2) Pituitary **(a) Neurohypophysis (Pass Nervosa)** **(b) Adenohypehypsis (contains diverse cell types)**	Store and release Oxytocin and Vasopressin.	Hormone release is related to physiological state and requirements.
	Proteincaceous or glycoprotein	Affect growth, development differential pubertal changes and other metabolic mechanism.
(3) Pineal	Melatonin-derived from the amino acid tyrosine	(1) Antagonist to FSH / LH (2) Regulates biological / circadian rhythms.
(4) Thyroid gland (amine	(a) Thyroxine, iodinated	(a) Controls basal metabolic rate (BMR). All organ /

hormone) having – NH_2 group)	amino acid called tyrosine (T_2, T_3, T_4).	system of body respond to thyroxine.
	(b) Thyrocalcitonin (Peptide)	(b) Facilitates Ca^{+2} absorption
(5) Parathyroid gland	Parathormane, Peptide	Ca^{+2} and PO^{-4} metabolism.
(6) Thymus	Thymosine (polypeptide)	Anti-FSH and LH; delays puberty
(7) Islets of lengerhans **(= Endocrine pancrease)** **(i) a-cells** **(ii) b-cells** **(iii) d-cells**	(i) Glucagon (ii) Insulin (iii) Secretin Isolated by banting polypeptide	(i) Gluconeogenesis / Glycogenolys (ii) Glycogenesis (iii) Gastric functions
(8) Adrenal gland **(a) Adrenal medulla** **(Amine hormone have – NH_2)**	(a) Catecholamines (epinephrine = adrenaline, and norepinephrine = noradrenaline (derived from tyrosine)	(a) Stresses = emergency = Fright, Fight and Flight Hormone (3F) acclerates cardiac functions muscle activity etc.
(b) Adrenal cortex	(b) Mineralcorticoids and glucocorticoids and traces of androgen and estrogen steroids derived from cholesterol	(b) Electrolyte and carbohydrate metabolism.
(9) Ovary **(a) Ganulosa cells steroid, fat soluble have sterol group derived from cholesterol**	Estrogen (Steroid) Estrone, estradiol	(a) Secondary sex character primary action on uterine endometrium mitogenic.
(b) Corpus luteum	Estrogen and Progesterone (Steroid)	(a) Secreted during luetal phase of menstrual cycle in human female and oestrous cycle of other mammals. Prepares uterine endometrium for receiving blastocytes for implantation. Progesterone is also called pregnancy hormone and is anti-FSH and anti-LH/anti-LTH.
(c) Placenta temporary endocrine gland formed	(a) Steroid secreted are estrogen and progesterone	(a) Maintenance of pregnant state prevents lactogenesis folliculogenesis, and Ovulation.

during pregnancy	(b) Relaxin-Polypeptide	(b) Act on pubic symphysis and enlarges the birth canal to facilitate birth. Acts synergestically with oxytocin during this process (parturition)
(10) Testis **(i) Sertoli cells** **(=sustentacular cells)**	Inhibin – Polypeptide	Inhibits FHS action and attenuates spermatogenesis decrementally
(ii) Leydig cells **(=Interstitial cells)**	(ii) Estradiol-Steroid Androgens (e.g. Testosterone) Steroid androstenedione)	(i) Pubertal changes in male (ii) Secy. sex characters in male (iii) Sex drives (iv) Spermatogenesis
(11) Gastro-intestinal hormones (secreted by cells of mucosa of stomach and intestine) also called hormones		Stimulates gastric juices secretion from gastric gland, movement of sphincters of stomach and increased movement of stomach
(a) Pyloric stomach (Argentophil cells) Intestine	Gastrin (i) Secreten (ii) Cholecystokinin (CCK) (iii) Enterogastrone (iv) Duedocrinin (v) Enterokinin (vi) Villikrinin	(i) Stimulates secretion of succus entericus (ii) Bile released from gall bladder (iii) Inhibits gastric secretin (iv) Stimulates secretion of mucous from Brunner's gland (v) Stimulate intestinal gland (vi) Stimulate villi movement

Circulation

Circulatory System

Functions of Circulatory System

(1) Transport of various substances such as nutrients, waste products, respiratory gases, metabolic intermediates (Such as lactic acid from muscle to liver), and vitamins hormones etc.

(2) Regulation of body pH by means of buffer, body temperature homeostasis, water balance etc.

(3) Prevention of disease by means of antibodies and antitoxins.

(4) Support or turgidity to certain organs like penis and nipples.

Heart of vertebrates

Class of vertebrates	Characteristics	Example
(1) Pisces (= Branchial heart)	Thick, muscular, made of cardiac muscles, has two chambers (i) auricle and (ii) ventricle. The heart is called venous heart since it pumps deoxygenated blood to gills for oxygenation. This blood goes directly from gills to visceral organs (single circuit circulation). A sinus venosus and conus arteriosus is present. Lung fishes have 2 auricles and 1 ventricle.	Labeo Scoliodon Neoceratodus
(2) Amphibians	**Heart consists of** (a) Two auricles (b) Undivided ventricle (c) Sinus venosus (d) Truncus arteriosus (conus + proximal part of aorta) Right auricle receives blood from all the visceral organs (deoxygenated) via precaval and post caval. Pulmonary artery carries deoxygenated blood to lungs for oxygenation. This blood returns to left auricle via pulmonary vein (Double circuit circulation)	Frog Toad
(3) Reptiles	**Heart consists of :** (a) Left and right auricle (b) Incompletely divided ventricle (Ventricle in crocodiles gavialis and alligator is completely divided) (c) Sinus venosus (d) Conus arteriosus divided into right systemic, left systemic and pulmonary arch.	Lizards Snakes Turtles
(4) Aves	**Heart consists of** (a) Left and right auricle (b) Left and right ventricle (c) Complete separation of arterial and venous circulation (d) Only right systemic arch is present (e) Sinus venosus and truncus arterisious absent	Pigeon
(5) Mammals	Same as bird except that mammals have left systemic arch.	Rabbit, man

Human Heart

Circulation of Blood through Heart

(1) The heart pumps blood to all parts of the body.

(2) The deoxygenated blood is drained into right auricle through superior and inferior vena cava and coronary sinus whereas the pulmonary veins carry oxygenated blood from lungs to the left auricle. This is called as Auricular circulation.

(3) About 70% of the auricular blood passes into the ventricles during diastole. This phase is called diastasis.

(4) The rest of 30% of blood passes into the ventricles due to auricular systole (contraction).

(5) In this way, blood reaches the ventricles and is called ventricular filling.

(6) During ventricular systole (which starts first in left ventricle than in right ventricle), the pressure increases in the ventricles, thus, forcing the oxygenated blood from left ventricle into systemic aorta and deoxygenated blood from right ventricle into pulmonary aorta.

(7) The systemic arch distributes the oxygenated blood to all the body parts except lungs while pulmonary aorta carries the deoxygenated blood to lungs for oxygenation.

Differences between Neurogenic heart and Myogenic heart

Neurogenic heart	Myogenic heart
(1) The heart beat is initiated by a ganglion situated near the heart.	(1) The heart beat is initiated by a patch of modified heart muscle.
(2) The impulse of contraction originates from nervous system.	(2) The impulse of contraction originates itself in the heart.
(3) The heart normally stops beating immediately after removal from the body. Therefore, heart transplantation is not possible.	(3) The heart removed from the body continues to beat for some time. Therefore, heart transplantation is possible.
(4) Examples: Hearts of some annelids and most arthropods.	(4) Examples: Hearts of molluscs and vertebrates.

Fractions of cardiac output :

Amount of pure blood going to an organ per minute is called as fraction of the organ.

(i) Cardiac fraction – 200 ml/min.

(ii) Hepatic fraction – 1500 ml/min. (28% of blood as liver is the busiest organ of body and has maximum power of regeneration).

(iii) Renal fraction – 1300 ml/min (25% of blood)

(iv) Myofraction – 600-900 ml/min.

(v) Cephalic organs – 700-800 ml/min.

Differences between first and seconds heart sounds

First heart sound (Lubb)	Second heart sound (Dup)
(1) It is produced by closure of bicuspid and tricuspid valves at the start of ventricular systole.	(1) It is produced by closure of semilunar valves at the start of ventricular diastole.
(2) It is low pitched, less loud and of long duration.	(2) It is higher pitched, louder, sharper and of short duration.
(3) It lasts for 0.15 seconds.	(3) It lasts for 0.1 second.
(4) Its principal frequencies are 25 to 45 cycles per second.	(4) Its principal frequency is 50 cycles per second.

Electrocardiogram (ECG)

(1) A graphic record of electrical events occurring during a cardiac cycle is called Electrocardiogram.

(i) Depolarisation waves: They represent the generation of the potential difference. These waves appear only when both electrodes of galvanometer are in different fields. When both the electrodes are in same field, there are no deflection and wave drops down to base line.

(ii) Repolarisation waves: They appear when depolarisation is over and the muscle fibre is returning to its original polarity. When both electrodes are in same polarity (means 100% repolarisation and 100% depolarisation), there is no deflection.

(a) ***P*** **wave:** Indicates impulse of contraction generated by S.A. node and its spread in atria causing atrial depolarisation. The interval *PQ* represents atrial contraction and takes 0.1 second.

(b) QRS complex: Indicates spread of impulse of contraction from A.V node to the wall of ventricles through bundle of His and pukinje fibres causing ventricular depolarisation. This complex also represents repolarization of S.A. node.

The RS of *QRS* wave and *ST* interval show ventricular contraction (0.3 seconds). QRS is related to ventricular systole.

- ***T*** **wave:** Indicates repolarisation during ventricular relaxation

Types of Blood Circulation in Human

(i) Coronary circulation: It involves blood supply to the heart wall and also drainage of the heart wall.

- **(a) Coronary arteries:** One pair, arising from the aortic arch just above the semilunar valves. They break up into capillaries to supply oxygenated blood to the heart wall.
- **(b) Coronary veins:** Numerous, collecting deoxygenated blood from the heart wall and drains it into right auricle through coronary sinus which is formed by joining of most of the coronary veins.

(ii) Pulmonary circulation: It includes circulation between heart and lungs. The right ventricle pumps deoxygenated blood into a single, thick vessel called pulmonary aorta which ascends upward and outside heart gets divided into longer, right and shorter, left pulmonary arteries running to the respective lungs where oxygenation of blood takes place.

(iii) Systemic circulation: In this, circulation of blood occurs between heart and body organs. The left ventricle pumps the oxygenated blood into systemic arch which supplies it to the body organs other than lungs through a number of arteries.

Lympahtic System

The lymphatic system is an extension of the circulatory system. It consists of a fluid known as lymph, lymph capillaries and lymph ducts.

(a) **Lymph:** It can be defined as blood minus RBC's. In addition to the blood vascular system all vertebrate possess a lymphatic system. It is colourless or yellowish fluid present in the lymph vessels. It is a mobile connective tissue like blood and is formed by the filtration of blood.

(b) **Lymph capillaries:** Small, thin, lined by endothelium resting on a basement membrane and fine whose one end is blind and other end unites to form lymphatic ducts.

(c) **Lymphatic ducts or vessels:** Numerous, present in various parts of body. These vessels are like veins as they have all the three layers – tunica externa, tunica media and tunica interna, and are provided with watch pocket or semilunar valves but valves are more in number than veins.

Reproduction in Plants & Animals

Reproduction in Organisms

Reproduction:

(1) Reproduction is defined as a biological process in which every living organism give rise to new organisms similar to themselves.

(2) Basic features of reproduction:

(i) Replication of DNA

(ii) Cell division (only mitotic, or both mitotic and meiotic)

(iii) Formation of reproductive bodies or units.

(iv) Development of reproductive bodies into offsprings.

Difference between Asexual and Sexual Reproduction

S.No.	Asexual Reproduction	Sexual Reproduction
1)	Offsprings are produced by single parents.	Involvement of single or two individual.
2)	New individual develops from one cell or a vegetative body part of one parent.	New individual develops from zygote or fusion product of two gametes, which may or may not be produced by two parents.
3)	Offsprings are genetically identical to their parents.	The offsprings are not genetically identical with their parents.
4)	Involves only mitotic divisions.	Involves meiosis at one or the other stage.
5)	It does not require the formation of sex organs.	Formation of sex organs is a pre-requisite for sexual reproduction.
6)	It does not introduce variability. Hence has no evolutionary importance.	It introduces variability and is, hence of evolutionary importance.

Asexual Reproduction

Asexual reproduction in plants

In flowering plants there are two main types of asexual reproduction:

(a) Agamospermy – The formation of embryo without fertilization and meiotic division. There are three different types of agamospermy:

(i) Diplospory

(ii) Adventive embryony

(iii) Apospory

(b) Vegetative propagation –

(i) Plants belonging to this category propagates by a part of their body other than a seed. The structural unit that is employed in place of seed for the propagation of new plants is called **propagule.**

(ii) In angiosperms any parts of the plants – roots, stemsand leaves can be used for vegetative propagation.

(5) Following are the asexual reproductive structures:

(a) Zoospores: aquatic fungi, *Chlamydomonas*
(b) Conidia: *Penicillium*
(c) Bud: *Hydra*
(d) Gemmules: *sponges*

(6) Below given are the vegetative propagation units in plant: (Vegetative propagules)

Runner, rhizome, sucker, tuber, offset, bulb

Sexual reproduction:

Sexual reproduction involves fusion of male and female gametes by the process of fertilization.

Features of sexual reproduction:

(a) The period between birth and sexual maturity is called juvenile phase.

(b) Juvenile phase is also known as vegetative phase in plant.

(c) **Oestrus cycle:** The cyclical changes during reproduction in non-primate mammals like cows, sheep, rats, deers, dogs, tiger etc.

(d) **Menstrual cycle:** The cyclical changes during reproduction in primate mammals like monkeys, ape, and humans.

(e) **Seasonal breeders:** The reproductive cycle takes place only in favorable seasons as in wild animals.

(f) **Continuous breeders:** They are reproductively active throughout their reproductive phase.

(g) **Gametogenesis** is the process of gamete formation.

(h) **Isogametes** are one of a pair of conjugating gametes, exhibiting no differences in form, size, structure, or sex.

(i) Gametes produced of two morphologically distinct types are called heterogametes.

(j) Male gamete is called antherozoid or sperm and the female gamete is called ovum or egg.

Sexuality in organism:

(a) Plants having only one sex organ is called heterothallic or dioecious.

(b) Plants having both male and female sex organ called homothallic or monoecious.

(c) In flowering plants, the unisexual male flower is staminate (bearing stamens), while the female is pistillate (bearing pistils).

(d) Animals having one type of reproductive system are called unisexual.

(e) Animals having both male and female reproductive system are called hermaphrodite or bisexual.

Cell division during gamete formation:

(a) Gametes in all heterogametic species are of two types namely male and female.

(b) Gametes are always haploid irrespective of parent's ploidy.

(c) Gametes are produced by a haploid parent by mitotic division.

(d) Gametes are produced by a deploid parent by meiotic division.

(e) In diploid organisms specialized cells called meiocytes undergo meiosis to produce haploid gametes.

Gamete transfer:

(a) Male and female gamete must be physically brought together to facilitate fusion called fertilization.

(b) In most cases female gametes are non-motile , male gametes are motile.

(c) In case of few fungi and algae, both male and female gametes are motile.

(d) In most cases the medium for gamete transfer is water.

(e) Number of male gametes are produced is several thousand times the number of female gametes produced to compensate the loss during transfer.

Fertilization:

The process of fusion of male and female gamete is called **fertilization or syngamy.**

Sexual Reproduction in Flowering Plants

Flower

Flower is a modified stem which functions as a reproductive organ and produces ova and/or pollen

(1) Structure of the flower:

The flower is commonly borne on short or long stalk called the pedicel. It has an upper swollen region known as receptacle (thalamus or torus).

(2) Parts of a flower:

A typical angiospermic flower consists of four whorls of floral appendages attached on the receptacle: calyx, corolla, androecium and gynoecium.

(i) Calyx: It is the outermost whorl of the flower. It is composed of leaf like green sepals. The sepals are essentially green in colour but in some cases they are coloured like petals. Such a condition of calyx is called petaloid.

(ii) Corolla: This is the second whorl of the flower and consists of a number of petals. Petals are generally brightly coloured and sometimes fragrant which make the flower to become attractive.

(iii) Androecium: It is the third whorl of flower and is the male reproductive organ consisting of stamens. Each stamen is made of filament and anther. The filament supports anther at its tip.

(iv) Gynoecium: This is the last and the fourth whorl of flower and is the female reproductive organ of the flower. It occupies the central position on the receptacle and composed of ovary, style and stigma and the component parts are called carpels.

(3) Functions of a flower

(i) Flowers are modifications of shoot to perform the function of sexual reproduction.

(ii) Flowers of most of the angiosperms are shaped variously to help diverse modes of pollination.

(iii) Flowers provide seat for germination of pollen, development of pollen tube, formation of gametes and fertilization.

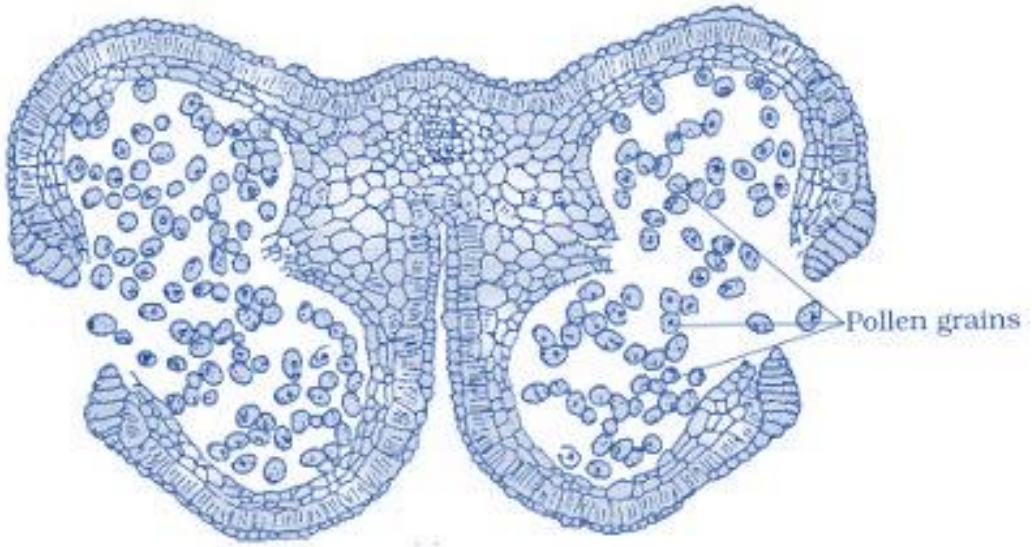
(iv) The ovary part of the carpel gets transformed into fruit and the ovules are transformed into seeds after fertilization.

(v) Some floral parts like calyx and various modifications in ovaries help in the dispersal of fruits and seeds.

Microsporogenesis

The process of the formation and differentiation of microspores (pollen grains) from microspore mother cells (MMC) by reductional division is called microsporogenesis.

Microsporogenesis is well studied under following heads:



(1) Structure of anther:

The fertile portion of stamens is called anther. Each anther is usually made up of two lobes connected by a connective. In turn each anther lobe contains two pollen chambers placed longitudinally. Each pollen chamber represents a microsporangium and is filled with a large number of pollen grains or microspores.

The pollen sacs are surrounded by following 4 layers :

(i) Epidermis: This is the outermost single layered and protective. In Arceuthobium, cells of epidermis develop a fibrous thickening and the epidermis is designated as exothecium.

(ii) Endothecium: Inner to epidermis, there is a single layer of radially elongated cells. Cells of endothecium develop fibrous thickening (made up of cellulose with a little pectin and lignin) which help in the dehiscence of anther. In between these cells, a few cells without thickening are also present. These thick walled cells collectively form the stomium.

(iii) Middle layer: Three to four layers of thin walled cells situated just below the endothecium are known as middle layers. Cells of this layer are ephemeral and degenerate to provide nourishment to growing microspore mother cells.

(iv) Tarentum: This is the innermost layer of the wall. The cells are multinucleate (undergo endopolyploidy) and polyploid. Tapetal cells are nutritive.

(2) Development of anther and formation of microspores (Pollen grains):

(a) The young anther consists of homogenous mass of paranchymatous cells surrounded by epidermis. It soon becomes four lobed.

(b) In each of the four lobes, some of the hypodermal cells begin to act as archesporial initials.

(c) Each archesporial initial divides into an outer primary parietal cell and an inner primary sporogenous cell.

(d) The primary parietal cell divides to form 3-5 wall layers, i.e., endothecium, middle layers and tapetum.

(e) The primary sporogenous cells divide to produce a mass of sporogenous cells or microsporocytes.

(f) Each microspore mother cell divides meiotically to form four haploid microspores or pollen grains and remains arranged in tetrads.

(3) Development of male gametophyte (Microgametogenesis):

(a) Microspore or pollen grain is the first cell of male gametophyte (partially developed).

(b) The wall of the pollen grain is made of two layers.The outer layer is called exine. It is made up of sporopollenin (derived from carotenoid). The inner intine is thin, delicate and is made of cellulose and pectose.

(4) Pre-pollination development:

(a) Microspores start germinating in situ (i.e. while enclosed inside the microsporangium or pollen sac) and are called precocious.

(b) Microspore nucleus divides mitotically to form a smaller generative cell lying next to spore wall and a much larger vegetative cell (or tube cell).

(c) A callose layer is deposited around the generative cell. The generative cell loses its contact with the wall of microspore and becomes free in the cytoplasm.

(d) The callose layer then dissolves. The pollen grains are shed from the anther at this bicelled stage (rarely three celled).

(5) Post-pollination development:

(a) The liberated pollen grains are transferred to the receptive surface of the carpel (i.e., stigma) by the process called pollination.

(b) On the stigma, the pollen grain absorbs water and swells within a few minutes.

(c) The vegetative (or tube) cell enlarges and comes out through one of the apertures in the form of a pollen tube.

(d) The wall of pollen tube is the extension of intine. The tube secretes exogenous pectinases and other hydrolytic enzymes to create a passage for its entry.

(e) The vegetative and generative nuclei are carried by the pollen tube, the farmer lying at its tip.

(f) The generative cell divides to form two non-motile male gametes.

(g) The tube nucleus has no important function and may disintegrate.

Megasporogenesis

The process of formation of megaspore from megaspore mother cell by meiotic division is known as megasporogenesis. This process takes place in ovule.

(1) Structure of ovule:

Ovule is considered to be an integumented megasporangium. The ovule consists of the stalk and the body. The stalk is called funicle. One end of the funicle is attached to placenta and the other end to the body of the ovule. The point of attachment of funicle with the body is called hilum. Sometimes funicle gets fused with the body of the ovule one side and forms a ridge known as raphe. The body of the ovule shows two ends: the basal end, often called the chalazal end and the upper end is called micropylar end. The main body of the ovule is covered with one or two envelopes called integuments. These leave an opening at the top of the ovule called micropyle. The integuments enclose a large parenchymatous tissue known as nucellus.

(2) Development of female gametophyte (Megagametogenesis):

The process of development of female gametophyte or embryo sac from megaspore is called megagametogenesis.

(i) Monosporic type (Polygonum): In this type, only one megaspore situated towards chalazal end takes part in the development of embryo sac.

(ii) Bisporic type: In this type two megaspore nuclei take part in embryo sac formation.

(iii) Tetrasporic type: This type of embryo sac develops from four megaspore nuclei.

Pollination

(1) The process of transfer of pollen grains from an anther to the stigma of the same flower or of different flower.

(2) It is of two types:

(i) Self pollination: This process involves the transfer of pollen grains from the anthers to the stigma of the same flower or of another flower borne by the same plant.

(ii) Cross pollination: Cross pollination involves the transfer of pollen grains from the flower of one plant to the stigma of the flower of another plant. It is also called xenogamy.

Fertilization

The fusion of two dissimilar sexual reproductive units (gametes) is called fertilization. This process was discovered by Strasburger (1884).

Germination of pollen grain on stigma and growth of pollen tube:

Pollen grains reach the receptive stigma of the carpel by the act of pollination.

Human Reproduction

(1) **Reproduction** is the formation of new individuals of their own kind by living organisms.

(2) The **Male Reproductive System** consists of:

(a) Primary sex organs i.e. a pair of testes suspended in a scrotum.

(b) Secondary sorgans i.e. a pair of ducts each differentiated into an epididymis, a vas deferens and an ejaculatory duct.

(c) A male urethra passing through an erectile penis.

(d) Three types of Glands - a pair of seminal vesicles, a prostate gland and a pair of Cowper's glands.

(3) The **Female Reproductive system** consists of:

(a) Primary sex organ i.e. a pair of ovaries

(b) Secondary sex organs i.e. a pair of fallopian tubes (oviducts) , a uterus (womb), a vagina.

(4) Ovaries produce female gametes called ova.

Phases of embryonic development.

(1) **Gametogenesis :** It involve the formation of haploid sex cells or gametes called sperms and ova from diploid primary germ cells called gametogonia present in the reproductive organs called gonads (testes and ovary). It is of two types;

   (i) **Spermatogenesis:** Formation of sperm.

   (ii) **Oogenesis :** Formation of ova

(2) **Fertilization:** It involves the fusion of haploid male and female gametes to form diploid zygote. The fusion of gametic pronuclei is called Karyogamy while the mixing of two sets of chromosomes of two gametes is called amphimixis.

(3) **Cleavage:** It includes the rapid mitotic division of the zygote to form a single layered hollow spherical larva called blastula and its formation is called blastulation.

(4) **Implantation:** The process of attachment of the blastocyst (mammalian blastula) on the endometrium of the uterus is called implantation.

(5) **Gastrulation:** It includes the mass and orderly migration of the organ specific areas from the surface of blastula to their predetermined position which finally produces a 3 layered gastrula larva. It is with 3 primary layers.

(6) **Organogenesis:** It includes the formation of specific organs system from three primary germ layers of gastrula and also includes the morphogenesis and differentiation.

Fertilization

(1) **Definition:** Fusion of a haploid male gamete (spermatozoon) and a haploid female gamete (ovum) to form a diploid cell, the zygote, is called fertilization or syngamy.

(2) **Site of fertilization:** Fertilization in human female is internal as in other mammals. It takes place usually in the ampulla of the fallopian tube.

(3) **Steps of fertilization**

   (i) **Approach of sperm to ovum:**

      (a) Male discharges semen (3.5 *ml*) in the female's vagina close to the cervix during coitus. This is called ejaculation or insemination. This ejaculation contains as many as 400 million sperms but only about 100 sperms reach the fallopian tube because many sperms are either killed by the acidity of female genital tract or engulfed by the phagocytes of the vaginal epithelium.

      (b) The sperm swim in the seminal fluid at the rate of 1-4 *mm* per minute by the aspiratory action of the uterus and peristaltic movement of the fallopian tube.

      (c) Capacitation is the phenomenon of physiological maturation of sperms by breaking of acrosome membrane inside the female genital tract. It takes about 5-6 hours.

(d) Ovum is released on the 14th day of menestrual cycle trapped by the fimbriae of the ampulla of fallopian tube and move towards the uterus by peristalsis and ciliary action.

(e) At the time of ovulation, egg is at secondary oocyte stage.

(f) Fertilizability of human sperm in the female genital tract is of 12 to 24 hours while its survival value is upto 3 days and of ovum is only 24 hours though it can live for about 72 hours.

(ii) **Penetration of sperm:**

(a) The ovum secretes a chemical substance called fertilizin, which has a number of spermophillic sites on its surface where the sperm of species specific type can be bound by their antifertilizin site.

(b) This fertilizin-antifertilizin interaction causes agglutination (sticking together) of egg and sperm.

(c) The sperm generally comes in contact with ovum in the animal pole (side of ovum with excentric nucleus) while the opposite side of ovum is called vegetal pole.

(d) Ovulation in the human female occurs at secondary oocyte stage in which meiosis-I have been complted and first polar body has been released but second maturation is yet to complete.

(e) Penetration of sperm is a chemical mechanism.

(f) In this acrosome of sperm undergoes acrosomal reaction and releases certain sperm lysins which dissolve the egg envelopes locally and make the path for the penetration of sperm.

(g) These sperm lysins contain a lysing enzyme hyaluronidase which dissolves the hyaluronic acid polymers in the intercellular spaces which holds the granulosa cells of corona radiata together; corona penetrating enzyme (that dissolves the corona radiata) and acrosin (which dissolves the zona pellucida). Then it dissolves the zona pellucida.

(h) Only sperm nucleus and middle piece enter the ovum. The tail is lost.

(iii) **Cortical reaction:**

(a) Immediately after the entry of a sperm into the egg, the later shows a cortical reaction to check the entry of more sperms.

(b) In this reaction, the cortical granules present beneath the egg's plasma membrane release chemical substance between the ooplasm and the plasma membrane (vitelline membrane).

(c) These substances raise the vitelline membrane above the egg surface. The elevated vitelline membrane is called fertilization membrane.

(d) The increased space between the ooplasm and the fertilization membrane and the chemical present in it effectively check the entry of other sperm.

(e) If polyspermy occurs, that is more than one sperm enter the secondary oocyte, the resulting cell has too much genetic material to develop normally.

(iv) **Fusion of gametic nuclei:**

(a) Entrance of spermatozoon serves to acts as stimulus which causes the second maturation division.

(b) As the head and middle piece of the sperm advance into the egg, those parts rotate through an angle of 180° so that the mitochondria and proximal centriole of the associated middle piece assume the leading position.

(c) Beside this rotation, the chromatin itself starts swelling by absorbing fluid from the surrounding cytoplasm and becomes vesicular.

(d) It is now called male pronucleus. This direction of movement of male pronucleus is called penetration path.

(e) The centriole brought in by the spermatozoon subdivides into two and as achromatic spindle is established in the center of the active cytoplasm.

(f) With the production of the second polar body, the egg nucleus or female pronucleus is ready for union with the male pronucleus provided by the sperm head.

(g) The male pronucleus which has been advancing the penetration path, now moves directly toward the female pronucleus. This in many cases involves a slight change in the course of sperm.

(h) In such cases, the later portion of its course is called the copulation path.

(i) The centrioles of middle piece of sperm form a spindle.

(j) The nuclear membrane of the gametic nuclei degenerates and two sets of chromosomes initially lie on two poles of the spindle but later these sets of chromosomes mix up and the process is called amphimixis.

(k) The fertilized egg is now called zygote and the zygote nucleus is called synkaryon.

Significance of fertilization

(a) It provides stimulus for the egg to complete its maturation.

(b) It activates the ovum to develop into a new individual by repeated mitotic division.

(c) Fertilization restores the diploid number of chromosomes (46 in man) in the zygote by adding male's haploid set of chromosomes.

(d) It makes the egg more active metabolically.

(e) It combines the character of two parents and introduces variations. So help in evolution.

(f) Sex chromosomes of sperm is either X or Y and helps in sex determination.

(g) Fertilization membrane formed after sperm entry, checks the entry of additional sperms.

(h) Copulation path sets the axis of division.

Menstrual Cycle

(1) Menstruation occurs in human, apes and old world monkeys.

(2) Menstruation is bleeding from the uterus of adult females at intervals of one lunar month.

(3) Beginning of menstruation or first menstruation is called **menarche**.

(4) The beginning of menstruation varies. It usually occurs between 12 and 15 years.

(5) The cycle of events starting from one menstruation till the next one is called **Menstrual Cycle**.

(6) In human females, menstruation is repeated at an average interval of about 28/29 days.

(7) One ovum is released (ovulation) during the middle of each menstrual cycle.

(8) It is regulated by certain hormones, some of which are secreted by the pituitary gland.

(9) The pituitary gland is stimulated by releasing factors produced in the hypothalamus.

(10) The menstural cycle consists of changes in the ovaries and uterine wall(endometrium). Gonadotropins like FSH and LH regulate these changes

(11) During each cycle of 28 days, only one ovum from either of the ovary is released.

On a average 13 eggs per year 32 years maximum 416 eggs mature

(12) The ceasing of menstrual cycle is called menopause and occurs by the age of 45-58 years.

Reproductive Health

Reproductive health – problem and strategies

(a) India was amongst the first countries in the world to initiate to the programme “family planning” initiated in 1951.

(b) Reproductive health in a society forms a crucial part of general health.

Population explosion and birth control

(a) The rapid increase in human population size over a relatively short period is called human population-explosion.

(b) Population growth rate depends on factors like fertility, natality, mortality, migration, age and sex structure.

(c) Increased health facilities and better living conditions are the cause behind population explosion.

(d) Out of 6 billion world population 1.3 billion populations is of Indians.

(e) Rapid decline in death rate, maternal mortalility rate (MMR) and infant mortality rate (IMR) are major cause of population growth.

(f) Growth rate of Indian population is around 1.7 percent.

(g) Most of the urban people are uneducated.

(h) The regulation of conception by preventive methods or devices to limit the number of offsprings is called birth control.

(i) A birth control method which deliberately prevents fertilization are referred to as contraception.

(i) Contraceptive methods are preventive methods and are of two types – temporary and permanent.

Characteristics of an ideal contraceptive are:-

(a) User friendly

(b) Easily available

(c) Nor or least side – effects

(d) No way interferes with sexual drive

Methods of Birth Control

S. No.	Method	Action
(1)	Rhythm Method	No intercourse during woman's fertility period (day 12-20).
(2)	Withdrawl	Penis is withdrawn before ejavculation.
(3)	Tubectomy / Tubal ligation	Women's fallopian tubes are cut and tied, permanently blocking sperm release.
(4)	Vasectomy	Man's vasa deferentia are cut and tied permanently blocking sperm passage.
(5)	Intrauterine device (IUD)	Small plastic or metal device placed in the uterus to prevent implantation. Some contain copper, other release hormones.
(6)	Oral Contraceptive	Synthetic estrogens and progestrones prevent normal menstrual cycle, primarily prevent ovulation.
(7)	Male condom	Thin rubber sheath on erect penis collects ejaculated semen.
(8)	Female condom	Plastic pouch inserted into vagina catches semen.
(9)	Diaphragm	Soft rubber cup covers entrance to uterus, prevents sperm from reaching egg and holds spermicide.
(10)	Cervical cap	Miniature diaphragm covers cervix closely, prevents sperm from reaching egg and holds spermicide.
(11)	Foams, creams, jellies etc.	Chemical spermicides inserted in vagina before intercourse, prevent sperm from entering uterus.
(12)	Implant (Norplant)	Capsules surgically implanted under skin, slowly release hormone that blocks ovulation.
(13)	Injectable contraceptive (Depo-Provera)	Injection every 3 months of a hormone that is lowly released and prevents ovulation.

Amniocentesis

(a) During pregnancy, the fetus is surrounded by amniotic fluid which is a water-like substance.

(b) Amniotic fluid contains live fetal skin cells and other substances, such as alpha-fetoprotein (AFP).

(c) These substances provide important information about baby's health before birth.

(d) These days amniocentesis is being misused also, i.e., for detecting the sex of the foetus.

(e) Normal foetus is being aborted if it is a female.

Sexually transmitted diseases (STDs)

Diseases which are transmitted sexually through sexual intercourse are collectively called as Sexually Transmitted Diseases (STDs) or Venereal Diseases (VDs) or reproductive tract infections (RTI). STDs can be classified as viral, bacterial, protozoan, fungal, etc.

Causes of STD's

STDs can be spread with any type of sexual activity, depending on the disease. STDs are most often caused by viruses and bacteria. Types of Sexually Transmitted DiseasesThe various types of sexually transmitted diseases include genital herps, chancroid, gonorrhoea, syphilis and most common HIV leading to AIDS.

(i) Chlamydiasis

(a) Chlamydiasis is a sexually transmitted disease in humans caused by the bacterium Chlamydia trachomatis.

(b) It is a major infectious cause of human genetial and eye diseases.

(ii) Gonorrhoea

(a) Gonorrhoea is transmitted sexually, by oral, anal or genital sex.

(b) Gonorrhea is caused by the bacterium Neisseria gonorrhoeae

Prevention

STDs are a major threat to a healthy society.

(i) Avoid sex with unknown partners as well as multiple partners.

(ii) Always use condoms during coitus.

(iii) In case of any doubt, go to a qualified doctor for early detection and get complete treatment if diagnosed with disease.

Infertility

(a) Inability to conceive or produce children even after 2 years of unprotected sexual cohabitation is called infertility.

(b) A large no of couples all over India are infertile.

(c) The reasons for this could be many-physical, congenital, diseases, drugs, Immunological or even Psychological.

Assisted Reproductive Technologies (ART)

Includes all fertility symptoms in which both sperms and eggs are handled. These are special techniques that assist couples to have children.

The main ART- techniques include:

(i) In-vitro fertilisation (IVF) or test tube baby

(ii) GIFT(gamete intra fallopian transfer)

Genetics & Evolution

Inheritance and Variation

Mendel's Law of Inheritance

(1) **Mendelism** means experiments performed by Mendel on genetics.

(2) Mendel's experiment involved 4 steps as selection, hybridization, selfing and calculations. His results led to the formation of laws of genetics later.

(3) Mendel performed monohybrid and dihybrid crosses and gave three principles of inheritance.

(4) Mendel's three principles of inheritance are:

(i) Law of dominance

(ii) Law of segregation or law of purity of gametes

(iii) Law of independent assortment

(4) **Law of Dominance –** The dominant characters are expressed when factors are in heterozygous condition.

(5) The recessive characters are only expressed in homozygous conditions. The characters never blend in heterozygous condition. A recessive character that was not expressed in heterozygous condition may be expressed again when it becomes homozygous.

(6) **Law/Principle of segregation** states that when a pair of contrasting factor or gene is brought together in a hybrid, these factors do not blend or mix up but simply associate themselves and remain together and separate at the time of gamete formation.

(7) **Principle of independent assortment** states that genes of different characters located in different pairs of chromosomes are independent of one another in this segregation during gamete formation.

(8) **Test Cross:** A cross between F1 hybrid (Aa) and its homozygous recessive parent (aa) is called Test Cross. This cross is called test cross because it helps to find out whether the given dominant phenotype is homozygous or heterozygous.

(9) **Monohybrid cross –** When we consider the inheritance of one character at a time in a cross, this is called monohybrid cross.

(10) **Dihybrid Cross –** A cross made to study the inheritance of two pairs of contrasting traits.

Exceptions of Conclusions of Mendel

Incomplete Dominance

(1) When neither of the alleles of a character is completely dominant over the other and the F1 hybrid is intermediate between the two parents, the phenomenon is called incomplete dominance.

(2) Incomplete dominance was first discovered by Correns in Mirabilis jalapa. The plant is called as 4'O clock plant or 'Gul-e-Bans'. Homozygous red (RR) flowered variety of the plant was crossed with white (rr) flowered variety. F1 offspring had pink flowers (Rr). This is called incomplete dominance.

(3) Incomplete dominance is also known to occur in snapdragon. The phenotypic ratio and genotypic ratio in F2 generation in case of incomplete dominance is 1:2:1.

Co-dominance

(1) In co-dominance both the gene expressed for a particular character in F1 hybrid progeny. There is no blending of characters, whereas both the characters are expressed equally.

(2) Co-dominance is seen in animals for coat colour. When a black parent is crossed with white parent, a roan color in F1 progeny is produced.

Sex determination

(1) Fixing the sex of an individual as it begins life is called sex determination. The various genetically controlled sex-determination mechanisms have been classified into following categories

(2) Chromosomal theory of sex determination: The X-chromosome was first observed by German biologist, Henking in 1891 during the spermatogenesis in male bug and was described as X-body. The chromosome theory of sex determination was worked out by E.B. Wilson and Stevens (1902-1905).

(3) They named the X and Y chromosomes as sex-chromosomes or allosomes and other chromosomes of the cell as autosomes.

(4) Sex chromosomes carry genes for sex. X-chromosomes carries female determining genes and Y-chromosomes has male determining genes.

(5) The number of X and Y chromosomes determines the female or male sex of the individual, Autosomes carry genes for the somatic characters. These do not have any relation with the sex.

Sex Determination by chromosomes:

Those chromosomes which are involved in the determination of sex of an individual are called sex chromosomes while the other chromosomes are called autosomes.

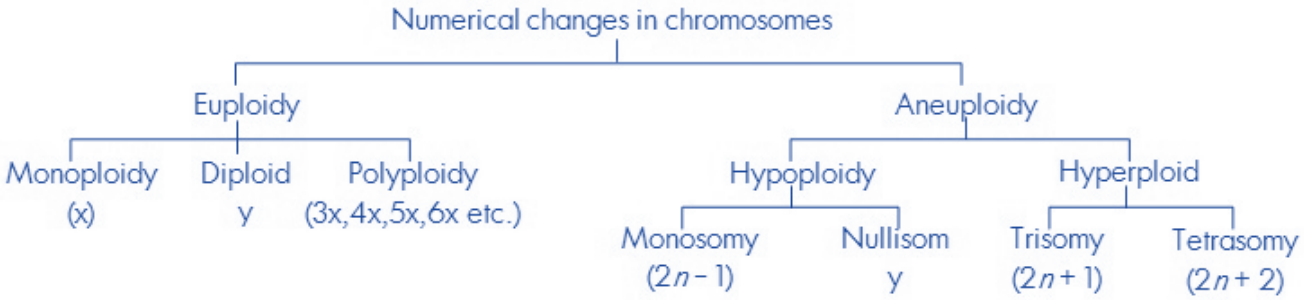
1) **XX – XY type:** In most insects including fruit fly Drosophila and mammals including human beings the females possess two homomorphic sex chromosomes, named XX. The males contain two heteromorphic sex chromosomes, i.e., XY. Hence the males produce two types of gametes / sperms, either with X-chromosome or with Y-chromosome, so they are called Heterogamety.

2) **ZZ – ZW type:** In birds and some reptiles, the males are represented as ZZ (homogamety) and females are ZW (heterogamety).

3) **XX – XO type:** In round worms and some insects, the females have two sex chromosomes, XX, while the males have only one sex chromosomes X. There is no second sex chromosome. Therefore, the males are designated as XO. The females are homogametic because they produce only one type of eggs. The males are heterogametic with half the male gametes carrying X-chromosome while the other half being devoid of it.

Numerical aberrations of chromosomes:

Each species has a characteristic number of chromosome. Variations or numerical changes in chromosomes (Heteroploidy) can be mainly of two types:



(1) **Turner's syndrome:** Such persons are monosomic for sex chromosomes *i.e.* possess only one X and no Y chromosome (XO). In other words they have chromosome number $2n - 1 = 45$. They are phenotypic females but are sterile because they have under developed reproductive organs. They are dwarf about 4 feet 10 inches and are flat chested with wide spread nipples of mammary glands which never enlarge like those in normal woman. They develop as normal female in childhood but at adolescence their ovaries remain under developed. They lack female hormone estrogen. About one out of every 5,000 female births results in Turner's syndrome.

(2) **Klinefelter's syndrome:** Since 1942, this abnormality of sex is known to geneticists and physicians. It occurs due to Trisomy of sex chromosomes which results in (XXY) sex chromosomes. Total chromosomes in such persons are $2n + 1 = 47$ in place of 46. Klinefelter (1942) found that testes in such male remain under developed in adulthood. They develop secondary sex characters of female like large breasts and loss of facial hair. Characters of male develop due to Y chromosome and those like female due to XX chromosomes. About one male child out of every 5,000 born, develops Klinefelter's syndrome.

Molecular Basis of Inheritance

DNA

(1) DNA is a long polymer of deoxyribonucleotides.
(2) The length of the DNA depends on the number of nucleotide pairs present in it.
(3) Bacteriophage lambda has 48,502 base pairs.

Central dogma of molecular biology

(1) Crick proposed the Central dogma in molecular biology
(2) It states that the genetic information flows from DNA à RNA à Protein.
(3) In some viruses like retroviruses, the flow of information is in reverse direction, which is from RNA à DNA à mRNA à Protein.

Structure of polynucleotide chain:

(1) A nucleotide has three components-
    (a) A nitrogen base
    (b) A pentose sugar (ribose in RNA and deoxyribose in DNA)
    (c) A phosphoric acid.
(2) There are two types of nitrogen bases:
    (a) Purines (Adenine and Guanine)
    (b) Pyrimidines (Cytosine, Uracil and Thymine)
(3) Adenine, Guanine and Cytosine are common in RNA and DNA.
(4) Uracil is present in RNA and in DNA in place of Uracil, Thymine is present.
(5) In RNA, Pentose sugar is ribose and in DNA, it is Deoxyribose.
(6) Based on the nature of pentose sugar, two types of nucleosides are formed - ribonucleoside and deoxyribonucleotides.
(7) Two nucleotides are joined by 3'-5' Phosphodiester linkage to form dinucleotide.
(8) More than two nucleotides join to form polynucleotide chain.
(9) The two strands of DNA (called DNA duplex) are antiparallel and complementary, i.i., one in 5'->3' direction and the other in 3"->5" direction.

History of DNA

(1) DNA is an acidic substance in the nucleus.
(2) It was first identified by Friedrich Meischer in 1869. He named it as 'Nuclein"
(3) In 1953 double helix structure of DNA was given by James Watson and Francis Crick, based on X-ray diffraction data produced Maurice Wilkins and Rosalind Franklin.

Packaging of DNA Helix

(1) The basic unit into which DNA is packed in the chromatin of eukaryotes.
(2) Nucleosome is the basic repeating structural (and functional) unit of chromatin, which contains nine histone proteins.
(3) Distance between two conjugative base pairs is 0.34nm
(4) The length of the DNA in a typical mammalian cell will be 6.6 X109 bp X 0.34 X10-9 /bp, it comes about 2.2 meters.
(5) The length of DNA is more than the dimension of a typical nucleus (10-6m)

DNA Replication

(1) DNA is the only molecule capable of self duplication so it is termed as a living molecule.
(2) All living beings have the capacity to reproduce because of DNA.
(3) DNA replication takes place in S-phase of the cell cycle. At the time of cell division, it divides in equal parts in the daughter cells.
(4) **Delbruck** suggested three methods of DNA replication i.e.
    (i) Dispersive
    (ii) Conservative
    (iii) Semi-conservative
(5) The process of DNA replication takes a few minutes in prokaryotes and a few hours in eukaryotes.

RNA

(1) RNA is the first genetic material.
(2) RNA is a non hereditary nucleic acid except in some viruses (retroviruses).
(3) RNA used to act as a genetic material as well as catalyst.
(4) It is a polymer of ribonucleotide and is made up of pentose ribose sugar, phosphoric acid and nitrogenous base (A,U,G,C).
(5) RNA may be of two types – genetic and non-genetic.

Genetic Code

(1) Term genetic code was given by **George Gamow (1954).** He was the first to propose the triplet code (one codon consists of three nitrogen bases).
(2) The relationship between the sequence of amino acids in a polypeptide chain and nucleotide sequence of DNA or mRNA is called genetic code.
(3) There occur 20 types of amino acids which participate in protein synthesis. DNA contains information for the synthesis of any types of polypeptide chain. In the process of transcription, information transfers from DNA to m-RNA in the form of complementary N_2-base sequence.
(4) A **codon** is the nucleotide sequence in m-RNA which codes for particular amino acid; whereas the **genetic code**is the sequence of nucleotides in **m-RNA** molecule, which contains information for the synthesis of polypeptide chain.

(5) 61 out of 64 codons code for only 20 amino acids.

(6) The main problem of genetic code was to determine the exact number of nucleotide in a codon which codes for one amino acid.

Characteristics of genetic code

(1) **Triplet in nature**

(a) A codon is composed of three adjacent nitrogen bases which specify one amino acid in polypeptide chain.

(b) For example- In m-RNA if there are total 90 N_2– bases. Then this m-RNA determines 30 amino acids in polypeptide chain.

(2) **Univerality**

(a) The genetic code is applicable universally.

(b) The same genetic code is present in all kinds of living organism including viruses, bacteria, unicellular and multicellular organisms. In all these organisms, triplet code for specific amino acid.

(3) **Non-ambiguous**

(a) Genetic code is non ambiguous i.e. one codon specifies only one amino acid and not any other.

(b) In this case one codon never code two different amino acids. **Exception** GUG codon which code both valine and methionine amino acid.

(4) **Non-overlapping**

(a) A nitrogen base is a constituent of only one codon.

(5) **Comma less**

(a) There is no punctuation (comma) between the adjacent codon i.e. each codon is immediately followed by the next codon.

(b) If a nucleotide is deleted or added, the whole genetic code read differently.

(c) A polynucleotide chain having 50 amino acids shall be specialized by a linear sequence of 150 nucleotides. If a nucleotide is added in the middle of this sequence, the first 25 amino acids of polypeptide will be same but next 25 amino acids will be different.

(6) **Degeneracy of genetic code**

(a) Only two amino acids – tryptophan and methionine are specified by single codon.
UGG for tryptophan, AUG for methionine

(b) All the other amino acids are specified or coded by 2 to 6 codons.

(c) Leucine, serine and arginine are coded or specified by 6-codons.

(d) Degeneracy of genetic code is related to third position (3'-end of triplet codon) of codon. The third base is described as 'Wobble base'.

Genomics and Human Genome project:

(1) The term genome has been introduced by **Winkler** in 1920 and the genomics is relatively new, coined by**Thomas Rodericks** in 1986.

(2) Genomics is the subdiscipline of genetics devoted to the mapping, sequencing and functional analysis of genomes. Genomics is subdivided into following types:

  (a) **Structural genomics:** It is the study of genome structure deals with the complete nucleotide sequences of the organisms.

  (b) **Functional genomics:** It is the study of genome function which includes transcriptome and proteome. Transcriptome is a complete set of RNAs transcribed from a genome while proteome is a complete set of proteins encoded by a genome and aims the determination of the structure and function of all the proteins in living organisms.

(3) The human genome project, sometimes called "biology's moon shot", was launched on october 1, 1990 for sequencing the entire human genome of 2.75 billion (2.75×10^9 or 2750000 bp or 2750000 kilobase pairs or 2750 megabase pairs) nucleotide pairs.

(4) Two important scientist associated with human genome are **Francis Collins**, director of the Human Genome Project and **J. Craig Venter**, founding president of Celera genomics.

(5) The complete sequencing of the first human chromosome, small chromosome 22, was published in December 1999.

Genome of Model organisms

S. No.	Organism	No. of base pair	No. of genes
(1)	Bacteriophage	10 thousand	–
(2)	E. coli	4.7 million	4000
(3)	Saccharomyces cerevisiae	12 million	6000
(4)	Caenorhabditis elegans	97 million	18,000
(5)	Drosophila melanogaster	180 million	13,000
(6)	Human	3 billion	30,000
(7)	Lily	106 billion	–

DNA finger printing

(1) **Alec Jeffreys et al** (1985) developed the procedure of genetic analysis and forensic medicine, called DNA finger printing.

(2) It is individual specific DNA identification which is made possible by the finding that no two people are likely to have the same number of copies of repetitive DNA sequences of the regions.

(3) It is also known as DNA profiling.

(4) The chromosomes of every human cell contain scattered through their DNA short, highly repeated 15 nucleotide segments called “mini-satellites” or variable-number Tandem Repeat (VNTR).

Technique for DNA fingerprinting

(1) Only a small amount of tissues like blood or semen or skin cells or the hair root follicle is needed for DNA fingerprinting.
(2) Typically DNA content of about 100,000 cells or about 1 microgram is sufficient.
(3) The procedure of DNA fingerprinting involves the following major steps:
    (i) DNA is isolated from the cells in a high-speed refrigerated centrifuge.
    (ii) If the sample of DNA is very small, DNA can be amplified by Polymerase Chain Reaction (PCR).
    (iii) DNA is then cut up into fragments of different length using restriction enzymes.
    (iv) The fragments are separated according to size using gel electrophoresis through an agarose gel. The smaller fragments move faster down the gel than the larger ones.
    (v) Double stranded DNA is then split into single stranded DNA using alkaline chemicals.
    (vi) These separated DNA sequences are transferred to a nylon or nitrocellulose sheet placed over the gel. This is called ‘Southern Blotting’ (after **Edward Southern**, who first developed this method in 1975).
    (vii) The nylon sheet is then immersed in a bath and probes or makers that are radioactive synthetic DNA segments of known sequences are added. The probes target a specific nucleotide sequence which is complementary to VNTR sequences and hybridizes them.
    (viii) Finally, X-ray film is exposed to the nylon sheet containing radioactive probes. Dark bands develop at the probe sites which resemble the bar codes used by grocery store scanners to identify items.

Applications of DNA fingerprinting

This technique is now used to:

(i) Identify criminals in forensic laboratories.
(ii) Settle paternity disputes.
(iii) Verify whether a hopeful immigrant is, as he or she claims, really a close relative of already an established resident.
(iv) Identify racial groups to rewrite biological evolution.

Evolution

(i) Ancient theories of origin of life:

(a) Theory of special creation.

(b) Theory of spontaneous generation or Abiogenesis.

(c) Biogenesis

(d) Cosmozoic theory

(e) Theory of sudden creation from inorganic material.

(f) Naturalistic theory

(ii) **Oparin's Modern Theory:**

(a) Oparin (1924) proposed that "life could have originated from non-living organic molecules."

(b) He believed in Biochemical origin of life. Haldane (1929) also stated similar views. Oparin greatly expanded his ideas and presented them as a book "The origin of life" in 1936.

(c) According to this theory, the Earth originated about 4,500 million years ago. When the earth was cooling down, it had a reduced atmosphere. In this primitive atmosphere nitrogen, hydrogen, ammonia, methane, carbon mono-oxide and water were present. Energy was available in the form of electric discharges by lightening and ultraviolet rays. As soon as the earth crust was formed, it was very much folded. Torrential rains poured over the earth for centuries and were deposited in deep places.

(d) **Miller's Experiment:** An American scientist (Biologist) Stanley Miller (1953) performed an experiment under support Oparin's theory of origin of life. He believed that basic compounds which are essential for life can be synthesised in the laboratory by creation in the laboratory, on a small scale, the conditions which must have existed at the time of origin of life on earth.

(e) Miller took a flask and filled it with methane, ammonia and hydrogen in proportion of 2:1:2 respectively at 0°C. This proportion of gases probably existed in the environment at time of origin of life. This flask was connected with a smaller flask, that was filled with water, with the help of glass tubes. In the bigger flask, two electrodes of tungsten were fitted. Then a current of 60,000 volts was passes, through gases containing bigger flask for seven days. At the end of seven days, when the vapours condensed, a red substance was found in the U-tube. When this red substance was analyzed, it was found to contain amino acids, Glycine and nitrogenous bases which are found in the nucleus of a cell.

(f) The entire process of the origin of life, as proposed by Oparin, can be summarised as under –

(i) **The Chemical Evolution:**

(1) Step 1: Formation of simple molecules

(2) Step 2: Formation of Simple organic compounds

(3) Step 3: Formation of complex organic compounds

(4) Step 4: Formation of nucleic acids and nucleoproteins

(ii) **Organic Evolution:**

(1) Step 5: Formation of Coacervates

(2) Step 6: Formation of Primitive cell

(3) Step 7: Origin of autotrophism

(4) Step 8: Origin of Eukaryotic cells

Evidences of Organic Evolution

The following are the evidences in favour of Organic Evolution:

(i) Evidences from Classification

(ii) Evidences from Comparative Anatomy

(a) Analogy and Homology

(b) Vestigeal organs

(iii) Evidences from Physiology

(iv) Evidences from Serology

(v) Evidences from Embryology

(vi) Evidences from Palaeontology

(vii) Evidences from geographic distribution

(viii) Evidences from Genetics

(i) **Evidences from Classification:** All the known living animals and plants have been classified into various species, genera, families, order, classes, phyla and kingdoms. The classification of a particular animal is attempted only after its extensive study.

(ii) **Evidences from Comparative Anatomy:** In all the living animals, the basic substance of life is Protoplasm. If the species had been created separately, then there should be no relationship in the various organs and systems of animals. But on the contrary, we see that large number of animals although unlike in appearance show most of the systems and organs made on the same plan. The resemblance is very close in the members of the same group.

(iii) **Evidences from Physiology**: Various types of chemical tests exhibit many basic similarities in physiological and chemical properties that show a physiological relationship among animals.

(iv) **Evidences from Serology:** This is a method by which the reactions of blood serum are observed. From the blood are also extracted the crystals of Oxyhaemoglobin. The structure differs in different vertebrates, but in a definite order. The reaction is nearly identical in man and anthropoid monkeys, but slightly less identical with other mammals.

(v) **Evidences from Embryology:** With the exception of a few, every multi-cellular animal originates from a zygote. The development from zygote to adult shows many similarities in various organisms. The development is termed as ontogeny

(vi) **Evidences from Palaeontology:** The study of fossils and their interpretation forms one of the great evidences of evolution. An Italian scientist, Leonardo da Vinci, was the first person to recognize their importance and said they were either remains of organisms of their impressions on some sort of clay or rock.

Important living fossils

1. Peripatus (Arthropoda)	**2. Limulus (Arthropoda)**
3. Nautilus (Mollusca)	4. Neopilina (Mollusca)
5. Lingula (Brachiopoda)	6. Latimeria (Coelacanth fish)
7. Sphenodon (Reptilia)	8. Didelphis (Opossum)

(vii) **Evidences from geographic distribution:** If the study of horizontal distribution of animals on the face of this earth is made, it would be seen that animals are not evenly distributed. Two identical places with the same climate and vegetation may not have same sort of animal fauna

(viii) **Evidences from Genetics:** Johan Gregor Mendel in 1866 published his work on experimental breeing. He bred two individuals differing in certain well-defined characters, and observed the ratio in which various contrasting parental characters appeared in successive generations.

(c) **Connecting links:** Intermediate or intergrading forms between two groups of organisms:

Organism	**Connecting link between**
1. Viruses	Living and nonliving
2. Euglena (Protozoa)	Plants and animals
3. Proterospongia (Protozoa)	Protozoa and Porifera
4. Peripatus (Arthropoda)	Annelida and Arthropoda
5. Neopilina (Mollusca)	Annelida and Mollusca
6. Balanoglossus (Chordata)	Nonchordata and Chordata
7. Dipnoi (Lungfish)	Pisces and Amphibia
8. Archaeopteryx (Aves)	Reptiles and Birds
9. Prototheria (Mammalia)	Reptiles and Mammals

Theories of organic evolution

(i) **Lamarckism:** Lamarck (1744 –1829) was one of the most brilliant stars on the horizon of the history of evolution. He was the first naturalist to put forward a general theory of evolution in his famous book. Philosophic Zoologique published in 1809. His evolutionary theory may be summarised in the form of following laws:

(a) The internal forces of life tend to increase the size of an organism.

(b) The necessity in animals to produce new structures.

(c) The effect of use and disuse.

(d) Inheritance of acquired characters.

(iii) **Darwinism:** Charles Robert Darwin was undoubtedly the first naturalist who put the idea of organic evolution on sound footing. His statements and theories were based upon practical experiences and large number of proofs which he collected directly from the nature.

His main ideas about the evolution are given below –

(a) Over – production of offspring

(b) Limited supply of food and shelter

(c) Struggle for existence:

(i) Intra –specific

(ii) Inter –specific

(iii) Environment

(d) Survival of the fittest

(e) Universal occurrence of variations

(f) Inheritance

(g) Natural selection

Difference between Darwinism and Neo–Darwinism

Darwinism (Natural Selection)	Neo–Darwinism
(1) It is the original theory given by Charles Darwin (1859) to explain the origin of new species.	(1) Neo–Darwin is a modification of the original theory of Darwin to remove its short–comings.
(2) According to this theory accumulation of continuous variations causes changes in individuals to form new species.	(2) Instead of continuous variations, mutations are believed to help form new species.
(3) It believes in the selection of individuals on the basis of accumulation of variation.	(3) Variations accumulate in the gene pool and not in the individuals.
(4) Darwinism does not believe in isolation.	(4) Neo–Darwinism incorporates isolation as an essential component of evolution.
(5) It can explain the origin of new characters.	(5) The theory can explain the occurrence of unchanged forms over millions of years.
(6) Darwinism cannot explain the persistence of certain forms in the unchanged condition.	(6) Normally only those modifications are transferred to next generation which influence germ cells or where somatic cells give rise to germ cells.

Enhancement in Food Production

Enhancement in Food Production

Poultry

Poultry includes the birds like chicken (hen), ducks, geese and turkey. Poultry farming deals with the rearing of them for their eggs and meat. it has become an important small scale industry due to modern need for palatable and nutritive food which it provides in the form of eggs as well as adult animal. An egg laying poultry bird is called layer and the poultry birds groomed for obtaining meat are called chicken or broilers.

Livestock

The word livestock refers to the domestic animals kept or dealt in for use or profit. It includes cattle, buffaloes, sheep, goats, pigs, horses, mules, donkeys and camels. The most important of these are cattle and buffaloes.

Importance of cattle and Buffaloes: Cattle and buffalo are most important forms of domesticated animals. They are next to land in use for farmers. They are widely used for:

(a) **Agricultural Operations:**
(b) **Milk:**
(c) **Transport:**
(d) Manure and fuel:
(e) **Leather:** .
(f) **Glue and gelatin:**
(g) **Meat:**
(h) **Hair:**
(i) **Hybridisation:**

Breed	Distribution
Murrah	Punjab, Haryana, Uttar Pradesh
Bhadawari	Uttar Pradesh, Madhya Pradesh
Jaffrabadi	Gujrat
Surti	Rajasthan, Gujrat
Mehsana	Gujrat
Nagpuri or Ellichpuri	Central and South India
Nili Ravi	Punjab, Haryana

Some Breeds of Indian Cattle

Milch Breeds	Distribution
1. Gir	Gujrat, Rajasthan
2. Sahiwal	Punjab, Haryana, Uttar Pradesh
3. Red Sindhi	Andhra Pradesh
4. Deoni	Andhra Pradesh

Some Breeds of Indians Buffaloes

Apiculture

(1) Apiculture is the science of rearing honeybees for obtaining honey, wax and venom. It is a profitable money-making hobby. It forms a cottage industry, when carried out on a large scale.

(2) Three species of honey bees are commonly found in india vig. *Apis indica* (The small indian bee). *Apis florea*(The little indian bee) and. *Apis dorsata* (the giant bee) other important species include *Apis milifera* (the common European bee.

(i) **Honeybee-*Apis*:** Like termites, honeybees are social insects known for producing honey and beeswax, and for living in very highly organized colonies. These feed upon nectar and pollen of flowers, possess "sucking and chewing" mouth parts, and undergo complete metamorphosis. Each colony has its own nest called honeycomb or beehive.

(ii) **Division of labour and polymorphism:** Each beehive harbours a colony of thousands of polymorphic bees belonging to a single family. The polymorphic individuals are of three main types (i) a single queen (fertile female)(ii) one to a few hundred drones (fertile males) and (iii) thousands (upto 60,000) of worker bees (sterile females).

(iii) **Life History:** Queen lays about 2,000 eggs a day. The eggs are laid in the comb, one in each cell. They hatch out into larvae in three days. They are fed on royal jelly for a few days. But the larva which develops into the queen will be fed on royal jelly continuously.

During breeding, the queen bee flies in the air along with the males. This phenomenon is called nuptial flight. During nuptial flight the queen copulates with a male Copulation occurs in the air. Then the bees return to the comb and the queen starts laying eggs.

(iv) **Bee-Hive**: Honey bee is one of the few domesticated insects. In modern days bee colonies are reared in artificial wooden boxes for maximum production of honey and wax. The artificial box where the bee colony is maintained and managed is called hive. The place where hives are kept and managed is called apiary.

(v) **Honey extraction:** Honey is stored in combs of super frames. It is extracted from the comb by a simple machine called honey extractor. It has a drum containing a rack inside to hold the super frames. It is made to rotate by a set of two-gear wheels, operated by a handle.

The super frames are removed from the hive. The caps of the comb cells are cut off by a double edged knife. Then the frames are fixed in the rack and the rack is made to rotate by operating the handle. The honey is forced out into the drum from the comb cells. From the drum the honey is collected in vessels through an exit present in the drum.

(vi) **Location of Apiary**

(a) The hives should be set, in places where there are plenty of flowering plants.

(b) They should be placed in shady places.

(c) The place should be neat and clean and free from any obnoxious smell.

(d) There should be clean drinking water nearby because each bee colony requires two glasses of water per day for their survival

(viii) **Chemical composition:** Honey contains nearly 80 different substances of importance to human beings. The important chemicals are as follows:

It contains a large amount of glucose or fructose.

Fisheries

(i) Fishes are a valuable and easily accessible source of food, rich in protein, highly nutritious and easily digestible. By the aquatic animals, they are abundantly available from sea, rivers, lakes, ponds and marshes.

(ii) **Classification of cultivable fish species**

Zoological name	Common Name	Areas of availability
(a) Fresh water fishes		
1. *Catla catla*	Catla	All over India common in Krishna and Godavari rivers
2. *Labeo rohita*	Rohu	North, East and South India
3. *Labeo calbasu*	Calbasu	North and South India
4. *Cirhinus mrigala*	Mrigal	North and South India
5. *Mystus singhala*	Singhala	All over India
6. *Heteropneustes fossilaris*	Singhi	All over India
7. *Wallago attu*	Malli	North, east and South India
8. *Clarius batrachus*	Fresh water shark magur	All over India
(b) Brackish water fishes		
9. *Chanos chanos*	Milk fish	A.P.coast
10. *Mugil cephalus*	Grey mullet	East coast
11. *Laters calcorifer*	Perch	East coast
(c) Marine fishes		
12. *Sardinella longiceps*	Oil sardine	West and south coasts
13. *Harpodon heherius*	Bombay duck	Maharastra coast
14. *Hilsa ilisha*	Hilsa/ Indian shed	Coastal India
15. *Stromateus sinensis*	Pomfret	Indo pacific coast
16. *Anguilla anguilla*	Eel	Coastal India
17. *Aluitheronema*	Salmon	East and west coast
18. *Cyano-glossus semifas- ciatus*	Flat fish	East coast of India

(iii) **Culture method:** The success in fish culture and the high production of table - size fish through carp culture depends largely on the designing and construction of ponds. The basic principles involved in designing and construction of carp culture ponds are of very specialized nature and vary from region to region depending upon several factors like topography, soil types, water supply etc. The requirements with regard to the designing and construction of fish farm are entirely different from those attributed to agriculture and animal husbandry farms.

Health & Diseases

Types of Diseases

The diseases may be broadly classified into two types: Congenital and acquired.

(i) **Congenital Diseases:** These are anatomical or physiological abnormalities present from birth. They may be caused by (i) a single gene mutation (alkaptonuria, phenylketonuria, albinism, sickle-cell anaemia, haemophilia, colour blindness); (ii) chromosomal aberrations (Down's syndrome, Klinefelter's syndrome, Turner's syndrome); or (iii) environmental factors (cleft palate, harelip). Unlike the gene-and chromosome-induced congenital defects, environmentally caused abnormalities are not transmitted to the children.

(ii) **Acquired Diseases:** These diseases develop after birth. They are further of two types: communicable and non-communicable.

(a) **Communicable (Infectious) Diseases:** These diseases are caused by viruses, rickettsias, bacteria, fungi, protozoans and worms.

(b) **Noncommunicable (Noninfectious) Diseases:** These diseases remain confined to the person who develops them and do not spread to others. The non-communicable diseases are of four kinds –

(1) **Organic or Degenerative Diseases:** These diseases are due to malfunctioning of some of the important organs, *e.g*, heart diseases, epilepsy. Heart diseases result from the abnormal working of some part of this vital organ. Epilepsy may result from abnormal pressure on regions of the brain.

(2) **Deficiency Diseases :** These diseases are produced by deficiency of nutrients, minerals, vitamins, and hormones, *e.g.*, kwashiorkor, beriberi, goitre, diabetes are just a few from a long list.

(3) **Allergies:** These diseases are caused when the body, which has become hypersensitive to certain foreign substance, comes in contact with that substance. Hay fever is an allergic disease.

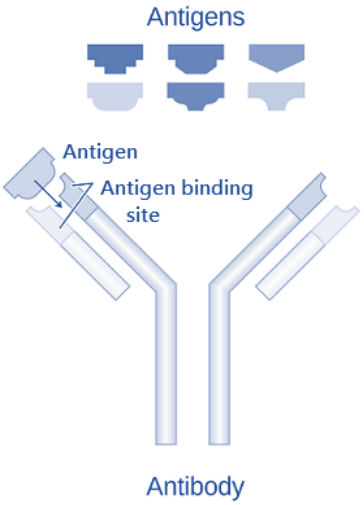
(4) **Cancer:** This is caused by a uncontrolled growth of certain tissues in the body.

Bacterial diseases and their pathogens

Disease	Causative Bacterium
Cholera	*Vibrio comma (Vibrio cholerae)*
Pneumonia	*Diplococcus pneumoniae*
Typhoid	*Salmonella typhi*
Tetanus	*Clostridium tetani*
Diphtheria	*Corynebacterium diphtheriae*
Whooping cough	*Bordetella pertussis*
Tuberculosis	*Mycobacterium tuberculosis*

Plague	*Pasteurella pestis*
Leprosy	*Mycobacterium leprae*
Syphilis	*Treponema pallidium*
Gonorrhoea	*Neisseria gonorrhoeae*
Diarrhoeal Diseases	*Escherichia coli, Shigella dysenteriae, Campylobacter, Salmonella*
Anthrax	*Bacillus anthracis*

The Immune System



(1) **Immunity –** The ability of the body to protect against all types of foreign bodies like bacteria, virus, toxic substances etc. which enter the body.

(2) The science dealing with the various phenomena of immunity, induced sensitivity and allergy is called immunology.

(3) **Immune Response -** Third line of defence. Involve production of antibodies and generation of specialized lymphocytes against specific antigens.

(4) **Antigens –** Substances which stimulate the production of antibodies, when introduced into the body.

(5) **Antibodies –** Immunoglobulins (Igs) which are produced in the body in response to the antigen or foreign bodies.

(6) All antibodies are immunoglobulins but all immunoglobulins are not antibodies.

(7) There are two major types of immunity: Innate or Natural or Non-specific immunity and Acquired or Adaptive or Specific Immunity.

Innate Immunity	Acquired Immunity
1. Includes all defence elements with which an individual is born.	1. The immunity which is acquired after the birth.
2. Consists of various types of barriers that prevent the entry of foreign agents.	2. Consists of specialized cells (T-cells and B-cells) and antibodies that circulate in the body fluid.
3. It remains throughout life.	3. It can be short lived or life long.

Malaria:

Malaria has been for thousands of years a very serious disease of the tropical and temperate regions. It was almost eliminated a few years back with the efforts of World Health Organization (WHO) and our National Malaria Eradication Programme (NMEP), but unfortunately, it has appeared again.

(a) **Symptoms:** The attack of malaria is preceded by yawning, tiredness, headache and muscular pain. During the fever, the patient feels chilly and shivers, and has acute headache, nausea and high temperature. After a few hours, the body perspires freely and the temperature becomes normal. The cycle is repeated if no medicine is taken. Blood smear made during fever shows the malarial parasites. No parasites are seen at other times. In chronic cases, there is general weakness and anaemia (paleness) due to large-scale destruction of red blood corpuscles. This is also accompanied by enlargement of spleen and liver.

(b) **Cause:** Malaria is caused by the toxins produced in the human body by the malarial parasites, *Plasmodium*.

(c) **Transmission:** The malarial parasites are carried from the infected to the healthy persons by the female*Anopheles* mosquito. The mosquito picks up the parasites with the blood, when it bites an infected person. When this infected mosquito bites a healthy person, parasites migrate into his blood with the saliva, which the mosquito injects before sucking up blood to prevent its clotting.

(d) **Types:** There are four species of *Plasmodium*, which cause different kinds of human malaria –

(1) *P. Vivax* : It causes **benign tertian malaria,** which attacks every third day, *i.e.*, after 48 hours. The fever is mild and seldom fatal. This species is wide-spread in the tropical and temperate regions.

(2) *P. ovale* : It also causes benign tertian malaria, which recurs every 48 hours. This species is found only in West Africa and South America.

(3) *P. malariae* : It causes **quartan malaria,** which recurs every fourth day, *i.e.*, after 72 hours. This species is found in both tropical and temperate regions, but it is not very common.

(4) *P. falciparum* : It alone is capable of causing three types of malaria, *viz*., quotidian malaria, which attacks almost daily, malignant tertian malaria, which occurs every 48 hours, but is very severe and often fatal; and irregular malaria. This species is found only in the tropical region.

(e) **Incubation Period:** The incubation period for malaria caused by *Plasmodium vivax* is about 10 days.

(f) **Life-history:** *Plasmodium* completes its life cycle in two phases and two hosts: asexual phase in the human host and sexual phase in the female *Anopheles* mosquito host.

Sexually Transmitted diseases

Acquired Immune Deficiency Syndrome (AIDS) :

Symptoms of AIDS: An HIV infection can be divided into 3 stages.

(1) **Asymptomatic Carrier:** Only 1%-2% of those newly infected have mononucleosis-like symptoms that may include fever, chills, aches, swollen lymph glands, and an itchy rash. These symptoms disappear, and there are no other symptoms for 9 months or longer.

(2) **AIDS Related Complex (ARC):** The most common symptom of ARC is swollen lymph glands in the neck, armpits, or groin that persist for 3 months or more.

(3) **Full-Blown AIDS:** In this final stage, there is severe weight loss and weakness due to persistent diarrhoea and usually one of several opportunistic infections is present.

(4) **Treatment of AIDS:** The drug **zidovudine** (also called azidothymidine, or AZT) and dideoxyinosine (DDI) prevent HIV reproduction in cells. Proteases are enzymes HIV needs to bud from the host cell; researchers are hopeful that a protease inhibitor drug will soon be available.

AIDS Prevention: Shaking hands, hugging, social kissing, coughing or sneezing and swimming in the same pool do not transmit the AIDS virus. You cannot get AIDS from inanimate objects such as toilets, doorknobs, telephones, office machines, or household furniture.

HIV has been isolated from semen cervical secretions, lymphocytes, plasma, cerebrospinal fluid, tears, saliva, urine and breast milk. The secretions known to be especially infectious are semen, cervical secretions, blood and blood products. Infection is spread :

(a) By sexual intercourse, vaginal and anal

(b) By infected blood, blood products, donated semen and organs

(c) By contaminated needles used :

(1) During the treatment of patients

(2) When drug abusers share needles

(d) From an infected mother to her child :

(1) Across the placenta before birth

(2) While the baby is passing through the birth canal

(3) Possibly by breast milk

Diagnosis: Once the host is infected by HIV. HIV detected by the ELISA Test. (Enzyme–linked immunosorbent assay a positive Elisa should be can firmed using another test called the western blot test.

Cancer: Cancer is an abnormal and uncontrolled division of cells, known as cancer cells that invade and destroy the surrounding tissues. Generally Cancer is defined as uncontrolled proliferation of cells without any differentiation.

(i) Neoplasms or Tumours : A neoplasm (new growth) is a mass of tissue that grows in excess of normal in an uncordinated manner and continues to grow after the initial stimulus has ceased. Tumours are classified as benign or malignant.

(ii) **Oncology:** (G. *onkos* – mass, tumour; logos – study of) is the field of biomedicine devoted to the study and treatment of tumours.

(a) **Types of Tumors:** There are two types of tumours : benign and malignant.

(1) **Benign Tumour – (=Nonmalignant Tumour) :** It remains confined to the site of its origin and does not spread to other parts of the body. It causes limited damage to the body. It is non-cancerous.

(2) **Malignant Tumour (= Cancerous Tumour):** It first grows slowly. No symptoms are noticed. This stage is called the latent stage. The tumor later grows quickly. The cancer cells go beyond adjacent tissue and enter the blood and lymph. Once this happens, they migrate to many other sites in the body where the cancer cells continue to divide. It is **metastasis**. Only malignant tumours are properly designated as cancer.

Differences between Benign Tumour and Malignant Tumour

Benign Tumour	Malignant Tumour
(1) It remains confined to the affected organ.	(1) It also spreads to other organs of the body.
(2) Rate of growth is usually slow.	(2) Rate of growth is usually rapid.
(3) There is no latent stage.	(3) There is latent stage.
(4) It causes limited damage to the body.	(4) The cancer cells migrate to other sites of the body.
(5) There is no metastasis.	(5) There is metastasis.
(6) It is non-cancerous.	(6) It is cancerous.

(b) **Types of Cancer (Types of Malignant Tumours) :** Malignant tumours are generally classified into three main types on the basis of cell type from which they arise.

(1) **carcinomas:** cancer of epithelial tissue

(2) sarcomas: cancer of connective tissue and muscular tissue

(3) Leukemia : cancer of blood

Microbes in Human Welfare

Bacteria

(1) Study of bacteria is called bacteriology.

(2) Linnaeous placed them under genus vermes.

(3) *Nageli* classified bacteria under schizomycetes.

(4) Bacteria are unicellular, microscopic organisms.

(5) These are the smallest cell wall having prokaryotic cell.

(6) They differ from animals in having a rigid cell wall and being capable to synthesize vitamins.

Size:

(i) Bacteria are the smallest of all known cellular organisms which are visible only with the aid of microscope.

(ii) They are 3 to 5 microns (1 m = 1/1000 millimetre or about 1/25,000 inch) in length.

(iii) A few species of bacteria are approximately 15*m* in diameter.

Shape:

(i) The shape bacteria usually remain constant.

(ii) Some of them are able to change their shape and size with changes in environmental conditions. Such bacteria, which change their shape, are called pleomorphic.

(e) **Filament:** The body of bacterium is filamentous like a fungal mycelia. The filaments are very small *e.g.*Beggiota, Thiothrix etc.

(f) **Stalked:** The body of bacterium posses a stalk *e.g.* Caulobacter.

(g) **Budded:** The body of bacterium is swollen at places *e.g.* Retrodomicrobiom.

Role of Bacteria in nitrogen cycle:

Nitrogen cycle existing in nature, comprises of –

Nitrogen fixation:

(1) Many free-living soil inhabiting bacteria such as, *Azotobacter* (aerobic), *Clostridium* (anaerobic), etc. have ability to fix atmospheric nitrogen into ammonia.

(2) The other group of nitrogen fixing bacteria lives in symbiotic association with other plants.

(3) The most important symbiotic nitrogen fixing bacteria is *Rhizobium* spp.

(4) The various species of *Rhizobium* inhabit different leguminous plants. For example, *R. leguminosarium* infects soyabeans, etc.

(5) They develop root nodules and fix atmospheric nitrogen into ammonia in symbiotic association with leguminous plants.

(6) The fixed nitrogen is partly taken up by the leguminous plants and metabolised.

(7) A part of fixed nitrogen is diffused out into the surrounding soil.

Ammonification:

(1) The nitrogenous compounds of the dead remains of plants, animals and their excretory products are decomposed into ammonia by a number of bacteria and other microorganisms.

(2) The conversion of nitrogenous organic compounds into ammonia is termed as ammonification.

(3) It is carried by many ammonifying bacteria such as *Bacillus ramosus, B. vulgaris, B. mycoides,* etc.

Nitrification:

(1) Many bacteria enhance the nitrogen fertility of soil by converting ammonium compounds to nitrites (*e.g., Nitrosomonas*) and nitrites into nitrates (*e.g., Nitrobacter*).

(2) The *Nitrosomonas* group oxidizes ammonia into nitrite –

$$NH_4^+ + 3/2\,O_2 \longrightarrow NO_2^- + H_2O + H^+ + \text{Energy} \uparrow$$

(3) The *Nitrobacter* group oxidizes nitrite to nitrates –

$$NO_2^- + 1/2\,O_2 \longrightarrow NO_3^- + \text{Energy} \uparrow$$

Denitrification:

The nitrates and ammonia are converted to nitrous oxide and finally to nitrogen gas by several denitrifying bacteria, *e.g., Pseudomonas fluorescence, P. denitrificans, Bacillus subtilis, Thiobacillus denitirficans,* etc.

Useful activities

(i) **Decay of organic wastes**

(ii) **Role in improving soil fertility**

(a) **Humus:** The microbial decomposition of organic matter and mineralization results in the formation of complex amorphous substance called **humus**. The humus improves the aeration, water holding capacity, solubility of soil minerals, oxidation-reduction potential and buffering capacity of the soil.

(b) **Composting:** It is conversion of farm refuse, dung and other organic wastes into **manure** by the activity of saprotrophic bacteria (*e.g., Bacillus stearothermophilus, Clostridium thermocellum, Thermomonospora* spp, etc.)

(c) **Adding sulphates:** A few sulphur bacteria (*e.g., Beggiatoa*) add sulphur into the soil by converting H_2S into sulphates.

(iii) **Sewage, disposal:** Ability of anaerobic bacteria to purify the organic matter is used in the the sewage disposal system of cities. The faeces are stored in covered reservoirs and allowed to purify.. The common bacteria involved in sewage disposal are –*Coliforms* (*E. coli*), *Streptococci, Clostridium, Micrococcus, Proteus, Pseudomonas, Lactobacillus,* etc.

(iv) **Role in Industry:**

(a) **Lactic acid**.

(b) **Curd**

(c) **Cheese**

(d) **Butter**

(e) **Retting process**

(f) **Vinegar**

(v) **Role of bacteria in human being**

(vi) **Medicinal uses**

(a) **Vitamins**

(b) **Serum and vaccines**

(c) **Enzymes**.

(d) **Antibiotics**

List of some common antibiotics, their sources and their applications

S. No.	Antibiotic	Obtained from	Used against
A	Streptomycin	*Streptomyces griseus*	Gram-positive and Gram-negative bacteria, TB, tularemia (rabbit fever), influenza, meaningitis, baciltary dysentery, etc.
B	Actidine	*S. griseus*	Plant diseases caused by fungi.
C	Chloromycetin	*S. venezuelae*	Gram-positive and Gram- negative bacteria, typhoid, rickettsias
D	Tetracycline	*S. aurefaciens*	Gram-positive and Gram-negative bacteria, rickettsiae.
E	Terramycin	*S. ramosus*	Gram positive and Gram-negative bacteria.
F	Erythromycin	*S. erythreus*	Gram positive bacteria, whooping cough, diphtheria.
G	Neomycin	*S. fradiae*	Gram- positive, Gram negative and TB bacteria.
H	Amphomycin	*S. carus*	Gram-positive bacteria,
I	Amphotericin B	*S. nodosus*	Yeast, fungi
J	Leucomycin	*S. kitasoensis*	Gram-positive bacteria.
K	Trichomycin	*S. hachijoensis*	Yeast and fungi.
L	Viomycin	*S. floridae*	Gram-positive, Gram-negative and TB bacteria.
M	Bacitracin	*Bacillus subtilis*	Gram-positive bacteria
N	Gramicidin	*B. brevis*	Gram-positive bacteria.
O	Tyrothricin	*B. brevis*	Gram-positive and Gram-negative bacteria.
P	Polymyxin B	*Aerobacillus polymyxa*	Gram-negative bacteria.

Microbes in production of biogas

Methanogens:

These are strict anaerobic bacteria and mainly occur in muddy areas and also in stomach of cattle, where cellulose is fermented by microbes. These are responsible for methane gas (CH_4) formation in bio-gas plants, because they have capacity to produce CH_4 from CO_2 or formic acid ($HCOOH$).

Biotechnology & its Applications

Recombinant DNA technology

Definition:

Genetic engineering, a kind of biotechnology, is the latest branch in applied genetics dealing the alteration of the genetic makeup of cells by deliberate and artificial means. Genetic engineering involves transfer or replacement of genes, so also known as recombination DNA technology or gene splicing.

Tools of genetic engineering:

(1) Two enzymes used in genetic engineering are restriction endonuclease and ligases.

(2) R.E. is used to cut the plasmid as well as the foreign DNA molecules of specific points while ligase is used to seal gaps or to join bits of DNA.

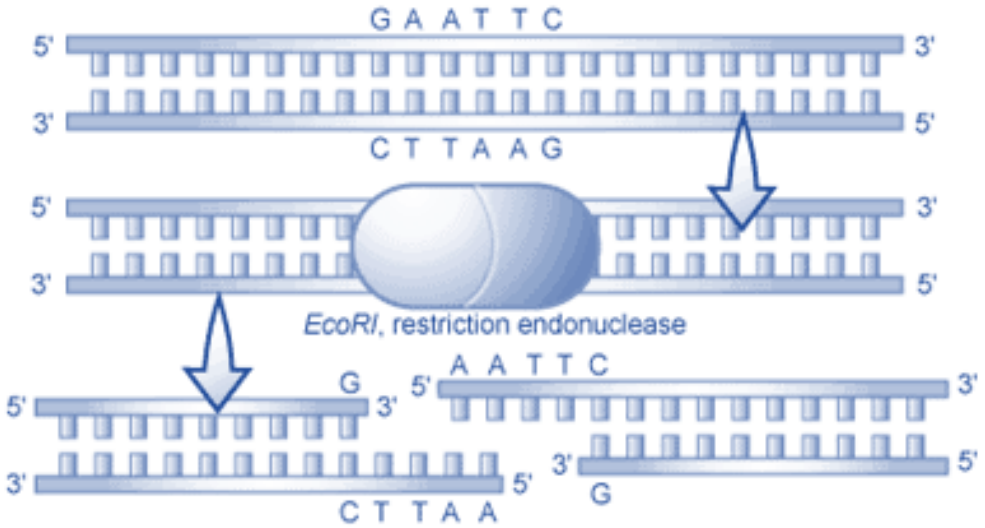
(3) The ability to clone and sequence essentially any gene or other DNA sequence of interest from any species depends on a special class of enzymes called restriction endonucleases.

(4) Restriction endonucleases are also called as molecular scissors or 'chemical scalpels'.

(5) Restriction endonucleases cleave DNA molecules only at specific nucleotide sequence called restriction sites.

(6) The first restriction enzyme identified from a bacterial strain is designated I, the second II and so on, thus, restriction endonuclease EcoRI is produced by Escherichia coli strain RY 13.

(7) Restriction enzyme called EcoRI recognizes the sequence



(8) It then cleaves the DNA between G and A on both strands. Restriction nucleases make staggered cuts; that is, they cleave the two strands of a double helix at different joints and blunt ended fragments; that is, they cut both strands at same place.

Steps of recombinant DNA technology

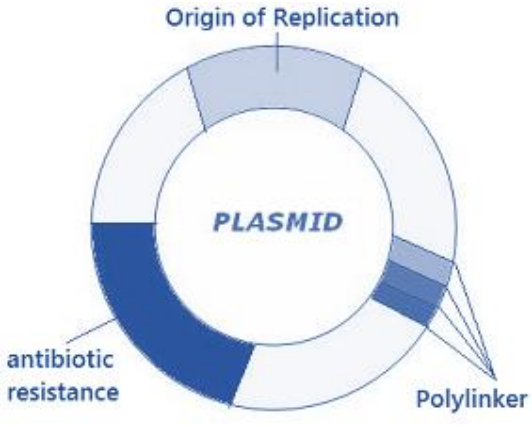
(1) Isolating a useful DNA segment from the donor organism.

(2) Splicing it into a suitable vector under conditions to ensure that each vector receives no more than one DNA fragment.

(3) Producing of multiple copies of his recombinant DNA.

(4) Inserting this altered DNA into a recipient organism.

(5) Screening of the transformed cells.



Vectors:

Vector in genetic engineering is usually a DNA segment used as a carrier for transferring selected DNA into living cells. These are as follows:

(1) **Plasmid:** Plasmid is extra chromosomal, closed circular double stranded molecules of DNA present in most eukaryotes. All plasmid carry replicons pieces of DNA that have the genetic information required to replicate. Plasmid pBR 322 was one of the first widely used cloning vectors, it contain both ampicillin and tetracycline resistance genes.

(2) **Phage:** It is constructed from the phage / chromosomes and acts as bacteriophage cloning vectors.

(3) **Cosmid:** The hybrids between plasmid and the phage / chromosome give rise to cosmid vectors.

(4) Beside all these there are artificial chromosomes like

(i) BACs (Bacterial Artificial chromosomes)

(ii) YACs (Yeast Artificial chromosomes)

(iii) MACs (Mammalian Artificial chromosomes) are very efficient vectors for eukaryotic gene transfers.

Application of recombinant DNA technology:

The technique of recombinant DNA can be employed in the following ways.

(1) It can be used to elucidate molecular events in the biological process such as cellular differentiation and ageing. The same can be used for making gene maps with precision.

(2) In biochemical and pharmaceutical industry, by engineering genes, useful chemical compounds can be produced cheaply and efficiently which is shown in table.

Applications of recombinant DNA products

Medically useful recombinant products	Applications
Human insulin	Treatment of insulin-dependent diabetes
Human growth hormone	Replacement of missing hormone in short stature people
Calcitonin	Treatment of rickets
Chronic gonadotropin	Treatment of infertility
Blood clotting factor VIII/IX	Replacement of clotting factor missing in patients with Haemophilia A/B
Tissue plasminogen activator	Dissolving blood clots after heart attacks and strokes
Erythropoitin	Stimulation of the formation of erythrocytes (RBCs) for patients suffering from anaemia during kidney dialysis or side effects of AIDS patients treated by drugs
Platelet derived growth factor	Stimulation of wound healing
Interferon	Treatment of pathogenic viral infections, cancer
Interleukins	Enhancement of action of immune system
Vaccines	Prevention of infectious diseases such as hepatitis B, herpes, influenza, pertussis, meningitis, etc.

Cloning:

Cloning is the process of producing many identical organisms or clones. In this process nucleus of ovum (n) is removed and replaced by nucleus of diploid cell of same organism. Now the egg with 2*n* nucleus is transferred to the uterus of mother to have normal pregnancy and delivers clone of itself.

Examples of organism cloning

(1) Cloning of sheep was done by **Dr. Ian Wilmut** (1995) of Roslin Institute, Edinberg U.K. and normal healthy lamb (DOLLY) was born in Feb, 1996. This lamb was exactly similar to her mother.

(2) The first cloned calves George and Charlie were born in January 1998.

(3) ANDI was the world's first genetically altered primate produced by inserting a jelly fish gene into the embryo of a rhesus monkey.

(4) Scientist at Scotland cloned POLLY and MOLLY. Unlike Dolly, polly and molly were transgenic (they carried human protein gene) polly and molly were born in july 1997.

(5) **Brigitte Boissliar**, a 46-year old french chemist announced the creation of the world's first cloned human boby nicknamed "Eve" (December 2002).

Polymerase chain reaction (PCR):

(1) It was developed by **Kary Mullis** in 1983 and won Nobel Prize in 1993.

(2) PCR is a method for amplifying a specific piece of DNA molecule without the requirement for time-consuming cloning procedure.

(3) This process require Target DNA, a heat stable DNA polymerase, which work at optimum temperature of 70°C usually Taq DNA and four types of nucleotides with small single stranded strands of DNA of about 20 nucleotide called primers, produce multiple copy of desired DNA.

Environment & Ecosystem

Organisms and Population

Population Dynamics

(1) Population density:

(i) Population density is the number of individuals present per unit area or volume at a given time.

(ii) For instance, number of animal per square kilometer, number of trees per area in a forest, or number of plank tonic organism per cubic meter of water.

(iii) If the total number of individuals is represents by letter N and the number of units of space by Letter S, the population density D can be obtained as D=N/S.

(iv) Space is indicated in two dimensions (m^2) for land organisms, and in three dimensions (m^3) for aquatic organisms and for the organisms suspended in space.

(2) Birth rate or Natality:

(i) The birth rate of a population refers to the average number of young ones produced by birth, hatching or germination per unit time (usually per year).

(ii) In the case of humans, it is commonly expressed as the number of births per 1000 individuals in the population per year.

(iii) The maximum birth rate of a species can achieve under ideal environmental conditions is called potential natality.

(iv) The actual birth rate under the existing conditions is much less. It is termed realised natality.

(v) Crude birth rate is the number of births per 1000 persons in the middle of a given year i.e. on July.

(vi) Natality increases the population size (total number of individuals of a population) and population density.

(3) Death rate or mortality:

(i) The death rate of a population is the average number of individuals that die per unit time (usually per year).

(ii) In humans it is commonly expressed as the number of death per 1000 persons in a population per year.

(iii) Lowest death rate for a given species in most favourable conditions is called potential mortality, while the actual death rate being observed in existing conditions is called realized mortality.

(iv) Crude death rate is the number of deaths per 1000 persons in the middle of a given year i.e. on July.

(v) Mortality decreases the population size and population density both.

Difference between Natality rate and Mortality rate

Character	Natality rate	Mortality rate
(1) Definition	Number of births per 1,000 individuals of a population per year.	Number of deaths per 1,000 individuals of a population per year.
(2) Population density	Increases population size and population density.	Decreases population size and population density.

(4) Vital index:

The percentage ratio of natality over mortality is known as vital index i.e. natality / mortality ×100. It determines the growth of a population.

(5) Immigration:

It is permanent entry of additional person into the existing population of a country or region from outside. Example; Many Nepalese and Chinese come to settle in India.

(6) Emigration:

(i) It is the permanent departure of some persons from the existing population of a region to a different state or a foreign country. Example; Many Indians go to Western countries to settle there.

(ii) Immigration and emigration bring about redistribution of population, and are common in animals.

(iii) These occur for various reasons, such as search for food, escape from competition due to overcrowding, need of shelter etc.

(7) Sex ratio:

The number of females in a population per 1000 males is called sex ratio.

Sex ratio = No. of females/ 1000(males)

(8) Age structure:

(i) The age structure of a population is the percentage of individual of different ages such as young, adult and old.

(ii) Age-sex structure of a population can be shown by a pyramid-like diagram by plotting the percentage of population of each sex in each age-group.

Patterns of Population Growth:

Growth of a population can be expressed by a mathematical expression, called growth curve in which logarithm of total number of individuals in a population is plotted against the time factor. Growth curves represent interaction between biotic potential and the environmental resistance.

Two basic types of growth curves:

(a) **Sigmoid or S-shaped growth curve:** It is shown by yeast cells and most of organisms. It is formed of five phases:

(1) **Lag phase.** In which the individuals adapt themselves to the new environment, so there is no or very little increase in population.

(2) **Positive Acceleration phase.** It is the period of slow increase in population in the beginning.

(3) **Logarithmic** or **Exponential phase:** It is the period of rapid rise in population due to availability of food and requirements of life in plenty and there being no competition.

(4) **Negative Acceleration phase:** In which again there is slow rise in population as the environmental resistance increases.

(5) **Stationary (Plateau) phase:** Finally, growth rate becomes stable because mortality and natality rates become equal to each other. So there is zero growth rate. A stable population is said to be in equilibrium, or at saturation level. This limit in population is a constant *K* and is imposed by the carrying capacity of the environment. S-shaped curve is also called logistic curve. Sigmoid growth curve was described by **Verhulst, (1839)**

(b) J-shaped Growth curve: It is shown by small population of **Reindeer** experimentally reared in a natural environment with plenty of food but no predators. It has only two phases:

(1) **Lag phase:** It is period of adaptation of animals to new environment so is characterized by slow or no growth in population.

(2) **Logarithmic or Exponential phase:** It is characterized by rapid growth in population which continues till enough food is available. But with the increase in reindeer population, there is corresponding decrease in the availability of food and space, which finally become exhausted, which leads to mass starvation and mortality. This sudden increase in mortality is called **population crash.** Lemming of Tundra, some insect, algal blooms and annual plants also show J-shaped curves. The population growth curve is S- shaped in most of the organisms, Human population also shows S-shaped curve.

Difference between S-shaped and J-shaped Growth curves

S.No.	S-shaped Growth Curve	J-shaped Growth Curve
(1)	It is formed of 5 phases: lag phase, positive acceleration phase, exponential phase, negative acceleration phase and stationary phase.	It is formed of 2 phases: lag phase and exponential phase.
(2)	Finally the population shows zero growth rate as birth rate equals death rate.	Finally, the population shows a population crash due to rapid increase in mortality rate.
(3)	*Examples.* Yeast cells in a culture medium.	*Examples.* Reindeers, algae blooms, lemmings of Tundras

Ecosystem

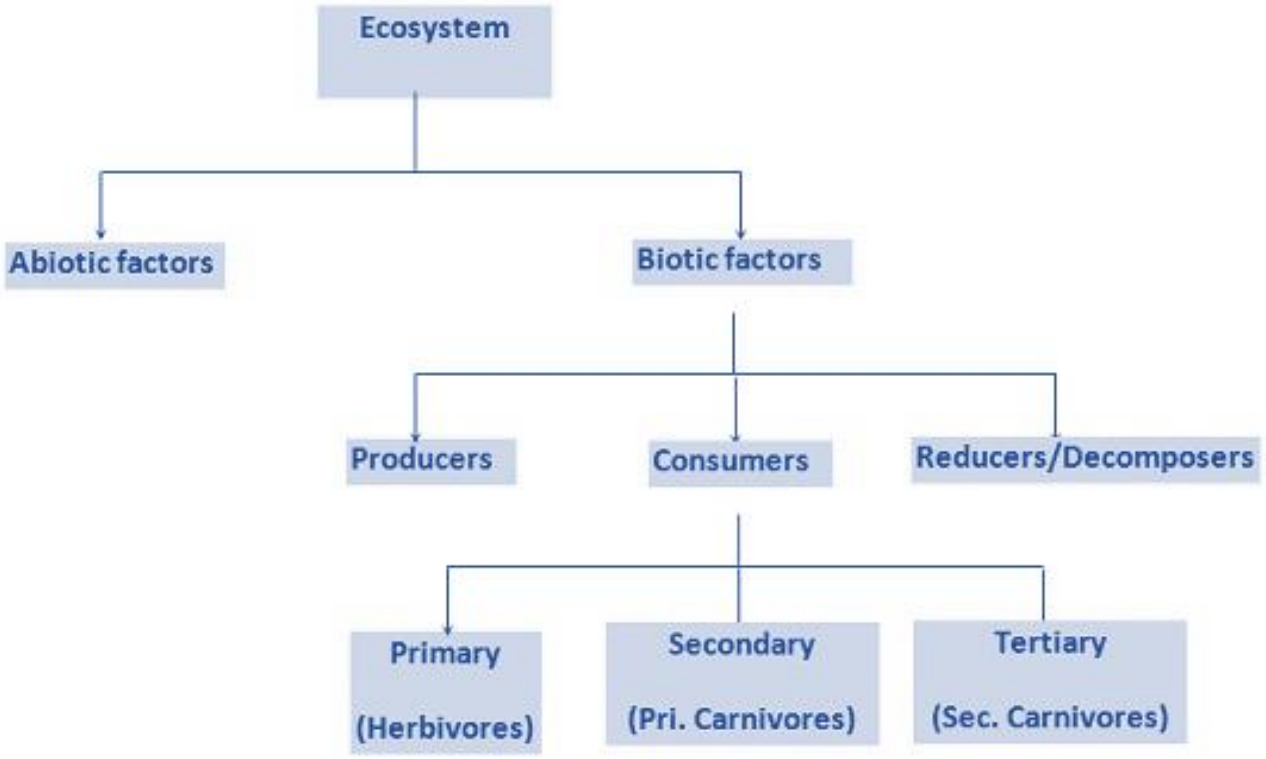
Ecosystem

(1) The word ecosystem was coined by **A.G. Tansley** in 1935.

(2) **Structure:** The structure of any ecosystem is formed of two components, namely:

(i) Abiotic factors

(ii) Biotic factors



Energy flow:

(1) The transfer of energy from one trophic level to another trophic level is called energy flow.
(2) The flow of energy in an ecosystem is unidirectional. That is, it flows from the producer level to the consumer level and never in the reverse direction. Hence energy can be used only once in the ecosystem.
(3) But the minerals circulate and recirculate many times in the ecosystem.
(4) A large amount of enregy is lost at each trophic level.
(5) It is estimated that 90% of the energy is lost when it is transferred from one trophic level to another.
(6) Only about 10% of the biomass is transferred from one trophic level to the next one is a food chain. And only about 10% of chemical energy is retained at each trophic level. This is called 10% law of Lindeman (1942).

Ecological pyramids:

(1) The number, biomass and energy of organisms gradually decrease from the producer level to the consumer level. This can be represented in the form of a pyramid called ecological pyramid.
(2) Ecological pyramid is the graphic representation of the number, biomass, and energy of the successive trophic levels of an ecosystem.
(3) The use of ecological pyramid was first described by Charles Elton in 1927.
(4) In the ecological pyramid, the producer forms the base and the final consumer occupies the apex.
(5) There are three types of ecological pyramids, namely:

(i) The pyramid of number:

The number of individuals at the trophic level decreases from the producer level to the consumer level. That is, in an ecosystem the number of producers is far high. The number of herbivores is lesser than the producers. Similarly, the number of carnivores is lesser than the herbivores.

(i) **In a cropland ecosystem:** In croplands the crops are more in numbers. The grasshoppers feeding on crop plants are lesser in number. The frogs feeding on grasshopper are still lesser in number. The snakes feeding on frogs are fewer in number.

Crop -> Grasshopper -> Frogs -> Snakes -> Hawks

(ii) **In a grassland ecosystem:** In grassland the grasses are there in large numbers. The consumers decrease in the following order.

Grass -> Grasshopper -> Lizard -> Hawk
Grass -> Rabbit -> Fox -> Lion

(iii) **In a pond ecosystem:** The number in a pond ecosystem decreases in the following order.

Phytoplankton -> Zooplankton -> Fishes -> Snakes

(b) The pyramid of biomass:

Biomass refers to the total weight of living matter per unit area. In an ecosystem the biomass decreases from the producer level to the consumer level.

(c) Pyramid of energy:

The energy flows in an ecosystem from the producer level to the consumer level. At each trophic level 80 to 90% of energy is lost. Hence the amount of energy decreases from the producer level to the consumer level. This can be represented in a pyramid of energy level to the consumer level. This can be represented in a pyramid of energy.

Succession

(1) Every community undergoes a series of changes until a group of organisms is established which can live and reproduce most successfully in the area. This is called biotic succession.

(2) The term succession was coined by Hult (1885).

(3) A biotic community normally undergoes continuous changes. Generally, definite and orderly sequences of communities gradually appear in an area over a period of time.

(4) A specific sequence of development of a community is related to particular set of physical and chemical conditions. This is known as sere.

(5) The last succession in a sere is called climax or a climatic climax.

(6) **Types:** Succession is of two types**:**

(i) **Primary succession:** It includes changes which occur when living things become established on a previously uninhabited area such as a newly exposed sea floor, lake sediments or sand dunes.

(ii) **Secondary succession:** It occurs where early communities have been damaged, leaving a few organisms and considerable organic matter. These remnant species, along with some new ones, regenerate a new community.

(iii) **Life forms: Raunkiaer** (1934) has distinguished plants into five forms on the basis of size, shape, branching, crown, life span and perennation.

(a) **Therophytes:** Annual plants which perennate in the form of seeds.

(b) **Cryptophytes:** Buds are occurs very deep in the soil *e.g.* Bulbs, rhizomes, corm, tubers etc.

(c) **Hemicryptophytes:** Perennating structures occur at ground level. Aerial shoots die in the onset of winter, e.g. rosette plants.

(d) **Chemaephytes:** Small plants of cold areas where perennating buds or shoot apices lie at or above the ground level.

(e) **Phanerophytes:** Perennial herbs, shrubs and trees, epiphytes, succulents, lianas, etc., where perennating buds occurs at 10 cm or more height above ground level.

Nutrient Cycling

Carbon Cycle

(1) The cycling of carbon between biotic and abiotic systems is called carbon cycle. It is a gaseous cycle.

(2) The main source of carbon is the carbon dioxide (CO_2).

(3) CO_2 is present in the air and water. Air is the main reservoir. CO_2 content of air is 0.03%. Its amount remains constant.

(4) **Flow of Carbon into the biotic system:** Carbon flows into the biotic system in two ways:

(i) **Photosynthesis:**

Carbon enters the biotic system through photosynthesis. In photosynthesis green plants utilize CO_2 and incorporate the carbon of CO_2 in glucose. Glucose is used for the synthesis of other types of carbohydrates, proteins and lipids. These compounds, containing carbon, are stored up in the plant tissues. When plants are eaten up by herbivores, the carbon flows into the body of herbivorous animals through food chain. When herbivores are eaten by carnivores, the carbon enters the body of carnivorus animals.

$$6CO_2 + 6H_2O \xrightarrow{®} C_6H_{12}O_6 + 6O_2$$

(ii) Formation of shell:

The CO_2 dissolved in sea water is utillized by the marine animals like protozoans, corals, molluscs, algae, etc., for the construction of shell. In these animals CO_2 is converted into calcium carbonate ($CaCO_3$) which is used for the construction of shells.

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (Carbonic acid)}$$

$$H_2CO_3 \rightarrow H^+ + HCO_3 \text{ (Bicarbonate)}$$

$$HCO_3 + Ca^+ \rightarrow H^+ + CaCO_3 \text{ (Calcium carbonate)}$$

(5) **Flow of Carbon into the abiotic system:** The carbon of the biotic system flows into the abiotic system in five ways:

(i) Respiration:

Plants and animals release CO_2 by respiration (biological oxidation).

$$C_6H_{12}O_6 \rightarrow CO_2 + H_2O + \text{Energy}$$

(ii) Decomposition:

When plants and animals die, the dead bodies are decomposed into CO_2 by decomposers like bacteria, algae, etc.

(iii) Shells:

After the death of marine animals, $CaCO_3$ stored in the shells is either deposited as sedimentary rocks or dissolved in water to release CO_2 by the reversion of the above said reactions.

(iv) Coal:

A certain proportion of carbon from plants is deposited as coal. Carbon from coal returns to air in the form of CO_2through combustion and weathering.

(v) Forest fire:

Combustion of wood in the forest releases carbon from plants in the form of CO_2.

Phosphorus cycle:

(i) The cycling of phosphorus between biotic and abiotic *system* is called phosphorus cycle. It is a sedimentary cycle.

(ii) Phosphorus is an important mineral nutrient.

(iii) The main source of phosphorus is rocks. Through erosion and weathering phosphorus is made available in the soil.

(iv) Plants absorb ionic phosphate through roots. In plants it is incorporated into the protoplasmic components like DNA, RNA, AMP, ADP, ATP, GDP, GTP, NADP, phospholipids etc. from plants, it

passes into herbivores and animals, the organic molecules containing phosphate are decomposed and phosphate is liberated as inorganic ion phosphate. It is again used by plants.

(v) The excess of phosphate in the bodies of animals is excreted out through faces. The bird guano (excreta) contains a large amount of phosphate.

(vi) Phosphate is also released to the soil through the combustion of forest trees and grasses.

(vii) A large amount of phosphate is lost in the sea by sedimentation. A certain amount of phosphorus gets locked in bones and teeth.

Environmental Issues

Air Pollution:

Air pollution refers to the undesirable change occurring in air causing harmful effects on man and domesticated species.

(i) **Air Pollutants :** The common air pollutants are : Dust, Smoke, Carbon monoxide (*CO*), Ammonia (NH_3), Sulphur dioxide (SO_2), Hydrogen sulphide (H_2S), Nitrogen dioxide (NO_2), Hydrogen cyanide, Hydrogen fluorides, Chlorines, Phosgenes, Arsines, Aldehydes, Ozone, Ionising and radiations. CO_2 is not a normal air pollutant. There is 0.03% CO_2 in the air its higher percentage is the cause of green house effect.

Types of air pollutants: It is two types:

(a) **Primary air pollutants:** Air is polluted by poisonous gases and undesirable substances. They are released by burning fossil fuels. These substances are called primary air pollutants. The primary air pollutants are the following:

- Soot released from unburned fuel.
- Sulphur dioxide (SO_2).
- Benzopyrene (hydrocarbon) released from cigarette smoke.
- Ammonia (NH_3).
- Oxides of nitrogen.
- Carbon monoxide (*CO*).
- Lead (*Pb*).

(b) **Secondary air pollutants:** Secondary air pollutants are poisonous substance formed from primary air pollutants. In bright sun light nitrogen, nitrogen oxides, hydrocarbons and O_2 interact to produce more powerful photochemical oxidants like ozone (O_3), peroxyacetyl nitrate (PAN), aldehydes, sulphuric acid, peroxides, etc. All these constitute photochemical smog, which retard photosynthesis in plants.

(ii) **Causes of air pollution**

(a) **Agriculture**

(b) **Dust:**

(c) **Industries**

(d) **Automobiles**.

(e) **Ionising radiations**

(f) **Freons**

(g) **Aerosols**

(iii) **Control of air pollution**

(a) The emission of exhaust from automobiles can be reduced by devices such as positive crankcase ventilation valve and catalytic converter.

(b) Electrostatic precipitators can reduce smoke and dust from industries.

(c) Gaseous pollutants arising from industries can be removed by differential solubility of gases in water.

(d) A finepray of water in the device called scrubber can separate many gases like NH_3, SO_2, etc. from the emitted exhaust.

(e) Certain gases can be removed by filtration or absorption through activated charcoal.

(f) Certain gases can be made chemically intert by chemical conversion.

(g) At the Government level pollution can be controlled by framing legislations.

(h) Vehicles based on compressed natural gas (CNG) should be introduced.

Water Pollution:

Water pollution refers to the undesirable change occurring in water which harmfully affect the life activities of man and domesticated species.

(i) **Water Pollutants:** The common water pollutants are : Domestic sewage, Industrial effluents, Pesticides, Herbicides, Fertilizers, Bacteria and Viruses, Plankton blooms and Heavy metals like Mercury, Temperature, Silt, Radioactivity, Oils etc.

(ii) **Causes of water pollution**

(a) **Domestic sewage**

(b) **Industrial effluents**

(c) **Thermal pollution**

(d) **Agricultural pollution**

(e) **Pesticides:**

(f) **Radioactive wastes** .

(g) **Oil pollution**

(h) **Eutrophication**.

(iii) **Control of water pollution**

(a) **Sedimentation**.

(b) **Dilution**

(c) **Storage**.

(iv) **Land pollution**

(i) **Land pollutants**.

(ii) **Pesticides**

(4) Radioactive pollution:

This pollution occurs through radiations. Radiations are of two types:

(i) **Non ionising radiations:** UV rays, IR rays, etc. UV rays cause skin burning, IR rays increases atmospheric temperature and leads to the green house effect.

(ii) **Ionising radiation:** *X* – rays, x-rays, beta-rays, gamma-rays cause genetic injury on mutation.

Certain elements continuously disintegrate by emitting ionizing radiations. These elements are called radioactive isotopes. Ecologically important radioactive elements are Strontium-90, Argon-41, Iodin-131, Cobalt-60, Cesium – 137, Plutonium – 238, etc. Among these Sr-90' is the most dangerous radioactive pollutant.

Types of ionizing radiations: Radioactive isotopes release three types of radiations:

(a) **Alpha particles:** These are large particles emitted by radioactive isotopes (as U^{238}). They travel only short distances. They cannot penetrate the organisms. They cause ionization.

(b) **Beta particles:** These are small particles emitted by radioactive isotopes. They can travel long distances. They can easily penetrate the body tissues and cause ionization.

(c) **Gamma rays:** These are short wavelength rays emitted by radioactive isotopes. They can travel long distances. They can easily penetrate the body tissues and cause ionization. On the basis of the biological effects produced, the radioactive radiations can be grouped into two types, namely internal emitters and external emitters.

(5) Noise pollution

Global Warming

Increase in atmospheric concentrations of green house gases (CO_2, CH_4, CFCs, N_2O) causes **global warming**enhanced green house effect), changes in sea level, weather and climate change etc.

Biodiversity and Conservation

Diversity ranges from macromolecules to biomes.

Biodiversity on earth exists in three levels of organization:

(i) Genetic diversity

(ii) Species diversity

Genetic diversity

(i) It is related to the variations of genes within species.

Speciesdiversity

(i) it is related to the variety of species within a region.

(ii) Species richness refers to the number of species per unit area.

Biodiversity in India

(1) Out of the twelve mega biodiversity counties, India is one.

(2) India has 10 biogeographical regions, 89 national parks, 500 wild life sanctuaries, 14 biosphere reserves, 6 westlands and 35 world heritage sites.

(3) There are about 45,000 species of plants and about 90,000-1,00,000 species of animals.

Patterns of Biodiversity

(1) Biodiversity changes with change in **latitude** or **altitude.**

(2) It is minimum at the poles and maximum near or at equator. Similarly, as one moves down from higher to lower altitudes, biodiversity is increased.

Loss of bio-diversity:

(1) Caused by three factors - Population, Urbanisation and Industrialisation.

(2) The colonisation of tropical Pacific Islands by human has led to the extinction of more than 2000 species of native birds.

(3) Loss of bio-diversity in a region leads to:

  (i) Decrease in plant production.

  (ii) Less resistance to environmental disturbances such as droughts.

  (iii) Increase in variability in ecosystem processes like plant productivity, water use, pest and disease cycles etc.

Biodiversity Conservation

In situ conservation

The most appropriate method to maintain species of wild animals and plants in their natural habitats. This approach includes conservation and protection of the total ecosystems and its biodiversity through a network of protected areas.

Hot spot of biodiversity are those regions of rich biodiversity which have been declared sensitive due to direct or indirect interference of human activities.

There are 25 terrestrial hot spots in the world including two from India.

Exsitu conservation

Threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care.

Convention on Biodiversity:

(1) "The earth Summit" held in Rio de Jeneiro in 1992 called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilization of its benefits.

(2) Second international Conference on Sustainable development held in 2002 in Johannesburg, South Africa, 190 countries pledged their commitment to achieve by 2010 a significant reduction in the current rate of biodiversity loss at global, regional and local level.