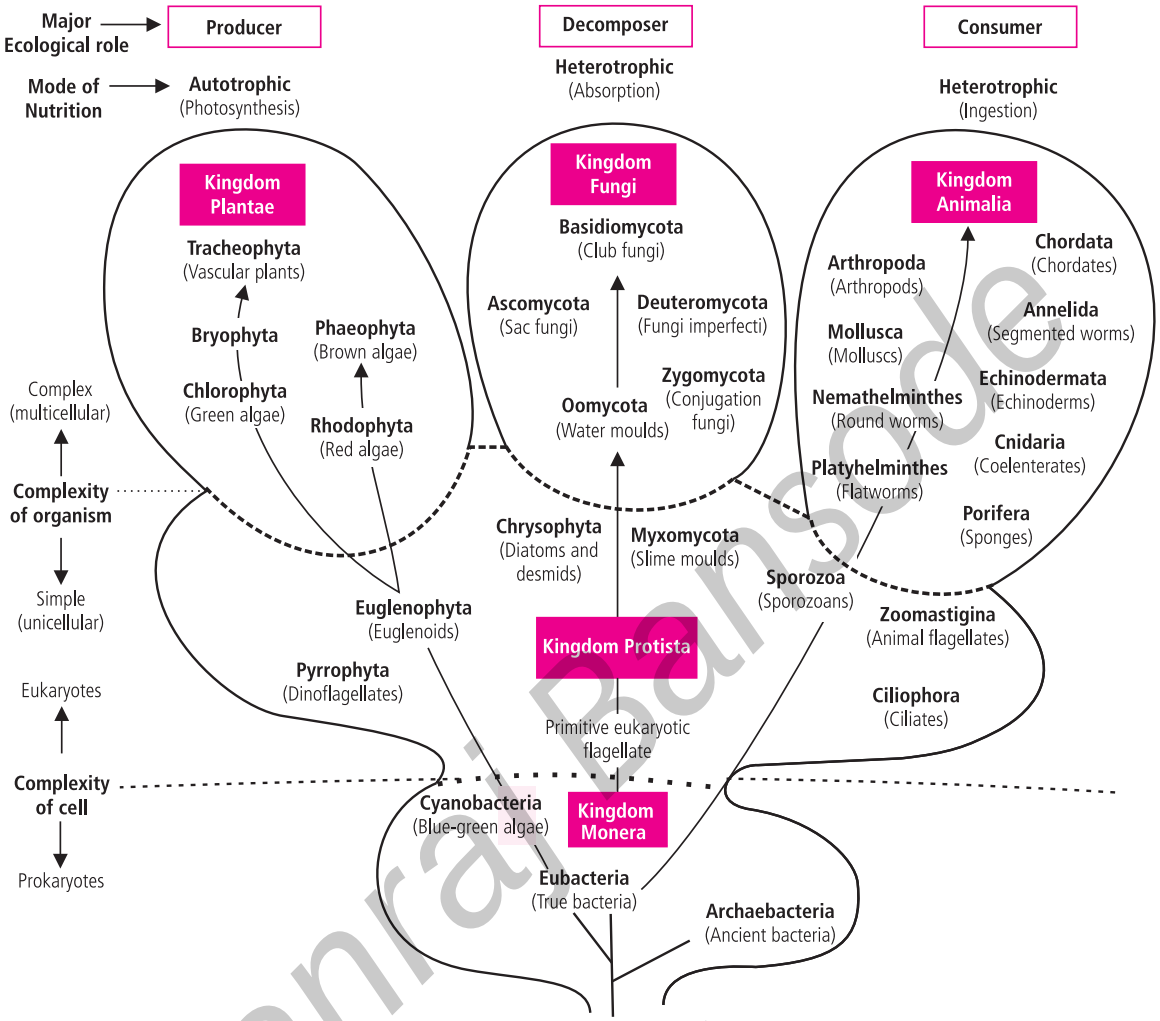


Fig.: Whittaker's Five Kingdom System of Classification

Table : Comparative account of characteristics of the Five Kingdoms of Whittaker's classification

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellulosic (polysaccharide + amino acid)	Present in some	Present (without cellulose)	Present (cellulosic)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multicellular/ loose tissue	Tissue/organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic or photosynthetic) and heterotrophic (saprotrophic or parasitic)	Autotrophic (photosynthetic) and heterotrophic	Heterotrophic (saprotrophic or parasitic)	Autotrophic (photosynthetic)	Heterotrophic (holozoic)

KINGDOM - PLANTAE

Cryptogamae (Plants without seeds)

Thallophyta
Thalloid, distinct roots, stem and leaves absent

Algae
Unicellular or multicellular, aquatic, green algae is considered as ancestors of land plants. e.g., Fucus, Volvox

Bryophyta
Plant amphibians, Can grow only on damp, watery places as male gametes require water to reach female gamete, protected sex organs, seeds absent, dominant gametophyte. eg., Funaria

Hepaticopsida
Liverworts, thallose or foliose; sporophyte is parasite. e.g., Riccia

Anthocerotopsida
Horn worts, thallose, horn like sporophyte is partial parasite on gametophyte. e.g., Anthoceros

Musci (Bryopsida)
Mosses, foliose, sporophyte partially dependent, sex organs borne on separate branches. e.g., Sphagnum, Sphaerocarpes

Pteridophyta
First true land plants, with vascular system, jacketed sex organs and dominant sporophyle. e.g., Salvinia, Pteris, Nephrolepis

Psilopsida
Most primitive, rootless leaves usually absent.
e.g., Rhynia

Lycopsida
Club moss/ground pine, true root, stem and leaves are present, usually gametophyte symbiotic, non-photosynthetic.
e.g., Lycopodium, Selaginella

Sphenopsida
Horse tail, mostly extinct, have distinct, nodes and internodes. e.g., Equisetum (sole living member)

Pteropsida (Filicopsida)
Ferns, stem, rhizomatous, macrophyllus, gametophyte, independent.
e.g., Adiantum

Phanerogamae (Plants with seeds)

Gymnospermae
Well developed vasculature but vessels and companion cells absent, mostly extinct, ovary absent thus fruit is not formed and seeds remain naked, gametophyte is highly reduced, endosperm is haploid. e.g., Ginkgo, Pinus

Cycadopsida
Comparitively primitive, small plants, female cones absent. e.g., Cycus, Zamia

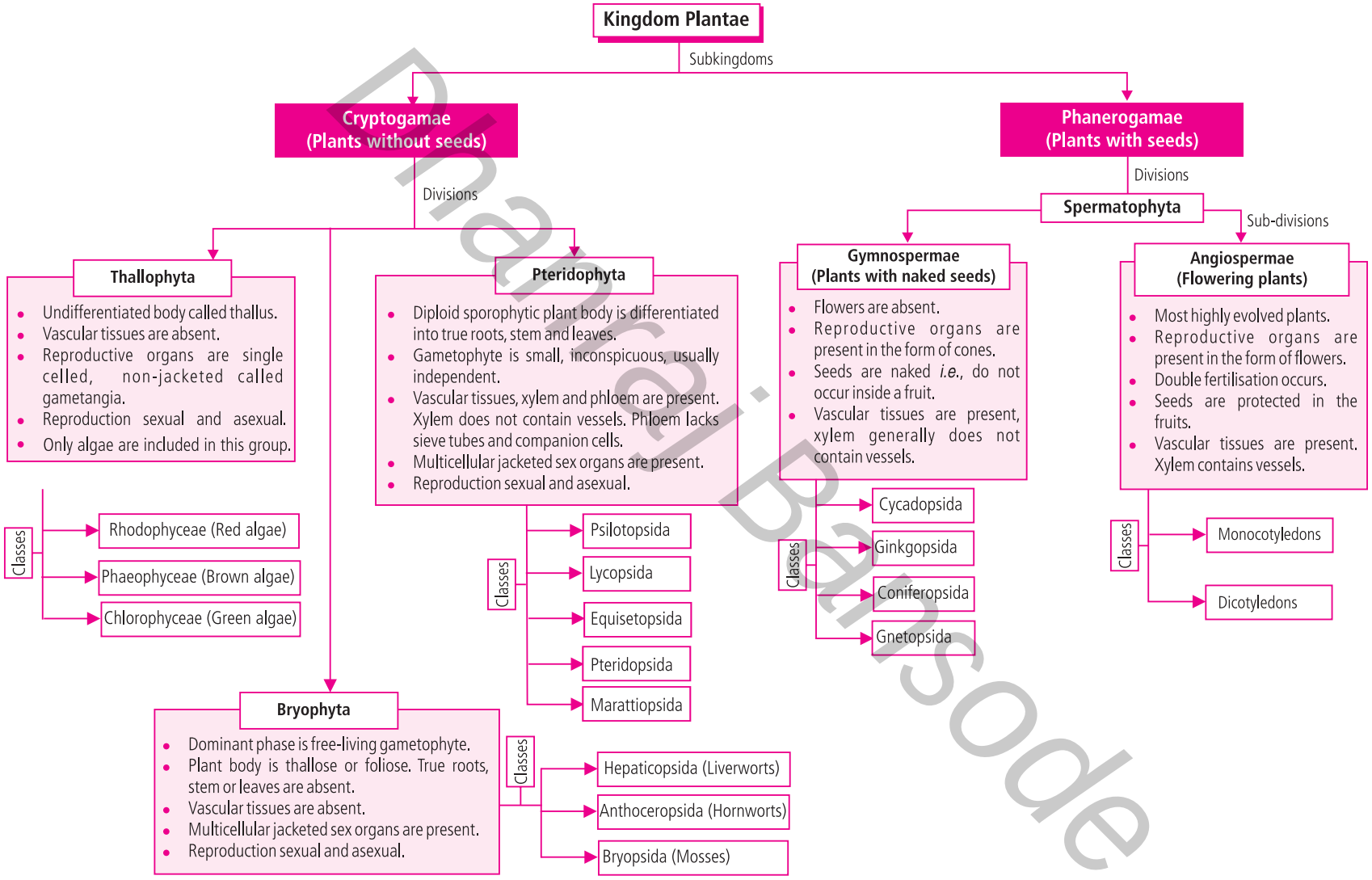
Coniferopsida
Larger, dominant, gymnosperms, evergreen
e.g., Gingko, Taxus

Gnetopsida
Advanced gymnosperms with vessels in xylem embryo has two Cotyledons, Considered closest to angiosperms. e.g., Gnetum

Angiospermae
Vessels and companion cells are present, ovary present thus seeds remain protected inside fruits till matarity, triploid, endosperm very diversified, found in all habitats. e.g., Oryza, Citrus

Monocotyledoneal
Seeds with single Cotyledon, leaves have paralled venation, trimerous flowers, adventitious roots, lack secondary growth. e.g., Wheat, Rice

Dicotyledoneal
Seeds with two Cotyledon, reticulate venation in leaves, Pentamerous flowers, tap roots, secondary growth present. e.g., Mango, Beans

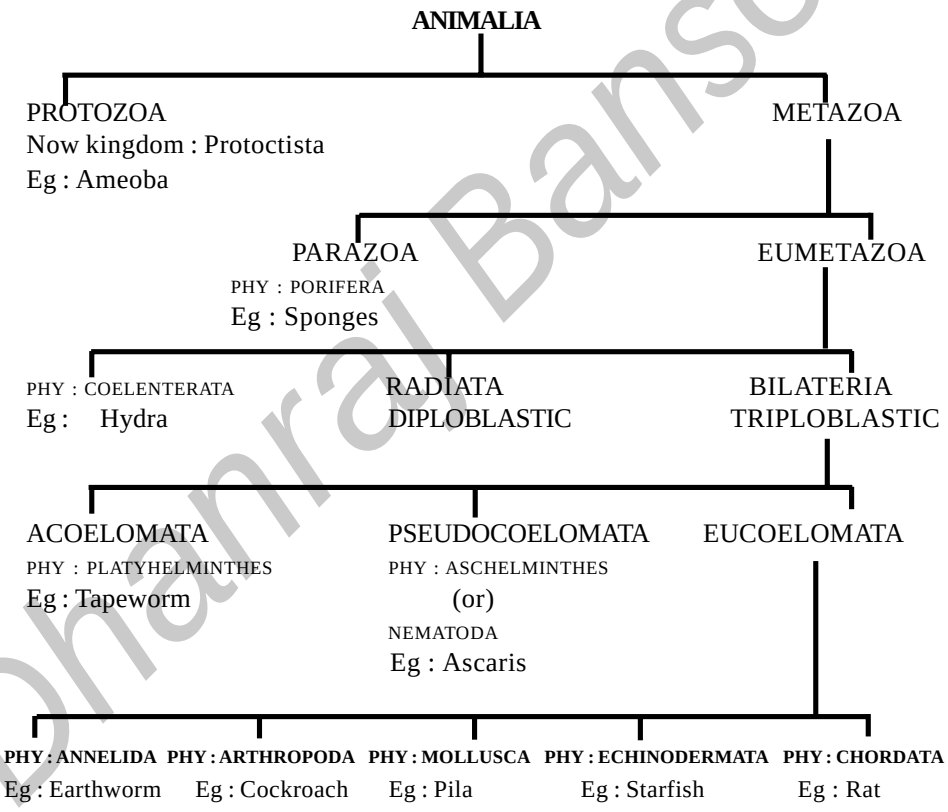


Flow chart : Classification of Kingdom Plantae

FIVE KINGDOMS

Kingdom 1	Kingdom 2	Kingdom 3	Kingdom 4	Kingdom 5
Monera	Protoctista	Fungi	Plantae	Animalia

Outline Classification of Animal Kingdom



KINGDOM - ANIMALIA (Multicellular, Eukaryotic)

Mesozoa
No tissues, body comprising an external layer of ciliated cells. Minute body, Worm like, Parasites of marine Phylum Mesozoa e.g., Dicyema

Parazoa
No tissues, diploblastic, cellular level of body organization, choanocytes present, called sponges. Phylum Porifera e.g., Leucosolenia, Sycon

Enterozoa or Eumetazoa
Tissue or organ system level of body organization

Division-Radiata
Body radially symmetrical, diploblastic, tissue level of body organization. *Phylum*-Cnidaria = Coelenterata. Cnidoblasts present. e.g., Hydra, Phylum ctenophora e.g., Chenoplana

Division-Bilateria
Body bilaterally symmetrical, triploblastic, organ system level of body organization

Sub-division Acoelomata
No Coelom
Phylum Platyhelminthes
e.g., Fasciota, Taenia

Sub-division Pseudocoelomata
Pseudocoelom
Phylum Nemathelminthes
e.g., Ascaris

Sub-division Eucoelomata
True Coelom

Schizocoelomata
Coelom develops from solid mesoderm
Phylum Annelida e.g., Earthworm
Phylum Arthropoda e.g., Cockroach
Phylum Mollusca e.g., Pila

Enterocoelomata
Coelom develops from enteric pouches
Phylum Echinodermata e.g., Starfish
Phylum Hemichordata e.g., Balanoglossus
Phylum Chordata

Phylum - Chordata

Sub Phylum - Urochordata
e.g., Herdmania

Sub Phylum - Cephalochordata
e.g., Amphioxus

Sub Phylum - Vertebrata

Section-Agnatha
Jawless Vertebrates
Class : Cyclostomata e.g., Petromyzon, Myxine
Class : Ostracodermi e.g., Cephalaspis, Pteraspis

Section-Gnathostomata
Jawed Vertebrates

Superclass - Pisces
True Fishes

Superclass - Tetrapoda
Typically 4 limbs

Class - Placodermi
All fossils have protective bony scales / plates
e.g., *Both riolepis panderi*

Class - Chodrichthyes
Cartilagenous fishes
e.g., Scoliodon

Class - Osteichthyes
Bony fishes e.g., Labeo

Class - Amphibia
e.g., Uraeotyphlus, Salamander, Frog

Class - Reptilia
e.g., Tortoise, Lizards, Snakes

Class - Aves
e.g., Birds

Class - Mammals
e.g., Rat, Man

integument. *i.e.* the eggs are covered by skin forming a single large brood pouch which opens posteriorly in front of the cloacal aperture.

- *Hyla fabre* prepares a nest in shallow water with mud and lays eggs in the nest.
- *Hyla resinfictrix* lines a shallow tree cavity with bees wax obtained from the hives of certain stingless bees. Female lays eggs when this cavity is filled with rainwater. Here, the youngs develop relatively free from predators.
- *Rhacophorous schlegeli* prepares small holes on the pond bank. During rains hatching tadpoles are washed down the sloping funnel into pond or river water for further development.

Neoteny and paedogenesis

- The term neoteny and paedogenesis are not synonyms to each other. They are basically different evolutionary processes.
- **Paedogenesis** (or paedomorphosis) refers to the development of gonads and/or production of young ones by an otherwise immature, larval or preadult animal *e.g.* gall fly, liverfluke, salamanders.
- **Neoteny** refers to the retention of a larval or embryonic trait in the adult body due to lack of metamorphosis.
- *E.g.* retention of embryonic cartilaginous skeleton in adult in chondrichthyes and larval gills in some adult salamanders.
- Thus, neoteny emphasises the retention of embryonic or larval features in the adult body whereas paedogenesis stresses precocious development of gonads in larval body.

- Axolotl represents the classical and most informative example of neoteny and paedogenesis because of the absence of iodine in water or abundant supply of water or it may be genetical process. 3 pairs of external gills and tail fin are the larval characters which are retained in the sexually mature adult (axolotl).

Table : Important examples of amphibians

Scientific name	Common name	Important notes
		Apoda (Limbless amphibians)
Ichthyophis	Blind worm	• Dermal scales embedded in the skin. • Male copulates with female by protrusible cloaca and thus fertilisation is internal. • Large eggs are usually laid in masses in moist ground near water. • Eggs hatch into tadpoles.
		Urodela (Tailed amphibians)
Necturus	Mud puppy	• Eyes are small without eyelids. • Tympanum absent, 3 pairs of external gills. • Represents a permanent **neotenic larval stage**. (*i.e.* larva is capable to reproduce again). This happens due to lack of iodine in water which causes deficiency of thyroxine hormone. • Unlike axolotl of *Ambystoma*, it cannot be induced to discard its external gills by administration of thyroxine.
Ambystoma tigrinum	Tiger salamander	• Its poisonous skin has round yellow and orange spots all over the body. • Shows both **neoteny** and **paedogenesis.** • Larva is called axolotl.
Salamandra salamandra	Spotted or Fire-salamander	• The terrestrial adult has shining black skin with yellow spots. • Viviparous. • Gills are absent in the adult. • Trunk bears fore and hindlimbs with four fingers and five toes respectively.
Siren lacertina	Mud-eel	• **Permanent neotenic** form showing almost no adult character. • 3 pairs of external gills and 3 pairs of gill slits. • It has no teeth, eyelids and hindlimbs, but only small forelimbs bearing 4 fingers each. • A well developed **vomeronasal organ** is present.

Anura (Tail-less amphibians)		
Alytes obstetricans	Mid-wife toad	• It is found in some European countries (France and Italy) and is 5 to 8 cm long. • It is characterised by having vertical pupil, disc-like, non-protrusible tongue, no teeth on lower jaw, ribs throughout life and no vocal sacs in male. • Males shows parental care by entangling eggs around their hindlegs.
Hyla	Arboreal frog	• Green in colour, **adapted for life on trees**. • Has adhesive pads on the digits for climbing tree. • An extra cartilage between two last phalanges gives them a better grip. • Large vocal sacs help in making a very loud voice which can be heard a long distance.
Rhacophorus	Flying frog	• The limbs are thin and long with well developed webs between the digits. • Webs and flattened body serve as a parachute in gliding from a higher elevation to a lower one.
Rana tigrina	Common Indian bull frog	• Undergoes aestivation (summer sleep) and hibernation (winter sleep). • Moulting and colour changes (called **metachromasis**) are well marked. • Larva of frog called tadpole, undergoes metamorphosis to become adult. • Males have vocal sacs and nuptial pad (used during amplexus which occur in water).
Bufo melanostictus	Indian toad	• They occur in all continents except Australia. • Visits water only for breeding. • They have broad waist, short hindlimbs, harsh warty skin, ridges on head. • Mouth does not contain teeth. • Secretions of its skin glands contain **bufotalin**, **bufonin** etc. which probably have the healing property. • Since it bears poisonous glands (parotoid glands), it is generally not eaten by other animals like snakes, birds etc.

Economic importance of amphibia

- Nearly all amphibians are beneficial to mankind but frogs and toads are of special economic importance.

Scientific study

- Frogs are dissected in laboratories.
- They are also used extensively for physiological experiments, human pregnancy tests, pharmacology and as fish bait.
- Mud puppies (*Necturus*) are also dissected in U.S.A., while the newt *Diemictylus viridescens* is widely used in research.

As food

- Millions of frogs are consumed as food by gourmets in U.S.A., Japan and many other countries.
- Other edible amphibians esteemed as food are *Necturus* and axolotls in America and giant salamanders (*Andrias*) in Japan.

Predation

- Frogs and toads are destroyers of noxious insects.
- *Bufo marinus* has been introduced in tropical sugarcane fields to destroy injurious insects.

Medicinal value

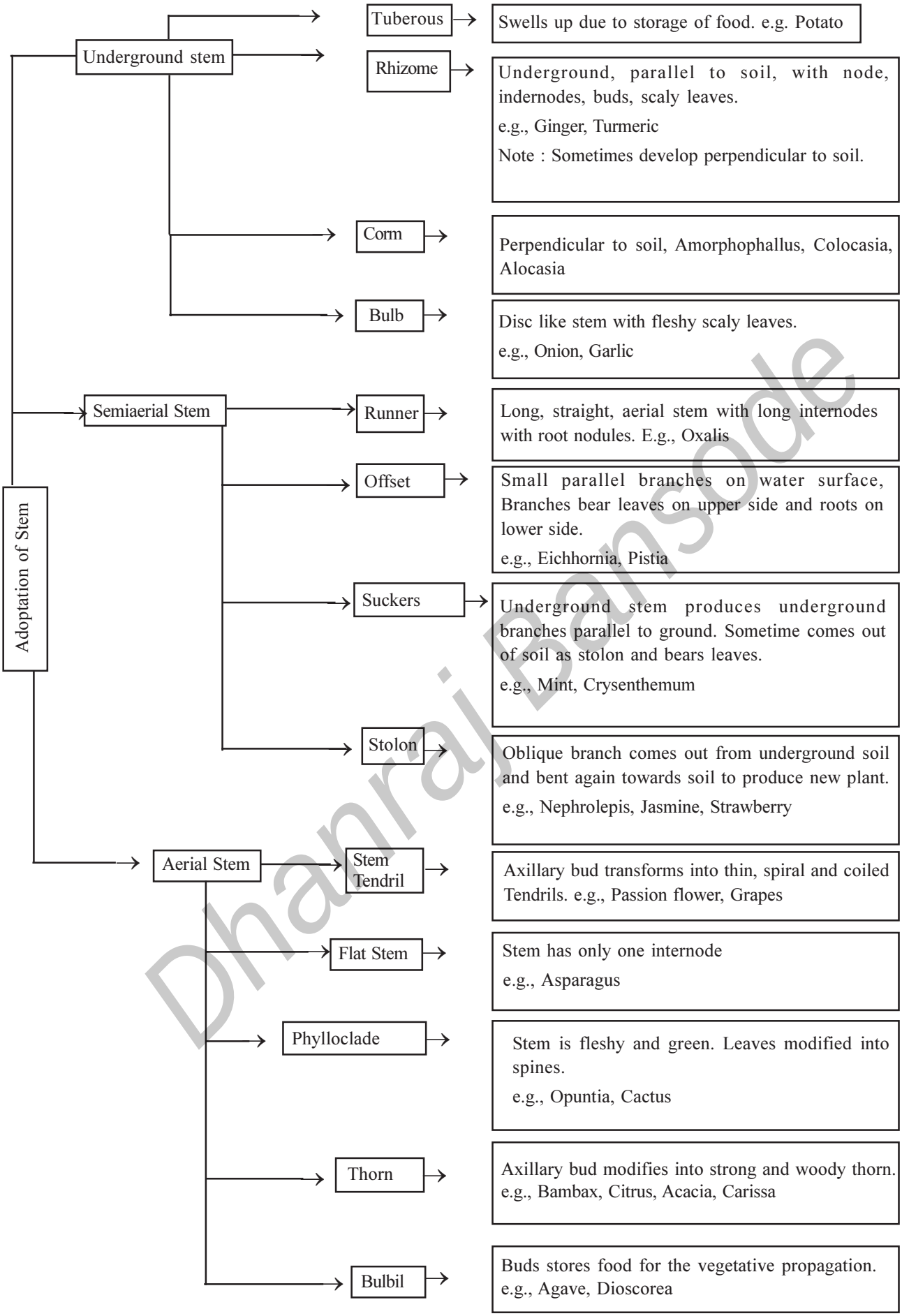
- Toads are used in Chinese medicines.
- Skin of toad secretes a digitalis-like substance that increases blood pressure when injected into humans.

Trade, art and recreation

- Skins of frogs are used for glue, book-bindings and making delicate purses.
- Toads have played a role in the religious beliefs of primitive people since ancient times.
- Tribal magicians in America used parts of frogs and toads in their magic.
- Frogs and toads are kept as pets in household aquaria.

Poisonous Amphibia

- A wide variety of irritating toxic compounds are produced by amphibians.
- Poisonous secretions (bufotoxins) of *Bufo marinus* are fatal to dogs and cats.
- Poison of *Dendrobates*, a South-American frog, is used by tribal people to poison the points of their arrows.



Adaptation of Root

Adventitious Root

Food stored Fleshy root

This root stores food and swells in different shapes...

- **Fasciculated tuberous root** e.g., Asparagus, Dahlia
- **Tuberous root -** e.g., Sweet potato (*Ipomoea batatus*)
- **Nodulose root -** e.g., Melilotus, Curcuma longa
- **Beaded or Moniliform root** e.g., Portulaca, Momordica
- **Palmate -** e.g. Orchid

Support root

It gives mechanical support

- **Prop root -** e.g., Banyan (Ficus, bengalnensis), *Ficus ementica*
- **Stilt root -** e.g., *Zea mays,* Pandanus
- **Climbing root -** e.g., Pothos, Betel

Tap Root

Food stored Fleshy root

It is also swells up by storing food

- **Fusiform root -** e.g., *Raphanus sativa*
- **Conical Tap root -** e.g., Daucus (Carrot)
- **Tuberous root -** e.g., *Mirabilis Jalapa*
- **Napiform root -** e.g., Brassica rapa, Beta vulgaris

Breathing root

Halophytic plants : Produces negatively geotropic root. They bears lenticels or pneumatophores. e.g., Rhizophora, Avicennia, Jussiaea

Butress root

Root develops from basal part of stem and spreaded parallel to soil.

e.g., Terminalia

Root Nonules

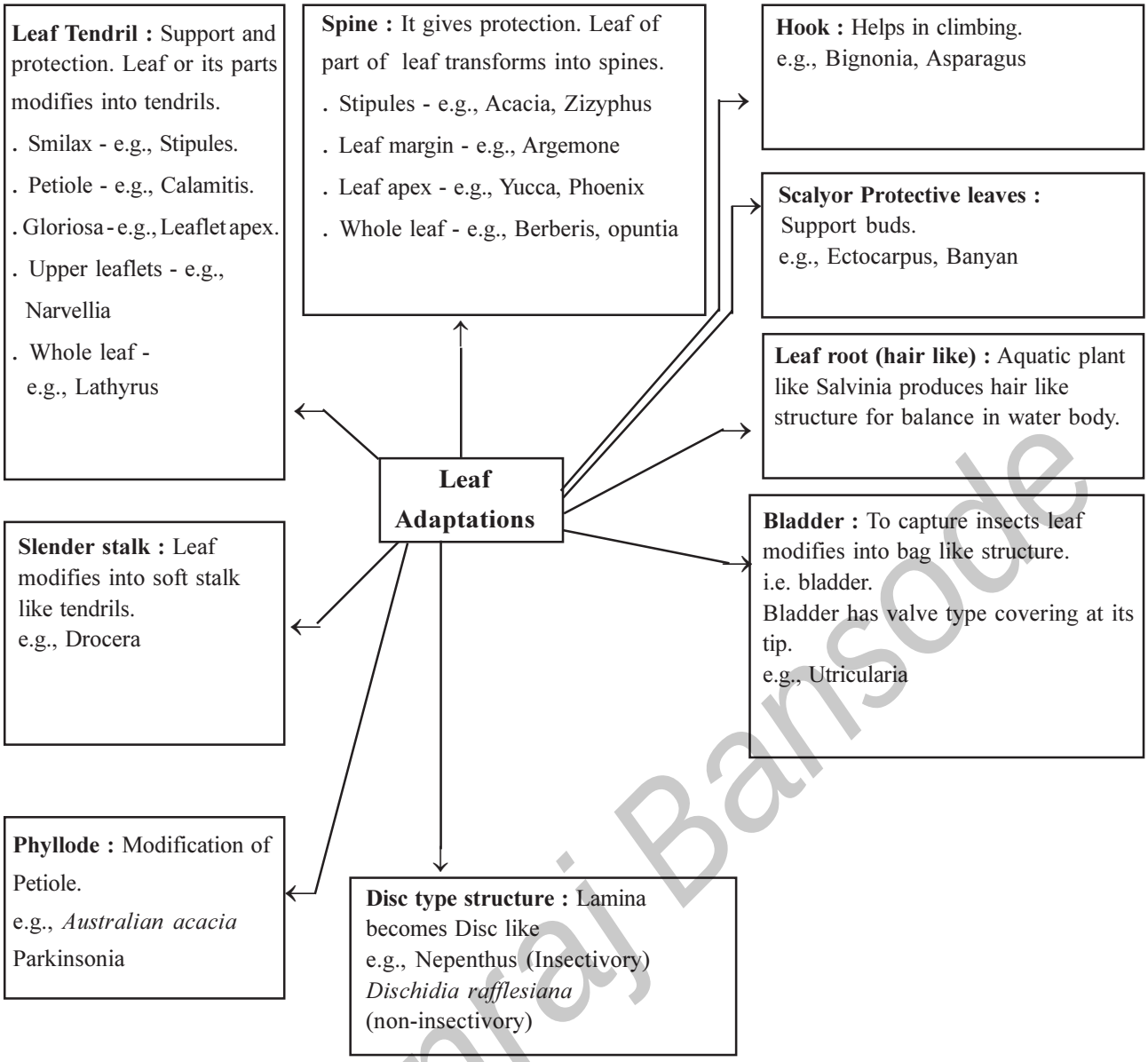
Leguminous plantlet let develops Rhizobium into root nodules.

E.g., Pea, Ground nut, *Cicer arietinum*

Specialized food :

They are performing special functions like photosynthesis, symbiosis etc., according to their functions, they can be classified as under :

- **Assimilory root -** Tinospora, Trapa
- **Epiphytic root -** Orchid
- **Parasitic root -** Cuscuta, Viscum
- **Root thorn -** Pothos ametum
- **Contractile root -** Crocus, *Alium cepa*
- **Microrhiza root -** Pinus



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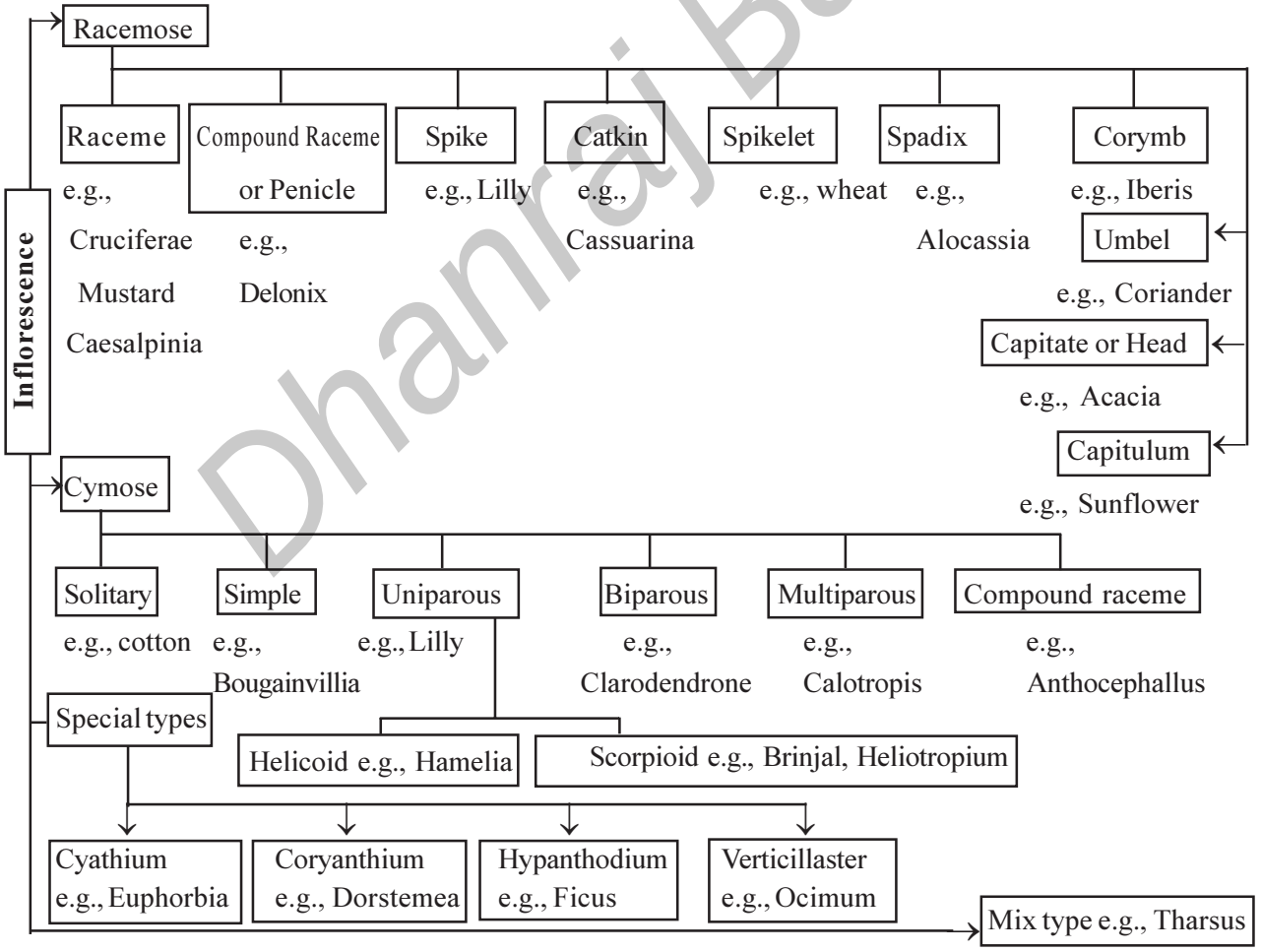
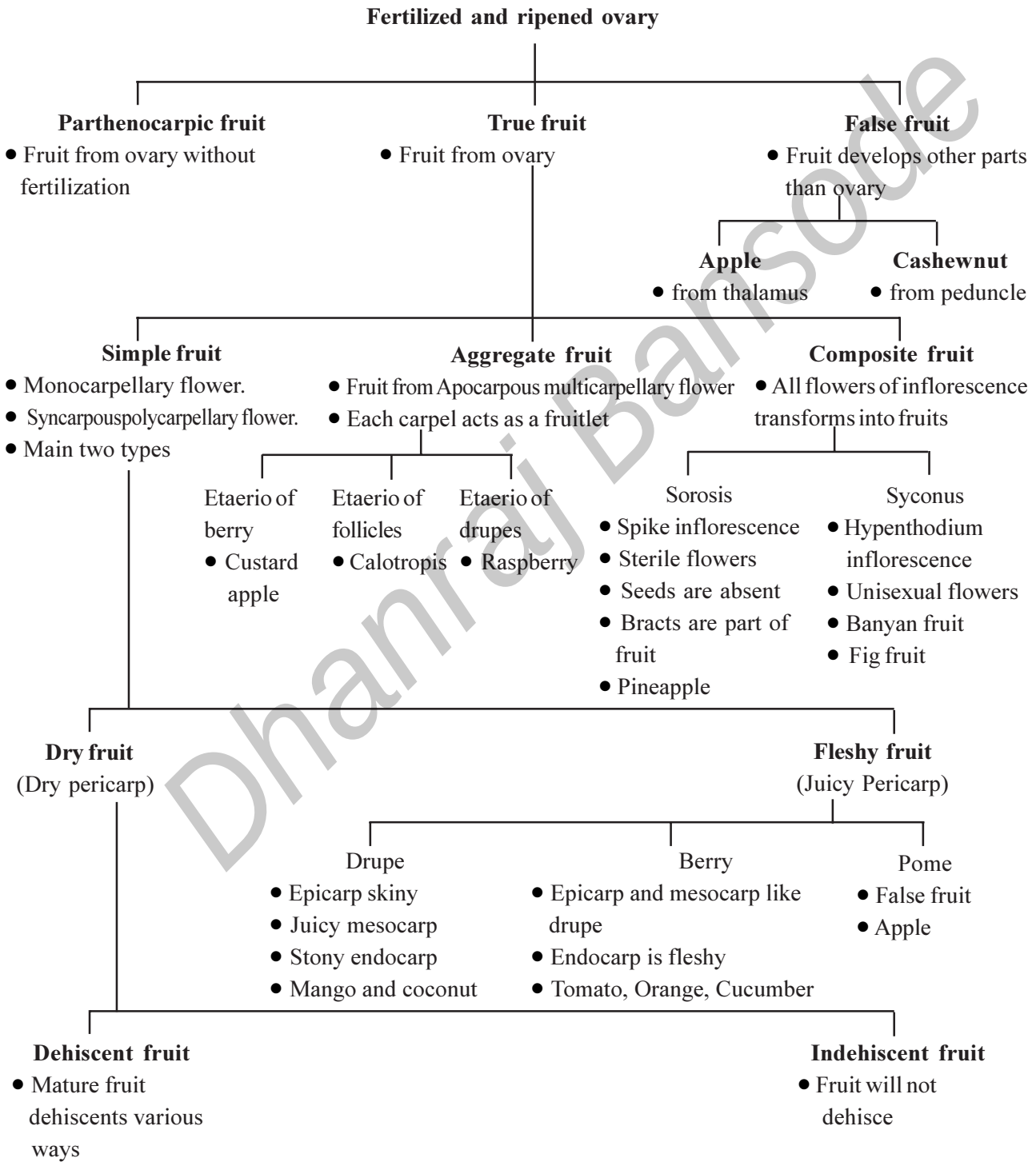


- **Fruit :**



Dry fruit
(Dry pericoarp)

Dehiscent fruit
- Mature fruit dehiscents various ways

Indehiscent fruit
- Fruit will not dehisce

Caryopsis
- Pericarp and seed coat fused to form "HULL" wheat, maize

Achene
- Pericarp and seed coat are free from each other. Naravelia, Ocimum

Nut
- Pericarp is hard and stony. Trapa and cashewnut

Cypsela
- Pericarp and seed coat are free from each other and hairy. Tridax and vernonia

Samara
- Pericarp is flat like a wing. Hiptage, Holoptelea

Follicles
- Fruit dehisces by one suture. Calotropis and vinca

Legumes
- Fruit dehisces by two sutures. Pea and Bean

Capsule
- Fruit dehisces by more than two sutures. Cotton and Datura

Siliqua
- Fruit dehisces from lower part to upper side by sutures. Mustard

Note : Calotropis flowers are bicarpellary. Stigma are joint but style and ovary are free, so that it can be included both in simple fruit and aggregate fruit as well.

- **Seed :**

Fertilized Ovule

According to number of cotyledons

Monocot
(Single Cotyledon)
- Maize, Wheat

Dicot
(Two Cotylodons)
- Pea, Bean

According to presence of Endosperm

Endospermic
- (Food Stored in Endosperm)
  Maize, Castor

Non-Endospermic
- (Food Stored in cotyledons)
  Bean, Pea

- **Structure of Bean Seed :** Hilum is on seed which is meant for connection of seed with fruit. It is flat, kindey shape and yellowish white in colour. It is dicot and non-endospermic seed. It has parts are as under :

Seed

Seedcoat

Testa (outer)
- Tough and yellow

Tegman (Inner)
- Thin and Transparent

Embryo

Two large cotyledons
(White, Fleshy)

Tip of plumule
(It is protected by two papery and minute leaves)

Embryonic axis

(Top) Tip region
- Plumule
  (forms shoot system)
- Region between plumule and cotyledons is known as Epicotyl

Lower region
- Radicle
  (forms root system)
- Region between radicle and two cotyledons is known as hypocotyl

- **Structure of Maize Seed :** It is narrow at one end and broad at other end. It is yellow in colour. Longitudinal section of seed stained with iodine shows purple endospermic region due to storage of starch and embryo is stained yellow due to protein. It has parts as mentioned below :

Endosperm Region

Hull or (Seedcoat and pericarp fused)

Aleurone Protein rich layer

Main large region starch is stored

Between these two regious, enzyme rich epithelial layer is present

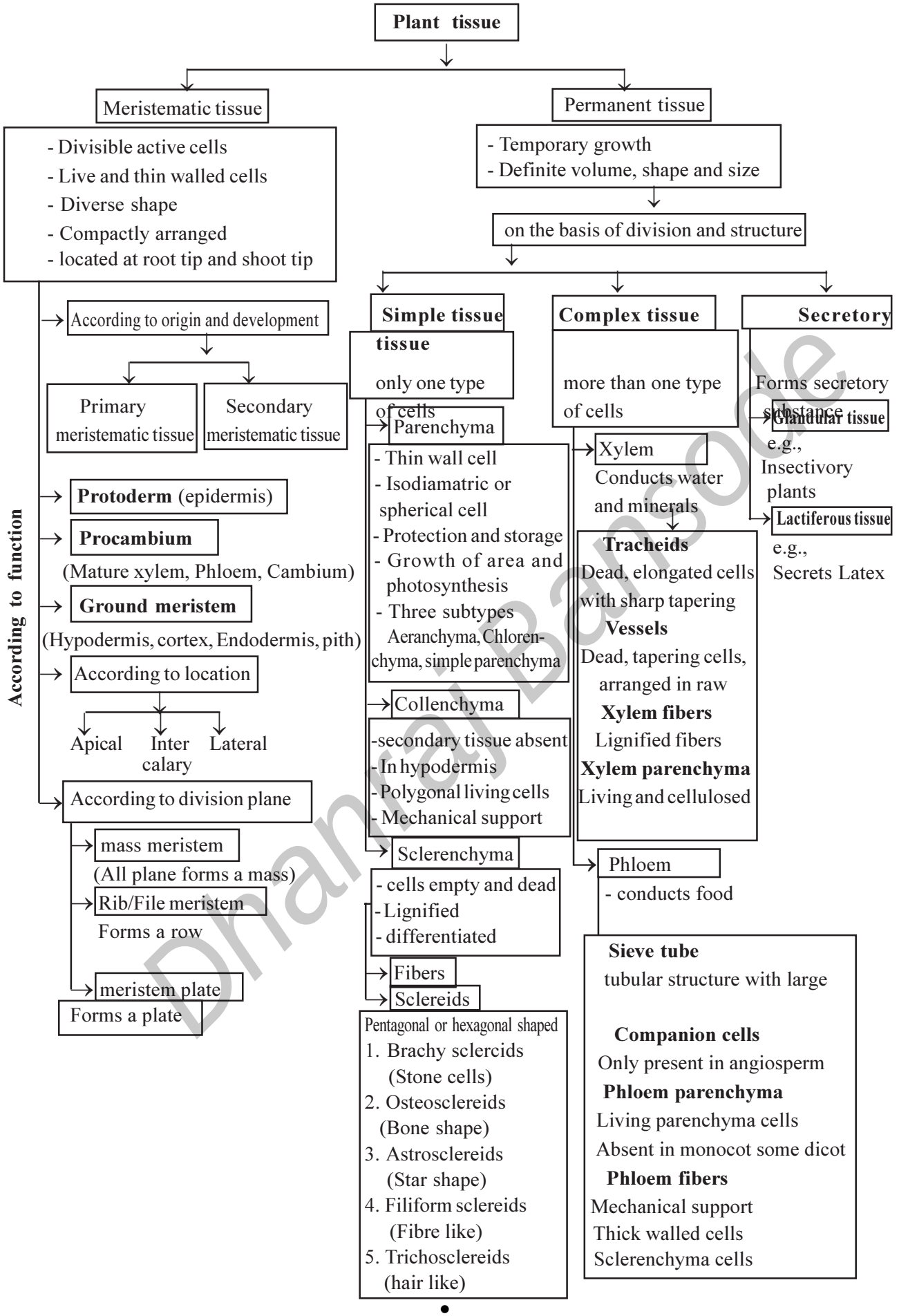
Embryo Region

Shield shaped Scutellum (Cotyledon)

Embryonic axis

Radicle
- Covered with coleorhiza

Plumule
- Covered with coleoptile



- **Anatomy of sunflower and maize stem :**

Region	Layer's name	Maize	Sunflower
(A) Epidermal tissue system	Epidermis	Structure : Unilayered parenchyma, cuticle is present, scattered stomata are present Function: Protection and regulation of transpiration	Multicellular trichomes are present
(B) Ground tissue system	Hypodermis	Structure : 2-4 layers of sclerenchyma Function : Mechanical support	Multilayered collenchyma Flexibility and elasticity
	Cortex	Absent	Structure : Parenchyma with intercellular space, Multilayered Function: Conduction and gaseous exchange
	Endodermis	Absent	Structure : Starch sheath, Inner most layer of cortex Function : control over conduction
	Pericycle	Absent	Structure : Multilayered Alternate parenchyma and sclerenchyma, Hard-bast (Bundle cap) is present above phloem and is schlerenchyma Function: Lateral branches
	Conjuctive tissue	Absent	Structure : Parenchymatous strips from pith to cortex is called medullary rays. Function: Packing tissue or support

	Pith	Absent	Function : support and conduction Structure : Inner most cells of Parenchyma
(C) Vascular tissue system	Vascular bundle	Scatteredly arranged. Small size at periphery and large size toward central part	wavy circular, ring arrangement
		Conjoint, unicollateral and closed - Endarch xylem - Phloem parenchyma absent	Conjoint, unicollateral and open - Endarch xylem - Phloem parenchyma present
		- Lysigenous cavity present	- Lysigenous cavity absent
		- Sclerenchymatous sheath around vascular bundle is present	- Bundle sheath is absent

- **Anatomy of Root :**

(A) Anatomy of sunflower and Maize root : A very thin transverse section of young root of sunflower and maize stained with very dilute solution of safranine, show the structure under the microscope as follows :

	Region	Name of Layer	Maize	Sunflower
(A)	Epidermal tissue system	Epiblema	Structure : Unilayer, barrel shaped cells, parenchymatous tissue, root hairs are present, cuticle is absent Function : Absorption of water and minerals	Like maize root
(B)	Ground tissue system	Exodermis	Structure : Unilayered, parenchymatous tissue, Thick walled. Function : Protection	Absent
		Hypodermis	Structure : Multilayered and sclerenchy matous Function : Mechanical Support	Absent
		Cortex	Structure : Thin walled, parenchymatous, Multilayered, Intercellular space present Function : Conduction and gaseous exchange	Like Maize root
		Endodermis	Structure : Inner most layer of cortex, Unilayesed parenchyma Function : Regulation of conduction	Casperial strips are present on wall of radial endodermis

	Pericycle	Structure : Unilayered, Parenchyma, barrel shaped cells Function : Lateral branch arise from it	Like Maize root
	Conjuctive tissue	Structure : Parenchymatous region between xylem and phloem. It is sometime of sclerenchyma Function : Helps and supports to function of xylem and phloem	Only Parenchyma
	Pith	Structure : Inner most, cells of Parenchyma Function : Support / Storage	Comparatively it is smaller
(C) Vascular tissue system	Stele	Structure : Radial, Alternate, Polyarch, Exarch xylem. Function : Conduction of water - mineral and food	Alternate, Radial, Tetrach, Exarch xylem

Note : Stele includes pericycle, Vascular bundles and pith. In exarch type of xylem, protoxylem remains towards pericycle and metaxylem remain towards pith.

ANIMAL TISSUES

Epithelial tissues
- One or more layers.
- Outer and inner layer of organ or body.

Simple Epithelium
- **Squamous** mosaic files like flat and single layer, polygonal cells
- **Cuboidal** Small, cube, shapecells, Villi at free end of cells, Brush like Villi
- **Columnar** Elongated cells like pillar
- **Ciliated** Diverse in shape with nucleus with cilia at free end

Compound Epithelium
- Keratinised, non keratinised, Transitional tissue is with 4 - 6 layers
- Transitional epithelial tissue :
  - 4 to 6 layers
  - maintains thickness

  It shows re-organisation

Glandular Epithelium
Secretory in nature. In glands

Connective tissues
- Structural frame, support to body.
- Interstitial liquid, cells and fibers.

Semiliquid/Semi solid
- **Areolar tissue** Connects different body parts
- **Adipose tissue** Eye ball and around kidney for absorption
- **Tendor** Joins muscle to bone
- **Ligament** Joins bone to bone

Supportive skeletal tissue
- **Cartilage tissue** Semi-solid matrix, Hyaline, Fibrous, Caclified and Elastic
- **Bones** Hardest tissue, Solid matrix, Bony and spongy bones

Liquid tissue
- **Blood** Red liquid, RBCs, WBCs platelets
- **Lymph** Pale yellow, Blood plasma and WBCs

Muscular tissues
- Contractive
- Becomes active by electricity
- Helpful in movement

- **Skeletal muscle** Elongated and unbranched muscles. Joined with bones.
- **Smooth muscle** Elongated and spindle shape fibers. Involuntary muscles. Visceral muscles.
- **Cardiac muscle** Elongated and cylindrical fibers. Never get fatigue. Antonomous.

Nervous tissues
- Controls the body according to stimulation and body response.
- It has conduction, co-ordination and response.
- Nerve cells, Neuroglial cells, Neuroganglion, etc.

- **Connective tissue** :

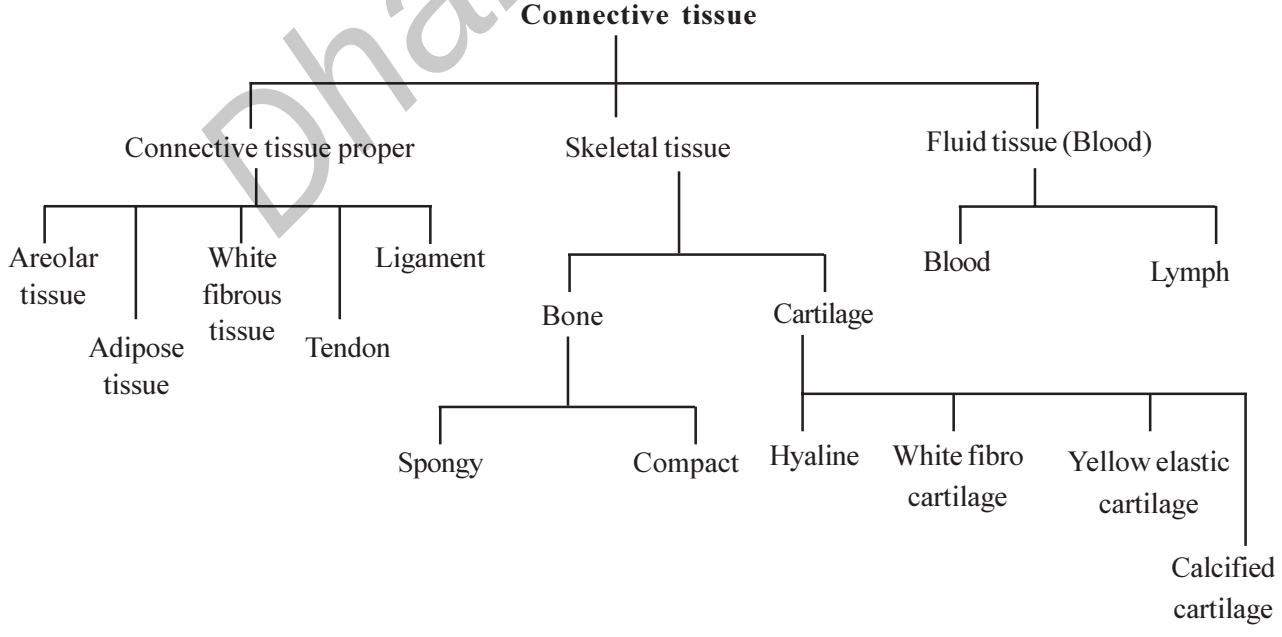
Definition : A tissue which connects together the other tissues of the body.

Features :

- It is the group of cells and matrix containing of intercellular substances secreted by cells themselves.
- Cells are consequently widely spaced.
- They are divisible.
- It forms from mesoderm.

Functions :

- To connect up structures.
- To form packing around organs.
- To replace tissue which have been destroyed by injury.
- To combat foreign toxins.
- To form a supporting framework.



- **Connective tissue** :

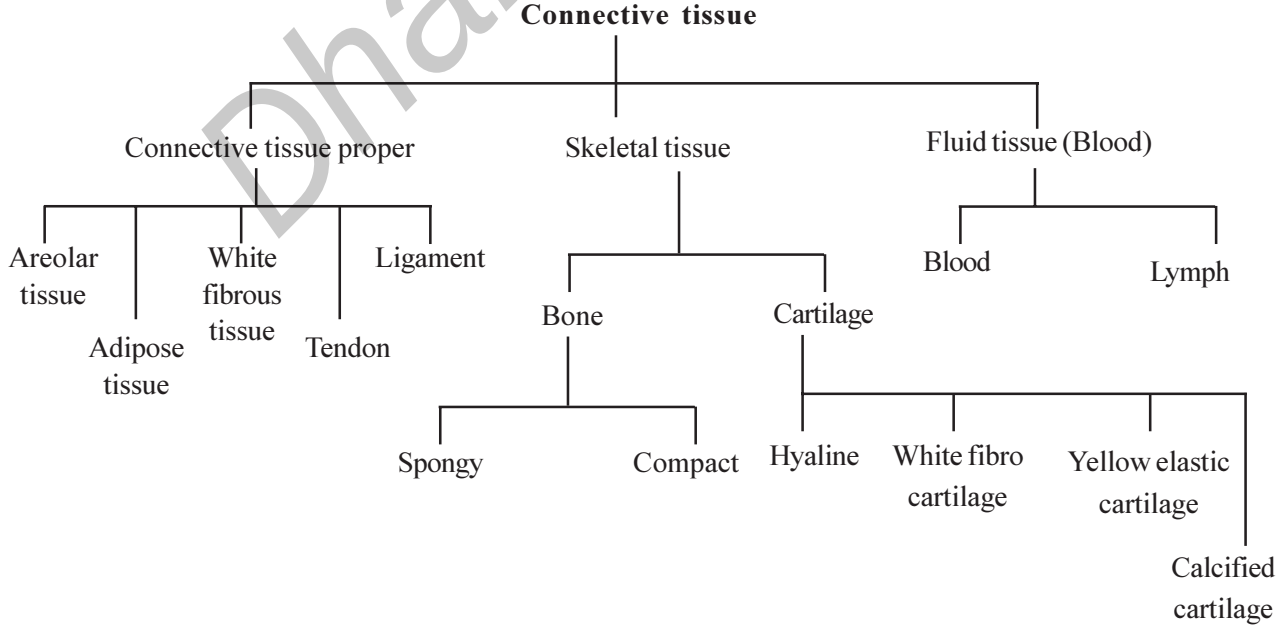
Definition : A tissue which connects together the other tissues of the body.

Features :

- It is the group of cells and matrix containing of intercellular substances secreted by cells themselves.
- Cells are consequently widely spaced.
- They are divisible.
- It forms from mesoderm.

Functions :

- To connect up structures.
- To form packing around organs.
- To replace tissue which have been destroyed by injury.
- To combat foreign toxins.
- To form a supporting framework.



ANIMAL TISSUES

EPITHELIAL TISSUES

Simple Epithelia

Squamous
- Large flat cells.
- Centrally placed flat nuclei.
- Help in protection, gas exchange, excretion, secretion, etc.
- Found in blood vessels (endothelium) coelom (mesothelium), etc.

Ciliated
- Cilia bearing cells.
- Centrally placed round nuclei.
- Helps to maintain CSF, urine and mucus flow in one direction.

Ciliated Columnar
- Columnar cells.
- Found in Fallopian tube, brain ventricles, etc.

Ciliated Cuboidal
- Cuboidal cells.
- Found in certain parts of kidneys.

Cuboidal
- Squarish cuboidal cells.
- Centrally placed round nuclei.
- Helps in protection, secretion, gamete formation, etc.
- Found in ovaries and seminiferous tubules (germinal epithelium), salivary ducts, etc.

Pseudostratified
- Unequal columnar cells.
- Centrally placed oval nuclei in long cells and round nuclei in small cells.
- Helps in protection, secretion, etc.

Pseudostratified Columnar
- Columnar cells
- Found in olfactory mucosa, male urethra, etc.

Pseudostratified Columnar Ciliated
- Cilia bearing cells
- Found in trachea, large bronchi, etc.

Columnar
- Elongated cells.
- Elongated nuclei near the base.
- Helps in protection, secretion, etc.
- Found in various glands (glandular epithelium), stomach, pancreatic lobules, etc.

Compound Epithelium

Transitional Epithelium (urothelium)
- Consists of 4-6 layers of cells.

Stratified Epithelium
- Consists of two to many layers of cells.

Stratified Cuboidal
- Outer layer possesses cuboidal cells and basal layer comprises columnar cells.
- It forms the epidermis of fishes and urodeles. It also lines sweat gland ducts and larger salivary and pancreatic ducts.

Stratified Ciliated
- Outer layer consists of ciliated columnar cells and basal layer is of columnar cells.
- It lines the larynx and upper part of the soft palate.

Stratified Columnar
- Both the outer and the inner layer comprise columnar cells.
- It lines epiglottis, mammary gland ducts and parts of urethra.

Stratified Squamous
- Outer layer is of squamous cells and inner layer is of columnar cells which undergoes continuous mitotic division, hence, this layer is called germinative layer.
- It forms epidermis of land vertebrates, lines oral cavity, vocal cords, vagina, cornea, etc.

Keratinised
- Forms protective covering against abrasions.
- Is impermeable to water.
- Present in dead superficial cells, epidermis of skin.

Non-Keratinised
- Forms moderately protective covering
- Permeable to water
- Present in superficial living cells
- Lines buccal cavity, pharynx, oesophagus, etc.

CONNECTIVE TISSUES

Proper Connective Tissue
More intercellular material than cells, intercellular material of structural glycoprotein and glycoaminoglycans, matrix is soft containing cells and fibres.

Reticular Connective Tissue
Consists of star-shaped reticular cells.

Pigmented Connective Tissue
Consists of irregular pigment cells or chromatophores.

Loose Connective Tissue
Loosely arranged cells and fibres in matrix.

- **Areolar Tissue**
  Contains small spaces (areolae) in between the fine threads. Forms the basic framework of body.
- **Adipose/Fatty Tissue**
  Contains fat storing adipocytes, acts as shock-absorber, produces blood corpuscles, etc.
  - **White (Yellow) Fat** Monolocular, i.e. single large fat globule present, less energetic.
  - **Brown Fat** Multilocular, i.e. several small fat globules present, iron containing cytochrome pigment is present, more energetic.

Dense Connective Tissue
Compactly arranged cells and fibres in matrix.

- **Dense Irregular**
  Contains fibroblasts and differently oriented fibres (mostly collagen)
- **Dense Regular**
  - **White Fibrous Connective Tissue** Collagen is dominant, tough and inelastic, e.g. tendon.
  - **Yellow Elastic Connective Tissue** Contains loose network of yellow fibres, elastic and branched, e.g. ligaments.

Vascular Connective Tissue
Different cells suspended in the liquid matrix, fibres are absent.

- **Lymph** Pale yellow tissue containing plasma and WBC. Platelets are absent.
- **Blood** Mobile connective tissue containing plasma and blood corpuscles. Platelets are present.

Skeletal Connective Tissue
Forms endoskeleton, supports and protects the body, rigid matrix enclosing few cells and fibres.

- **Bone** Hard, non-pliable tissue containing osteoblasts, osteocytes and osteoclasts, matrix contains 62% inorganic phase and 38% organic phase (ossein).
- **Cartilage** Soft, avascular tissue containing chondrocytes, chondrin (matrix) and aggrecan (core protein).
  - **Hyaline Cartilage** Clear, elastic matrix with less fibres, most prevalent cartilage, found in articular surfaces, embryonic skeleton, etc.
  - **White Fibrocartilage** Firm matrix containing white fibres, strongest cartilage, found in intervertebral discs.
  - **Elastic Cartilage** Matrix contains yellow fibres, found in pinna, Eustachian tube, etc.
  - **Calcified Cartilage** Matrix contains granules of calcium carbonate, hard, found in vertebral column of shark.

MUSCULAR TISSUES

Smooth Muscles	Skeletal Muscles	Cardiac Muscles
• Uninucleate	• Multinucleate	• Uninucleate
• Involuntary	• Voluntary	• Involuntary
• Does not get fatigued	• Soon get fatigued	• Never gets fatigued
• Slow contraction	• Very rapid contraction	• Rapid contraction
• Spindle-shaped and unstriped	• Cylindrical and striped	• Cylindrical and striped

NERVOUS TISSUES

Neurons

On the basis of structure
- **Apolar neurons** Neurons without polarity. No axon and dendrites differentiation. Fibres carry information towards or away from the cell body, e.g. neurons of *Hydra*.
- **Unipolar neurons** Neurons with unidirectional flow of information. Contain one axon and no dendron, e.g. early embryos of invertebrates and vertebrates.
- **Bipolar neurons** Same as unipolar, but one axon and one dendron at opposite poles.
- **Multipolar neurons** Show directional flow of information with one axon and many dendrites, e.g. neurons of nervous system of adult vertebrates.

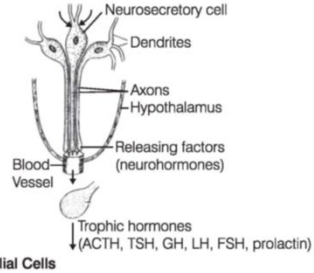
On the basis of function

Sensory or Afferent neurons	Motor or Efferent neurons	Interruncial
• Connect sensory or receptor cells to the CNS	• Connect the CNS to effectors	• Occur only in the CNS
• Conduct sensory impulses	• Conduct motor impulses.	• Serve to connect two or more neurons for distant transmission of impulses.

- Branched or unbranched and naked or capsulated free endings of neurons act as **exteroceptor** in skin epidermis.
- Similar endings in skeletal muscles, joints, ligaments, tendons, etc., serve as **interceptors**.

Ependymal Cells
Epithelial cells lining cerebrospinal fluid-filled ventricles of brain and central canal of spinal cord. Modified ependymal cells form choroid plexus that produces CSF in ventricles.

Neurosecretory Cells
Afferent neural stimuli, secrete and release neurohormones that are released into blood stream

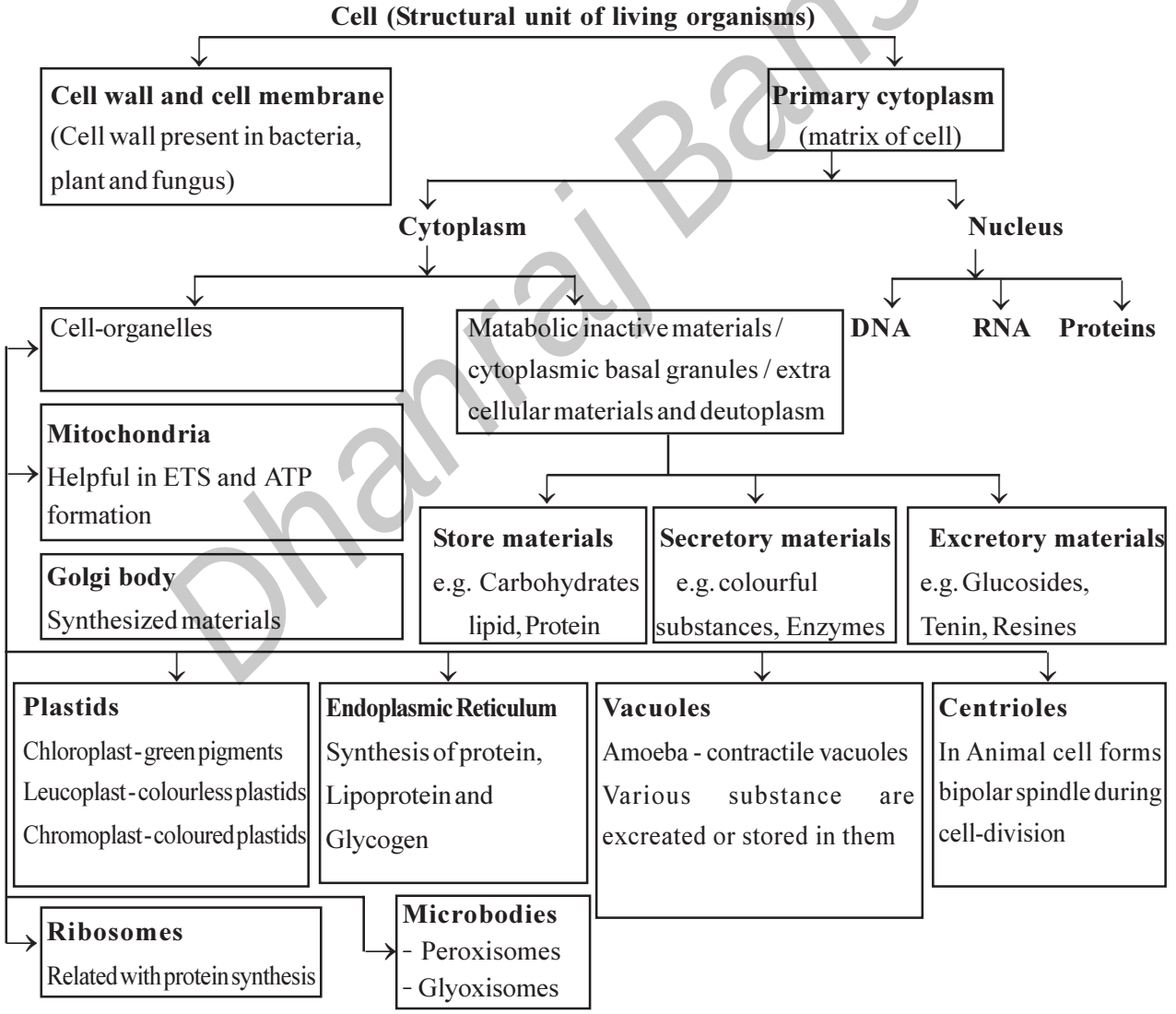


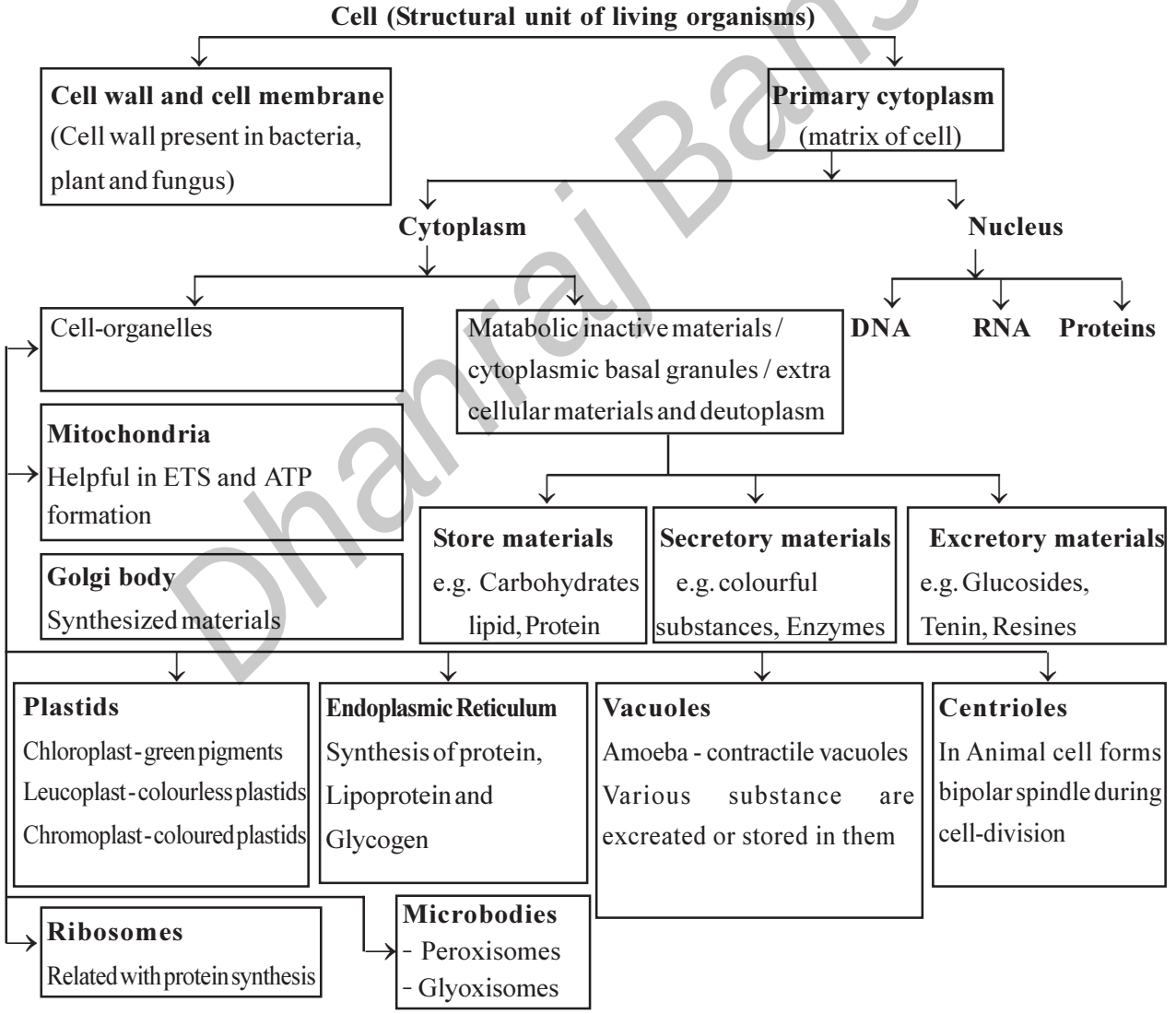
Neuroglial Cells
Supporting cells of brain that do not carry any nerve impulse

Oligodendrocytes
- Cells with few processes
- Play metabolic role in function and protection of myelin sheath in nerve fibre of CNS matter

Microglial cell
- Small cells with two or more finely branched processes
- Specialised macrophages and scavengers of nervous system
- Found diffused in grey and white matter

Astrocytes
- Most abundant supporting cells of CNS
- Provide repair mechanism and replace lost tissue
  - **Protoplasmic astrocytes** Present in white matter
  - **Fibrous astrocytes** Present in grey matter





Biomolecules

Carbohydrates
Hydrates of Carbon, Units are linked by glycosidic bond

- **Monosaccharides**
  Simple sugars,
  All reducing sugars
- **Oligosaccharides**
  Condensation of 2-9 monosaccharides.
  Disaccharides are the common oligosaccharides
- **Polysaccharides**
  Made by joining of many monosaccharides
  - Homopolysaccharides
    e.g., starch, cellulose, glycogen
  - Heteropolysaccharides
    e.g., chitin, pectin, hemicellulose

Proteins

- Most abundant bio macromolecules
- Synthesized from amino acids linked by peptide bonds
- 20 amino acids

- **Primary Structure**
  Sequence of amino acids linked by peptide bonds
- **Secondary Structure**
  Stable arrangement to form structural patterns α - helix and β - pleated sheets
- **Tertiary Structure**
  3D folding of polypeptide
- **Quaternary Structure**
  3D Molecule of protein formed by two or more polypeptides

Nucleic Acids

- Genetic material of all living organisms
- Deoxy ribonucleic acid (DNA)
- Ribonucleic acid (RAN)

- **Sugar (Pentose)**
  Ribose in RNA, Deoxyribose in DNA
- **Nitrogenous base**
  Purines (Adenine and Guanine)
  Pyrimidines (Cytosine and Thymine / Uracil)
- **Phosphoric acid**
  Forms ester linkage during condensation with sugar

Lipids
Water insoluble carboxyl group attached to R-group

- Simple lipids (homolipids)
- Tryglycerides and waxes
- Compound lipids (heterolipids)
  Phospho lipids, Glycolipids, lipoproteins
- Derived lipids, Steroids, glycezol, fatty acid

Enzymes

- Proteinaceous substances; Holoenzyme is made up of apoenzyme (protein part) and cofactor (non-protein part)
- Cofactors are of 3 types : Inorganic ions (Zn, Mg), Prosthetic group (haem, biotin) and coenzyme (NAD^+, $NADP^+$)

Competitive inhibition

- Reversible
- Due to substrate or enzyme analogue
- K_m is increased but V_{max} remains the same Where, Km = Michaelis - Menten constant V_{max} = Maximum velocity

Non-competitive inhibition

- Inhibitor forms a complex with enzyme other than the active site
- V_{max} decreases

Uncompetitive inhibition

- Inhibitor binds to E_S complex
- V_{max} and K_m decrease

Feedback inhibition

- End product or intermediates functions as temporary inhibitor which combines with the regulatory site of the enzyme and thus functions as negative modulator

Interphase (I-Phase)

- Non dividing phase / Preparatory phase / Energy phase
- Also called intermitosis

Cell Cycle

(G_1 Phase)

- Period of maximum growth
- Take place at the end of all division
- RNA and Protein synthesis
- Duration varies from cell to cell

At the end of this phase, cell reaches antephase **(Bullough, 1952)** where it will divide under unfavourable conditions having abundant storage of energy in the form of ATP.

(S-Phase)

- Also called synthetic phase
- DNA Replication
- Duration – 7 hours

After duplication, chromosome of a pair is called chromatids. Pairs are joined by the centromere.

(G_2 Phase)

- DNA synthesis stops
- Macromolecules synthesis
- Nuclear volume increases
- Duration : 2 to 5 hours

(M-Phase)
Actual dividing phase

Involves two types of divisions

Karyokinesis
(Nuclear division)

occurs in 4 main steps

- Prophase
- Metaphase
- Anaphase
- Telophase

Cytokinesis
(Cytoplasmic division)

After division daughter cells enter

Eithter in G_1 phase

Or in G_0 phase (stage when ell cyele is arrested)

- Lajtha, 1963 introduced the term **G_0 phase.**
- Cell which attain G_0 phase does not divide further due to activation of certain genes.
- Now cell grow in size and become differentiated

(M-Phase)

Occurs in

- Plant cell by cleavage and cell plate formation
- Animal cell by cleavage and cell plate formation

Mammalian cartilage diseased cells Paramlecium, etc.

Amitosis

- Also called direct cell division
- Occurs without formation of spindle and appearance of chromosomes.
- No differentiation

Somatic cells → **Mitosis**
It is an equational division in which parent cell divides into 2 identical daughter cells

Germ cells → **Meiosis**
It is reduction division in which diploid parent cell divides into 4 haploid daughter cells

Transportation in Plants

Transport in Plants

- Methods of transport
  - Transport proteins
    - Carrier Proteins
      - Carry the molecules with them
    - Channel Proteins
      - Remain at their place and make entry/exit channel for molecules, may be of two types : ion channels and porins
  - Types
    - On the basis of direction of molecular movement
      - Cotransport
        - Simultaneous movement of two molecules; Symport / antiport occur
      - Uniport
        - Only one molecule either enters / exits the cell at a time
    - On the basis of energy consumption and carriers
      - Diffusion
        - Movement of molecules among the concentration gradient
      - Faciliated Diffusion
        - Movement same as diffusion but requires transport proteins
      - Active Transport
        - Against concentration gradient and required metabolic energy and transport proteins
- Plant Water Relations
  - Imbibition
    - Adsorption of liquid by solid particles without forming solution
  - Water Potential
    - Difference between free energy of water molecules in pure water and that in any other system
  - Osmosis
    - Special type of diffusion of solvent molecules a their concentration gradient through semipermeable membrane; can be two types – Exosmosis and Endosmosis
      - Apoplast
        - Movement through cell wall
      - Symplast
        - Movement through cell cytoplasm
  - Plasmolysis
    - Shrinkage of protoplast after exosmosis
- Pathways of Water Movement
- **Transpiration :** Loss of water vapour from stomata
- **Ascent of Sap :** Sap consists of the mineral nutrients dissolved in water. Upward transport of sap through Xylem against gravity sap is absorbed by root hairs.
- **Phloem transport :** Bidirectional transport of food from source to sink actively

Concept Map

Plant Nutrients

- **Minerals**
  - Nutrients that are absorbed from soil E.g., Fe, Mg, Ca, etc.
- **Non-mineral**
  - Nutrients that are absorbed from atmosphere. These are C, H and O.
- **Essential**
  - Nutrients absolutely necessary for normal growth and development. Their deficiency produces visible symptoms which are nutrient specific.
    - **Microelements**
      - Elements that are present in plant tissues in concentration less than 10 mmole/kg^{-1} of dry matter. They include Mn, Fe, Cu, Mo, Zn, B, CI and Ni.
    - **Macroelements**
      - Elements that are present in plant tissues in excess of 10 mmole/kg^{-1} of dry matter. They include C, H, O, N, P, K, S, Ca and Mg.
- **Non-essential**
  - Required for normal functioning of plant but their deficiency can be supplemented by another elements.

Metabolism of Nitrogen

Gaseous form of nitrogen is unusable by plants it must be 'fixed' into its salts.

- **Nitrogen fixation**
  - **Abiological fixation**
    - By lightning and industries, etc.
  - **Biological fixation**
    - By free living or symbiotic bacteria. Symbiotic bacteria directly provide nitrates to plant. Free living bacteria release fixed nitrogen after their death. They fix N_2 by ammonification and nitrification.
- **Nitrogen assimilation**
  - Incorporation of N into amino acids is called nitrogen assimilation. It is required for protein synthesis. Nitrogen assimilated by plants reaches animals via food chain
- **Denitrification**
  - Denitrifying bacteria work upon dead organisms and release nitrogen trapped in their tissue. Thus released nitrogen re-enters cycling pool. i.e., nitrogen cycle

Essential plant nutrients : their source, relative amounts, functions and classificaiton :

Element	Chemical Symbol	Source	Absorbed Form	Major functions	Relative % in plant
Macronutrients					
Non mineral elements					
Carbon	(C)	Atmosphere	CO_2	In all organic molecules	–
Oxygen	(O)	Atmosphere	O_2	In most of organic molecules	–
Hydrogen	(H)	Soil	H_2O	In most of organic molecules	–
Nitrogen	(N)	Soil	NH^+_4,NO^-_2 and NO^-_3	In protens, nucleic acids etc.	100
Mineral Nutrients					
Phosphorus	(P)	Soil	$H_2\ PO^-_4$	In nucleic acids, ATP, Phospholipids etc.	6
Potassium	(K)	Soil	K^+	Enzyme, activation, water balance, ion balance	25
Sulphur	(S)	Soil	SO_4^{2-}	In structure of coenzymes ionic balances	3
Calcium	(Ca)	Soil	Ca^{2+}	Affects the cytoskeleton, membranes and many enzymes, second messenger	12.5
Magnesium	(Mg)	Soil	Mg^{2+}	In structure of chlorophyll and many enzymes, stabilizes ribosomes	8
Micronutrients					
Iron	(Fe)	Soil	Fe^{3+}	In active site of many redox enzymes and electron carriers, In chlorophyll synthesis	0.2
Chlorine	(CI)	Soil	CI^-	In photosynthesis, ionbalance	0.3
Manganese	(Mn)	Soil	Mn^{2+}	Activation of many enzymes	0.1
Boron	(B)	Soil	$H_2BO^-_3$, $H_2BO_3^{-2}$	Carbohydrate transport, Cell wall component	0.2
Zinc	(Zn)	Soil	Zn^{2+}	Enzyme activation, auxin synthesis	0.03
Copper	(Cu)	Soil	Cu^{2+}	In active site of many redox enzyme and electron carriers	0.01
Molybdenum	(Mo)	Soil	MoO^{3-}_4	Various process of nitrogen fixation	0.0001
Nickel	(Ni)	Soil	Ni^{2+}	Required for iron absorption	
Sodium	(Na)	Soil	Na^+	Involved in osmotic (water movement) and ionic balance in plants	
Cobalt	(Co)	Soil	CO^{2+}	Required for nitrogen fixation in xeguminous plants	
Silicon	(Si)	Soil	Si^{4+}	As a component of cell walls	
Vanadium	(V)	Soil	$V^{3+,4+,5+}$	Necessary for the activation of nitrogenase in the nitrogen fixing bacteria	

Photosynthesis

Formation of glucose from Co_2 and water in the presence of sunlight and chlorophyll

Factors affecting Photosynthetisis

- External Factors: Light, Co_2 conc, temperature, Water, O_2 etc.
- Internal Factors: Chlorophyll conc, leaf age, phytohormones, etc.,

Site of photosynthesis

Chloroplasts that consists of Stroma, Grana stacks, Thylakoids and stroma lamellae.

Thylakoids contain Photosynthetic pigments.

Photosynthetic Pigments

Photosynthetic pigments include Chlorophylls, Carotenes and phycobilins. These pigments are packed in two major pigment system.

- P_{S-I}: Includes P_{700} as photocentre and light harvesting complex (LHC) with electron carriers
- P_{S-II}: Includes P_{680} as photocentre and LHC

Photosynthetic Mechanism

An enzymatic anabolic reaction involving many intermediates

Photochemical Phase

Light dependent phase occuring in Thylakoids

Photolysis

Water molecule is broken down into H^+ and OH^- ions by absorbing light energy. It produces e^-

Photophosphorylation

Electons released in photolysis of water are used for production of ATP

- Cyclic photophosphorylation: Only P_{S-I} involves in electron transport and producs only ATP
- Non-cyclic photophos phorylation: Both P_{S-I} and P_S-II involve and produce both ATP and NADPH

Biosynthetic Phase

Light independent reaction that occurs in Stroma

CAM Cycle

In xerophytes, CO_2 is fixed at night. It helps in reducing transpiration.

C_3 Cycle

Also called Calvin cycle. Co_2 combines with RuBP and produces glucose. 3C phosphorlyceric acid is first stable product

C_4 Cycle

Glucose is formed by Co_2 fixation but initial acceptor is PEP in mesophyll calls and first stable product is 4C Oxaloacetic acid. C_4 plants have Kranz Anatomy and are more efficient than C_3 plants.

Photorespiration

Light dependent oxygenation of RuBP and releases CO_2 in photosynthetic cells of C_3 plants.

Gaseous Exchange

It occurs between enviroment and organism according to organism's needs through body surface or special respiratory organs. It does not involve any chemical reaction

Respiration

Liberation of energy from food by chemical breakdown

Cellulor Respiration

Chemical breadown of food substrate mediated by several enzymes to release energy stored in chemical bonds

Respiratory Quotient

Ratio of value of CO_2 evolved to the volume of O_2 consumed in respiration per unit time per unit weight at standard temperature and pressure

Anaerobic Respiration

Respiration that occurs in absence of oxygen It is common in microorganism

Aerobic Respiration

It is more efficient in terms of ATP production than anaerobic respiration. It occurs in mitochondria

Glycolysis

Series of biochemical reactions in which glucose is broken down to pyruvate with the release of usable energy in the form of ATP

Fermentation

Conversion of pyruvate to alcohol and organic acids in the absence of oxygen

Depending upon its products

Alcoholic Fermentation

Eathanol and CO_2 are produced

Lactic acid Fermentation

Only lactic acid is produced

Mixed Fermention

Produces lactic acid ethanol, formic acid and succinic acid

Glycolysis

It is same as that in anaerobic respiration and occurs in cytoplasm

Pyruvate Oxidation

It involves conversion of rlycolysis product pyruvate into acetyle coA that enters next step krebs' cycle. It is also a link reaction as it links glycolysis with krebs' cycle.

Kreb's Cycle

Acetyle CoA is converted to oxaloaccetate by enzymes and can be regained by intermediates. Thus, this the stage of cyclic processes

Terminal oxidation

Culminating step in which the energy of oxidation drives the synthesis of ATP

Electron Transport chain

Sequential arrangement of electron carriers in inner mitochondrial membrane that carry electrons to final electron acceptor i.e., oxygen

Oxidative Phosphorylation

Synthesis of energy rich ATP molecules with the help of energy liberated during oxidation of reduced coenzymes (NADH, FADH) produced in respiration.

Plant growth and development

Growth
- Irreversible permanent increase in size of an organ or its parts or even of an individual call.
- Growth includes 3 phases division, elongation and maturation.

Development
- Includes all changes that an organism goes through during its life cycle from seed germination to senescence. It involves differentitation, dedifferentitation and redifferentitation of cells.

Photoperiodism
It is the flowering response of plants to periods of day/night phytochrome is the receptor pigment.

Vernalisation
Low temperature treatment of plants to decrease the time period of vegetative phase and to promote early flowering.

Growth Rate
Increased growth per unit time is termed as growth rate. It is of two types.

→ **Arithemetic Growth**
After mitotic cell division only one daughter cell continues to divide while other differentates and matures.

→ **Geometric Growth**
Both of the daughter cells of mitotic cell division keep on dividing regularly

Growth Curve
Graphical representation of growth rate of an organism or population.

→ Arithmetic growth curve linear graph obtained by plotting arithmetic growth.

→ Exponential growth curve curved graph showing initial slow growth and later rapid increase in growth which is obtained by plotting a geometrical growh

→ Sigmoid growth curve
S-shaped curve obtained in natural condition where exponential growth is limited or even ceased at later stages. It occurs so because in nature nutrient supply is limited.

Growth Regulators
Chemical substances also called as phytohormones, produced naturally in plants which regulate one or more physiological conditions.

Growth Promoters
Chemicals that increase growth of cells tissues or organs

→ Auxins : Weakly acidic hormone which induces apical dominance, photoropism and geotropism etc., Sequence of amino acids linked by peptide bonds.

→ Cytokinins : Basic hormone which promotes cell division and differentitation along with many other physiological effects.

→ Gibberellins : Weakly acidic hormones with gibbane ring structure. They mainly enhance seed germination, overcome seed dormancy and induce, bolting in rosette plants.

Growth inhibitors
Phytohormones which perform growth inhibiting activities like inducing dormancy and abscission.

→ Abscisic acid - Mildly acidic stress hormone that induces abscision and dormancy.

→ Ethylene - Gaseous hormone which enhances abscision and senesence induces fruit ripening.

Digestion and Absorption

Mouth

ALIMENTARY CANAL

Salivary Glands
(secrete saliva with pH. 6-7)

- **Parotid Gland**
  - Largest salivary gland
  - Lie on the sides of the face
- **Sub lingual Gland**
  - Lie under front part of the tongue
- **Sub maxillary Gland**
  - Lie at the angles of the lower jaw

Oral/Buccal cavity
- Ingestion occurs; food is tasted by the taste buds, moistened with mucus and saliva, masticated by grinding teeth to smaller smaller particles and swallowed.
- Saliva contains salivary amylase which digests starch into maltose.

Pharynx

Gastric glands

Digestive Glands

- **Fundic (oxyntic glands)**
  - Secrete Hcl (oxyntic /parietal cells)
  - Secrete pepsinogen (peptic / chief cells)
- **Pyloric**
  Secrete Mucin
- **Cardiac glands**
  - Secrete mucin and very little pepsinogen

Oesophagus
- Oral cavity leads through pharynx into tube-like oesophagus.
- Food is pushed through the oesophagus by involuntary muscular movement called peristalsis.
- No digestion occurs here.

Liver
- It secretes bile which contain bile salts, bile pigments (bilirubin and biliverdin, cholesterol and phospholipids.)
- Bile salts and phospholipids help in the digestion of fats in the smal intestine by emulsification.

Stomach
- Widest organ of the alimentary canal; acts as food reservoir.
- The gastric glands of the stomach secrete gastric juice which is thoroughly mixed with food.
- Mostly protein digestion occurs in stomach, carbohydrate digestion gets inhibited due to highly acidic medium.

Pancreas
- Pancreatic juice contains $NaHCO_3$, trypsinogen, chymotrypsinogen, procarboxy peptidase, Amylase, DNAase, RNAase, lipase and helps in digestion of protein, carbohydrate, nucleic acids and fats.

Small intestine
- Largest, narrow, tubular part of the alimentary canal.
- It is divisible into 3 parts - Duodenum, Jejanum and ileum.
- Secretion from intestinal glands called succus entericus acts on all types of food.

Intestinal glands
- They lie in the wall of the small intestine and are of two types : Crypts of Lieber Kuhn and Branner's glands.
- Crypts of Lieberkuhn secrete enzymes and mucus and Brunner's glands secrete alkaline watery fluid, a little enzymes and mucus.
- Intestinal juice contains aminopeptidases, dipeptidases, amylase, maltase, dextrinase, sucrase, lactase, lipase, nucleotidases, nucleosidases.

Large intestine
- It is divisible into 3 parts - caecum, colon and rectum.
- Peristalsis pushes the indigestible materials (faccees) of the small intestine into the large intestine or colon.
- As facces enter the rectum, distension of it induces defaection reflex. It is initiated by peristalsis and forces the facces out towards anus.

Digestion by intestinal juice :

$$\text{Dipeptides} \xrightarrow{\text{Erepsin}} \text{Amino acid} \qquad \text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose} + \text{Glucose}$$

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose} + \text{Galactose} \qquad \text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

$$\text{Di and mono glyceride} \xrightarrow{\text{Lipase}} \text{fatty acid} + \text{glycerol}$$

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidase}} \text{Nucleoside} \xrightarrow{\text{Nucleosidase}} \text{Sugar} + \text{Nitrogenous base}$$

- In small intestine complete digestion can occurs. It is alkaline fluid, which is called chyle.
- Huge Mass of water absorption takes place in large intestine.

Role of Hormones in digestion :

No.	Hormone	Secretory part	Function
1.	Gastrin	Wall of stomach	Stimulates gastric gland to release gastric juice.
2.	Pancreozymin (Pz)	Wall of duodenum	Stimulates pancreas to release pancreatic juice and helps in secretion of intestinal juice.
3.	Secretin	Wall of duodenum	Secretion along with pancreozymin stimulates secretion of pancreatic juice and intestinal juice.
4.	Cholecytokinin (cck)	Wall of Duodenum	Stimulates gall bladder to release bile juice.
5.	Enterogastrone Or gastric inhibitory Peptide (GUP)	Wall of duodenum	Inhibits gastric juice secretion and stops stomach churning.

Breathing and Respiration

Human Respiratory System

Respiratory Tract

- It is a passage way for the respiratory gases.
- Gaseous exchange does not occur here.
- It consists of nostrils, nasal cavity, pharynx, larynx, trachea, bronchi and alveoli.

Breathing

- It is withdrawing in air and releasing CO_2 rich air into atmosphere.
- It involves inspiration (inhalation) and expiration (exhalation).
- It is brought out with the help of diaphragm and intercostal muscles on rib cage.

Respiratory Organs

- A pair of lungs which comprise of bronchi, bronchioles and alveoli.
- Alveoli are the primary sites of exchange of gases.

Exchange of Gases

- Alveoli are the primary sites of exchange of gases.
- At alveolar surface, the blood has lower PO_2 and higher PCO_2 than the alveolar air. This results in diffusion of CO_2 out of the blood into the alveolus.
- At tissues surface, blood has more PO_2 than that in the tissues. As a result O_2 from blood diffuses in the tissues and CO_2 from tissues diffuses into the blood.

Transport of Gases

- Blood is the medium of transport for O_2 and CO_2. About 97 percent of O_2 is transported by RBC in the blood. The remaining 3 percent of O_2 is carried in a dissolved state through the plasma.
- Nearly 20-25% of CO_2 is transported by RBCs where as 70% of it is carried as bicarbonate.
- About 7% of CO_2 is carried in a dissolved state through plasma.

Regulation of Respiration

- Respiration is controlled by nervous regulation, mechanical regulation and chemical regulation.
- Nervous regulation involves respiratory centre located in the medulla oblongata and pons Varolii. Respiratory centre is very sensitive to CO_2 in the arteries and to the pH level of blood.
- Mechanical control involves stretch receptors located in the walls of bronchi and bronchioles which get stimulated by overstocking of the lungs and inhibit inspiratory centre.
- Chemical regulation is performed by chemo sensitive area near respiratory centre and chemoreceptors present in the carotid and aortic bodies. They get stimulated by rise in CO_2 of H^+ consentration of blood.

Biology through Diagrams on Anatomy of Respiratory System

Nasal Cavities
External nostrils open into 2 nasal cavities which are separated from each other by a thin, cartilaginous medium vertical partition called **nasal septum.**

External Nose
These are the paired openings that open into nasal cavities. The portion inside nose is called **vestibule** which contains mucus lining and hair epithelium

Pharynx
It provides the passage to both air and food. It comprises nasopharynx, oropharynx and laryngopharynx.

Trachea
Air conducting tube with non-collapsible walls due to the presence of cartilaginous C-shaped, incomplete rings. Their number is 16-17 in humans. It enters into the lungs after their first branching. It helps in the conduction of air as it is lined by pseudostratified ciliated columnar epithelium bearing mucous glands.

Upper Respiratory System

Larynx
It is the uppermost portion of trachea made up of cartilages in humans. Its opening is **glottis**, which is covered by cartilaginous epiglottis. It is called as **voice box** and is more prominent in man (Adam's apple).

Epiglottis
Hyoid bone
Thyrohyoid membrane
Thyrohyoid ligament
Thyroid cartilage
Cricothyroid ligament
Cricoid cartilage
Trachea

Parietal Pleura
Outer membrane
Pleural Cavity
Contain pleural fluid
Visceral Pleura
Inner membrane

Pleurae
Two membranes that covers the lungs. The two membranes encloses a pleural cavity containing pleural fluid.

Right Lung
It has 3 lobes and 2 fissures. It is broader, larger and heavier than the left lung.

Superior Lobe
Divided by horizontal fissure
Middle Lobe
Divided by oblique fissure
Inferior Lobe

Left Lung
Smaller, lighter and narrower than right lung. Possess two lobes and a cardiac notch.

Superior Lobe
Divided by horizontal fissure
Inferior Lobe
Cardiac Notch
(accommodates heart)

Lower Respiratory System

Mediastinum
Partition between the two lungs, includes the pleura of both sides. Contains heart, oesophagus, etc.

Diaphragm
It is a muscular partition that separates the abdominal and thoracic cavities.

Oesophagus
Aorta
Pleural membranes
Both oesophagus and aorta pass through thorax between pleural sacs
Right lung
Left lung
Heart
Right pleural cavity
Pericardial cavity
Left pleural cavity

View of TS of anatomy of lungs

Capillary
Elastic fibres
Type I alveolar cell (for gas exchange)
Endothelial cell of capillary
Type II alveolar cell (surfactant cell) synthesises surfactant
Alveolar macrophage (ingests foreign material)

Structure of alveoli

Cartilago corniculata
Apex
Colliculus
Fovea triangularis
Crista arcuata
Cartilago arytenoidea
Facies anterolateralis
Processus vocalia
Basis
Processus muscularis
Fovea oblongata

Arytenoid cartilage

Cartilago cricoidea
Facies articularis arytenoidea
Lamina
Facies articularis thyroidea
Arcus

Cricoid cartilage (ventral view)

Larynx
Trachea
(the trachea bronchus into two primary bronchi)
Cartilage ring
Left primary bronchus
(the primary bronchus divides 22 more times terminating in a cluster of alveoli.)
Secondary bronchus
Trachea enter into lungs after their branching into bronchus. They are further divided into bronchioles (lobular, terminal and respiratory) which further ends into alveolus.
Bronchiole
Alveoli
Basic functional unit of lung, approx 300 million in number in humans, specialised air filled sacs which are richly supplied with blood capillaries.

Branching of airways

Bronchiole
Bronchial artery nerve and vein
Branch of pulmonary artery
Smooth muscle
Elastic fibres
Branch of pulmonary vein
Capillary beds
Lymphatic vessel
Alveoli
Alveolar sac

Structure of lung lobules

Incisura thyroidea superior
Cartilago thyroidea
Lig. vocale
Rima glottidis (pars intermembranacea)
Conus elasticus
Processus vocalis
Cartilago corniculata
Rima glottidis (pars intercartilaginea)
Cornu superius cartilaginis thyroideae
Lig. cricoarytenoideum posterius

Cri covocal membrance (conus elasticas) and vocal ligaments (ligamenta vocalia)

Blood Vascular System

- It is a circulatory system containing body fluid and pumping organ

Blood Vessels

- They are intricate network of hollow tubes that transport blood throughout the entire body.

Arteries

- They are elastic vessels that transport blood away from the heart

Veins

- They are elastic vessels that transport blood to the heart

Capillaries

- They are extremely small vessels that transport blood from the arteries to the veins. Respiratory gases, nutrients and wastes are exchanged through the capillaries within the tissues

Blood

- It is mobile fluid connective tissue

Plasma

- It is slightly alkaline, non-cellular, pale yellow fluid that constitutes about 60% of the blood

Formed elements

Erythrocytes

- Most abundent cells filled with haemoglobin

Leucocytes

- Colourless cells that show amoeboid movement

Agranulocytes

- Grarnules are not found in cytoplasm and are of two types - Lymphocytes and Monocytes
- They are motile and phagocytic in nature

Granulocytes

- Gradules are present in cytoplasm and are of three types - eosinophils, basophils and neutrophils

Platelets

- They release platelet factors that help in the clotting of blood (or thromosplastin) on injury

Blood Coagulation

- They response to repture of blood vessel or tissue damage, a complex, cascade of chemical reaction occur which results in the formation of blood clot

Heart

- It is a mesodermally derived organ that comprises four complete chamers (two auricles and two ventricles)
- Right auricle receives deoxygenated blood from the body and left auricle receives oxygenated blood from lungs

Heart beat

- Rhythmic contraction and relaxation of the cardiac muscles is known as heart beat

Cardiac Cycle

- It is the sequence of events that occurs in the heart during one full heart beat

Blood cells

Red cell or Erythrocytes or RBC_S	White cell or Leucocytes or WBC_S	Thrombocytes or platelets
50 lac to 60 lac/mm^3 – O_2; CO_2, transport of respiratory gases	4,000 to 11,000/mm^3	- 2.5 to 5 lacs/mm^3 - Essential for reactun of blood clotting

White cell or Leucocytes or WBC_S

Granular		Agranular		
Neutrophil amount	Eosinophils	Basophils	Lymphocytes	Monocytes
3000 to 7000	100 to 400	20 to 50	1500 to 3000	100 to 700
40 to 70 % of total WBCs	1 to 4%	0 to 1%	20 to 45%	4 to 8%
Function : Active phagocytes	– Detoxification – Inflammatory chemicals are inactivated – Kill parasitic microbes	- Play significant role in allergic reaction	In immune system Synthesize and transport antibodies	Active phagocytic

Nitrogenous Excretion

- Depending upon the excretory product, animals show the following types of nitrogenous excretion.

Ammonotelism

- Excretion of ammonia. It is readily soluble, excreted by diffusion.
- Bony fishes, aquatic amphibians, aquatic insects.

Ureotelism

- Excretion of Urea. It is less toxic.
- Mammals, Terrestrial amphibians and Marine fishes.

Uricotelism

- Excretion of uric acid, Its crystals are non-toxic and almost insoluble in water, excreted as pellets.
- Reptiles, birds, land snails and insects.

Human Excretory System

Kidney

- Paired, bean-shaped, dark red in colour
- Two distinct Zones- (i) renal cortex, outer and darker. (ii) renal medulla, inner and lighter, it is made up of 8 to 10 conical renal pyramids.

Ureters

- Ureters are paired smooth muscle tubes.
- They open into urinary bladder and carry urine from the kidney.

Urinary Bladder

- Urinary bladder is a chamber of smooth muscles.
- It stores Urine.

Urethra

- It is the duct that conveys Urine from the bladder to be discharged to the outside of the body.
- Muscular urethral sphincters keep the Urethra closed

Regulation of Kidney

- Juxta Glomaruler Appartus (JGA) is special region formed by cellular modifications in the DCT and afferent arteriole supplying Bowman's capsule.
- JG cells contain granules of the proteolytic enzyme renin which activates renin - angiotensin- aldosterone pathway (RAAS) that loads to activation of angiotensin-II.
- Angiotensin-II increases the synthesis and release of aldesterone.
- Aldosterone causes sodium and water reabsorption by the distal part of the tubules.
- Anti Diuretic Hormone (ADH) or vasopressin from posterior pituitary facilities water reabsorption from DCT and CT.

Nephron

- It is the structural and functional unit of kidney. Each nepharon is made up of Bowman's capsules and tubules.

Bowman's Capsule

- Bowman's capsule enclose a tuff of a glomerular capillaries
- Epithalial cells called podocytes from filtration slits through which ultrafiltration is carried out
- Glemerular filtration occurs due to the pressure gradient between glomerular capillaries and Bowman's capsule.

Tubules

Proximal Convoluted Tubules (PCT)

- PCT is lined bycuboidal epithalial cells.
- About 70-80% of electrolytes and water are reabsorbed in PCT.
- It helps in maintaining pH and ionic balance
- Filtrate is isotonic.

Henle's loop

- Descending limb is permeable to water and impermeable to electrolytes. Filtrate becomes hypertonic.
- Ascending limb is impermeable to water but permeable to K^+, $C1^-$ and Na^+ Filtrate becomes hypotonic.

Distal Convoluted Tubule (DCT)

- DCT absorbs sodium chloride and other inorganic salts while retaining water.

Collecting Tubule

- Entire duct is permeable to water. Water is reabsorbed.

Locomotion and movement

Skelatal Muscle
- Attached to bones, voluntary, exhibit transverse strips hence called striated.

Sarcomere
- Functional unit of contraction. They are delivered by a very thin and comparitively dense Z-line.

Primary Myofilament
- It is formed of myosin protein
- Myosin (thick) filament is a polymerized protein of many monomers.
- Myosin monomer has head and short arm which project outwords at regular distance and angle from myosin filament.
- Head has ATPase and binding site for actin.

Secondary Myofilament
- It is composed of actin and regulatory proteins tropomyosin and tronin.
- In resting state, subunit of troponin masks the active binding sites for myosin on the actin (thin) filament.

Sliding filament theory of muscle contraction

Neural Signal → Ach released → Action potentinal generated → Ca^{+2} released → Binds to troponin → Change in shape exposes active sites → Myosin - actin cross bridges are formed → Myosin ATPase in presence of Ca^{2+} and Mg^{2+} breaks ATP to ADP → Energized myosin cross bridges bind to actin and move → Thin myofilament slide along the thick myofilament

Skeletal System

Each limb contains 30 bones
- Fore limb : 1 humerus
  1 radius, 1 ulna, 8 carpals
  5 metacarpals, 14 Phalanges
- Hind limb : 1 femur,
  1 tibia, 1 fibula, 1 patella,
  7 tarsals, 5 metatarsals
  and 14 Phalanges

Girdles
- Pectoral girdles (4 bones)
- Pelvic girdle (2 bones)
  articulation between axial and appendicular skeletal components

Joints
- Fibrous / immovable joint
  Eq : Joints of skill bones
- Cartilagenous / partially movable joints
  Eq : Joints between vertabrae
- Synovial / freely movable joints
  Eq : Ball and socket joints hinge joints

Skeletal System
Out of total 206 bones of human, 6 bones are present in ears 3 bones in each ear as ear ossicles and remaining are distributed into axial and appendicular skeleton

Axial Skeleton - 80 bones

Skull
- Skull consists of cranium and facial bones
- 22 total bones ; out of these 8 are bones of cranium and 14 are facial bones

Foramen Magnum
- Skull possesses a posterior aperture called foramen magnum.
- Through which the brain communication with spinal cord.

Ribs
- Ribs joins with strenum and form a rib-cage 12 pairs of ribs 1 to 7 pairs are true ribs; 8, 9, 10 pairs are false ribs 11, 12 pairs are floating ribs.

Sternum
- Single flat bone located at mid- ventral region of theracic cavity

Vertabral column
- formed by union of 26 small bones called vertabrae

7 - Cervical vertabrae
12 - Thoracic vertabrae
5 - Lumbar vertabrae
1 - Sacral vertabrae (5 bones join to from 1 bones)
1 - Coccygeal bone (4 bones join to from 1 bone)

Human Neural System

- Neural system performs three basic functions : receiving, processing and responding

Central Nervous System

Brain

- Central information processing organ

Central Nervous system (CNS)

Brain

Central information processing organ

Spinal Cord

- It conducts impulses to the brain and controls most of the reflex activities.

Fore brain

- Fore brain consists of olfactory lobes, cerebrum and diencephalon.
- The largest and complex cerebrum is divided into two cerebral hemisphere, Each one contain frontal, parietal, temporal and occipital lobes.
- Diencephalon contains epithalamus, thalamus and hypothalamus.

Mid brain

- Dorsal portion contains four lobes of corpora quadrigemina which is equivalent to optic lobes of lower animals.

Hind brain

- Cerebellum maintains posture and equilibrium and controls muscular activities.
- Medulla oblongata is cardiac centre, respiratory centre, vasomotor centre and reflex centre
- Pons varolii has respiratory centre pneumotaxic and apneustic centre.

Preripheral Nervous System

- Nerves outside the brain and spinal cord

Cranial nerves

- 12 pairs, 10 pairs from brain stem

Peripheral Nervous System

Nerves outside the brain and spinal cord

Carnial Nerves - 12 pairs, 10 pairs from brain stem

Spinal nerves

- 31 pairs of spinal nevers; (1) cervical nerves-8 pairs, (2) thoracio nerves - 12 pairs, (3) lumbar nerves - 5 pairs, (4) sacral nerves - 5 pairs, (5) coccygeal - 1 pair

- **Human Nervous System :**

Human Nervous System (parts)

- Central Nervous System (CNS)
  - Brain
  - Spinal cord
  - Systemic Nervous System
    - Conduction of nerve impulsions toward skeleton muscles
- Peripheral Nervous System(PNS)
  - Cranial Nerves → Sensory, motor or mixed types ← Spinal nerves
  - Auto nomous Nervous system (ANS)
    - Sympathatic Nervous System (SNS) → Involuntary organs and visceral muscles toward coduct of nerve impulse ← parasympathatic Nervous system(PNS)

- **Central Nervous system :** The CNS consists of the brain and the spinal cord. The CNS has two distinct regions (1) White matter- White in colour and consists of myelienated fibres (2) Gray matter- cyton bodies along with their dendrites and axon.

- Meaninges of Central Nervous System (CNS):

(1) The *inner membrane* is pia matter which is thin highly vascular membrane

(2) Middle membrane arachnoid matter which is a thin transparent membrane but non vascular

(3) The outer membrane is dura matter. The thickest membrane which covers the brain. It is also adherent to the inner surface of cranial bones by fibrous and vascular processes.

- **Human brain :**
  - Weight about 1200 to 1400 gm.
  - Number of neurons is about 100 billions.
  - The brain can be divided into three major parts.
    (1) Fore brain (2) Mid brain (3) Hind brain

(1) Fore brain :

A. Olfactory Lobes : Small, club shaped solid appear- only found in ventral view, covered by cerebral, hemisphere.

B. Cerebrum : The largest parts of brain. - They are separated from each other by a longitudinal cerebral fissure. Two hemispheres are connected by a large bundle of myelinated fibres known as corpus callosum. Surface of the ecrebral cortex is highly folded to increase the area for accommodating more nerve cells. The folds are called gyri and the depression between them are Known as Sulci Three wide and deep sulci are termed as fissures. Which divide each hemisphere into four lobes.

(B1) Anterior frontal lobe: The premotor area fronted lobe controls involuntary movements and autonomic nervous system. The associated area of the frontal lobe is concerned with memory, reasoning,learning and creative ability- control voluntery movements.

(B2) Middle parietal lobe : Associated touch, cold, temperature and pain.

(B3) Posterior occipital lobe : Visual and auditory areas which are centres for hearing and sight. Each cerebral hemisphere encloses a cavity called lateral ventricle, whcih is closed in front but open behind into third ventricle of diencephalon by a aperture known as formen of manro.

(B4) Lateral temporal lobe : Concerned with sound, smell, emotion and memory.

C. Diencephalon : Enclosed a cavity of the third ventricle, the roof of the cavity is known as the epithalamus, the right and left sides are known as thalamus and floor as the hypothalamus. Epithalamus is not formed of nervous tissues, but it is made up of blood vessels possessing folds. Which form anterior choroid plexus. Just behind this the epithalamus forms a short stalk; the pineal stalk and at its tip is a rounded body known as pineal body is present. Pineal body recreates hormone melatonin. The hypothalamus is visible in the ventral view of the brain. The optic nerve originating from the eyes forms acrossing, the optic chiarma in front of the hypothalamus. The hypothalamus is small, possessing 4gm weight. The pituitary is attached to the hypothalamus by a stalk called the infundibulum. The diencephalon encloses a cavity termed as third ventricle which communicates arterially with the lateral ventricle of cerebrum by the foramen of monro and posteriosly with the forth ventricles of medulla oblongata by a narrow passage called the iter which is present in mid brain.

(2) Mid brain- Very small and it consists of four small lobes; the coropora quadrigemia.

Quadrigemia

Upper a pair of lobes

- Superior colliculi

Which receives impulses from the eyes and muscles of head and controls visual reflexes.

Lower a pair of lobes

- Inferior Colliculi

Which receives impulses from the ears and muscles of the head and controls the auditory reflexes.

(3) Hind brain : It is made up by three structures.

Hind brain

Cerebellum

- very large and well developed.
- Two large lateral parts,the cerebral hemispheres and small vormis.
- Branching tree like structure of white matter surrounded by a sheath of greatly folded grey matter.
- Control muscular activities like running, talking and typing.

Pons Varolli

- An oval mass which consists of mainly nerve fibres.
- Bridges the cerebellar hemispheres and medulla oblongata.
- It relays impulses between medulla oblongata, cerebellar hemispheres and between the brain and cerebellum.

Medulla Oblongeta

- It is pyramid shaped.
- The posterior most of the part of the brain that connects the spinal cords.
- It encloses a cavity, the fourth ventricle.
- This ventricle has a very thin non nervous epithelial, folded roof is called postorior choroid plexus.
- Centres for cardiac activities, respiration, vasoconstrictor that control heart beat, breathing, blood pressure salivation, swallowing vomiting, sneezing, coughing and other involuntary fuctions.

Human Endocrine System

Hypothalamus

- Supreme commander of endocrine system.
- Hypothalamic releasing hormones reach the pituitary gland through a portal circulatory system and regulate its secretion.

Thyroid

- It is the largest endocrine gland.
- It secretes two iodine - containing thyroid hormones that control the rate of all metabolic processes.
- It also contains Cells which secrete calcitonin that lowers the blood calcium level.

Pituitary

- Orchestra of endocrine system.
- Regulate the growth and activity of several other endocrine glands.
- It has two main lobes : anterior labe (or) adenohypophysis (or) parsdistalis and posterior lobe (or) neurohypophysis (or) pars nervosa and an intermediate lobe (or) pars intermedia.

Para thyroid

- Two pairs of endocrine glands located behind the thyroid gland.
- They secrete parathormone which acts opposite to calcitonin.

Anterior Pituitary

- Master endocrine gland regulates the activity of several other glands.

Adrenal

- Located above kidneys.
- It has two parts-externel adrenal cortex and internal adrenal medulla.
- Adrenal cortex secretes mineralo corticoids, gluco-rticoids and ganado corticoids.
- Adrenal Medulla is an extension of the sympathetic system. It secretes norcepinephrine and epinephrine.

Posterior pituitary

- Stores and releases oxytocin and vasopression which are actually synthesized by the hypothalamus.

Pineal gland

- Secretes melatonin which helps in regulating sleep wake rhythmic cycle.

Pancreas

- Islets of langerhans is the endocrine region.
- α-cells secrete glucagon, β-cells produce insulin, δ cells secretes somatostatin.

Goanads

- Ovaries secrete estrogen, progesterone, relaxin and inhibin.
- Testes secrete androgens by leydig's cells.
- Pars qntermedia Secretes melanocyte stimulating hormone which imparts skin colouration.

Reproduction in Organisms

Asexual reproduction

- It is the production of offspring by and single parent wihtout the formation and fusion of gametes

Types

- Binary fission
- Budding
- Strobilisation
- Fragmentation
- Gemmae
- Regeneration
- Spore formation

Vegetative reproduction

- Formation of new plants from vegetative units such as buds, tubers, rhizomes, etc.

Natural vegetative reproduction

- Examples are root tubers, suckers, rhizomes, corm, bulbs, runners, stolons, offsets, etc.

Artificial vegetatitive reproduction

- Examples are cutting, layering, grafting, micropropagation, etc.

Sexual reproduction

- it is the process of development of new individual through formation and fusion male and female gametes.
- It is grouped into three distinct stages

Pre-fertilization

- This includes gametogenesis (process of formation of gametes) and gamete transfer.

Fertilization

- It is complete and permanent fusion of two gametes to form a diploid zygote.

Internal fertilizations

Enternal fertilizations

Post-fertilization

- It is described under 2 headings :

Zygote

- It is formed after fertilization in all sexually reproducing organisms.

Embryorgenesis

- It is the process of development of embryo from zygote.

Sexual Repreduction in floweing plants

Flower

Gynoecium (carpels)

- **Stigma** (pollen receiving structure)
- **Style** (tube connecting ovary and stigma)
- **Ovary**
  - ovule present inside the ovary serves as integumented megasporangium.
  - It develops into seed after fertilization

1 Gametogenesis

- Male gametes and female gametes formed inside the male and female gametophyte respectively

Female gametophyte

- The megaspore mother cell divide meiotically to form 4 haploid megaspores. Out of which one remains functional and others degenarate
- Functional megaspore grows in size and divides by mitosis of form 2-nucleated cell forms embryosac, the female gametophyte.
- Each nucleus moves to other poles and divides there twice to form 8 nucleate embryo sac.

Androecium (stamens)

Anther

- It is called as microsporangium.
- It contains sporogenous tissue
- Cells of sporogenous tissue transform into microspore mother cells or pollen mother cells (PMC)
- PMC produce poller grains by meiosis

Filament

Male gemetophyte

- inside the microspore (pollengrain) mitosis occur and 2-celled male gametophyte is formed, large one is tube cell and the small one is generative cell

2 Pollination

- Transfer of 2-celled male gametophyte from anther to stigma of a flower

Self Pollination

- Transfer of pollen from anther to stigma of the same flower or different flower of the same plant

Cross pollination

- Transfer of pollen from anther to stigma of different flower belonging to different plant of same species

3 Fertilization

- Pollen tube along with generative cell and tube cell enters the embryo sac through micropyle (porogamy) chalaza (chalazogamy) or sides (mesogamy),
- Generative cell divides into two by mitosis. Tube cell degenerates, Double fertilization occurs, ie - one male gamete fuses with egg to form 2n-zygote and another male gamete fuses with secondary nucleus to form 3n-endosperm.

Human Reproduction

Primary Sex Organs
- Produce gametes called gonads male gonad testes and female gonad ovaries.

Secondary Sex organs
- Do not produce gametes
- Essential for transport of gemetes fertilizaion etc.
- In males, prostate, seminal vesicles, vasa deferentia, penis.
- In females, fallopian tubes, uterus, vagina and mammary glands.

Male reproductive system

Testes
- Paired structures lying in scrotum.
- Helps in spermatogenesis.

Accessory glands
- Include paired seminal vesicles, a prostate and paired bulbourethral glands.

Female Reproductive System
- Consists of a pair of ovaries along with a pair of oviducts, uterus, cervix, vagina and external genitalia.
- Ovaries help in Oogenesis.
- A cyclic change in the reproductive tract of female occur, which is called menstrual cycle.

Fertilization
- It is the process of fussion of sparn and egg to produce zygote.
- Amphimixis occurs.
- The presence of X and Y chromosomes daternime the sex of the embryo.

Significance
- Restores diploid number of chromosomes
- Initiates cleavage
- Results in determination of sex
- Introduces variation

Pregnancy
- Zygote undergoes repoated mitotic division to form a blastocyst, which is implanted in the uteras resulting in pregnancy.

Embryo Development
- Embryo after implantation differentiates into 3 germinal layered embryo.
- Three germinal layers of the embryo undergo organogenesis.
- By the end of 9th month of the embryo the foetus is fully developed.

Parturition and Lactation
- Parturition is the process of child birth.
- Parturition is induced by neuro-endocrine mechanism.
- Mammary glands differentiates and secrete after child birth.
- New born baby is fed with mother's milk is called lactation.
- Milk produced during initial few days of lactation is called colostrum which is rich with antibodies.

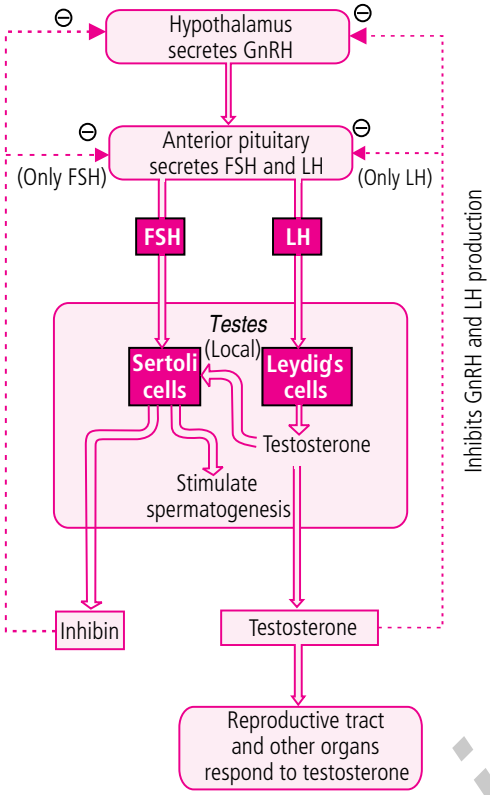


Fig.: Summary of hormonal control of male reproductive system

Gametogenesis in males

- The process of formation of male gametes *i.e.*, sperms is called **spermatogenesis**.
- It occurs in the seminiferous tubules of the testes. The seminiferous tubules are lined by germinal epithelium and Sertoli cells.
- The germinal epithelium consists largely of cuboidal primary or primordial germ cells.

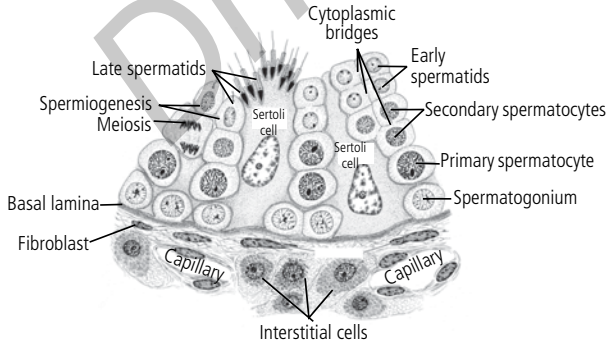


Fig.: T.S. of Seminiferous tubule

Formation of spermatids

- **Multiplication phase:** The undifferentiated germ cells, divide mitotically again and again for a specified number of division cycles to form large number of spermatogonia.
- **Growth phase :** Each spermatogonium actively grows to a larger primary spermatocyte by obtaining nourishment from the nursing cells. The phenomenon of formation of primary spermatocytes from spermatogonia, is called spermatocytogenesis.
- **Maturation phase :** Each primary spermatocyte increases markedly in size and undergoes the first meiotic or reductional division to form two **secondary spermatocytes**. Each of which contains haploid set of (23 in humans) chromosomes. Each secondary spermatocyte undergoes the second meiotic or equational division to form **spermatids**. Thus, each primary spermatocyte, containing 46 chromosomes, produces four spermatids, each having 23 chromosomes.

Formation of spermatozoa

- The transformation of spermatids into spermatozoa is called **spermiogenesis** or **spermateleosis** or differentiation phase.
- The different changes occurring during spermiogenesis are:
  (i) Formation of acrosome by Golgi apparatus. The latter then degenerates.
  (ii) Elongation and condensation of nucleus.
  (iii) Separation of centrioles.
  (iv) Formation of axial filament from distal centriole.
  (v) Development of mitochondrial spiral around upper parts of axial filament.
  (vi) Formation of flagellum.
- The entire process of spermatogenesis, from primary spermatocytes to mature spermatozoa (sperms) takes approximately 64 days in man. The normal human male manufactures nearly 30 million sperms per day. A very high rate of sperm production appears to be necessary to overcome the odds against internal fertilisation.

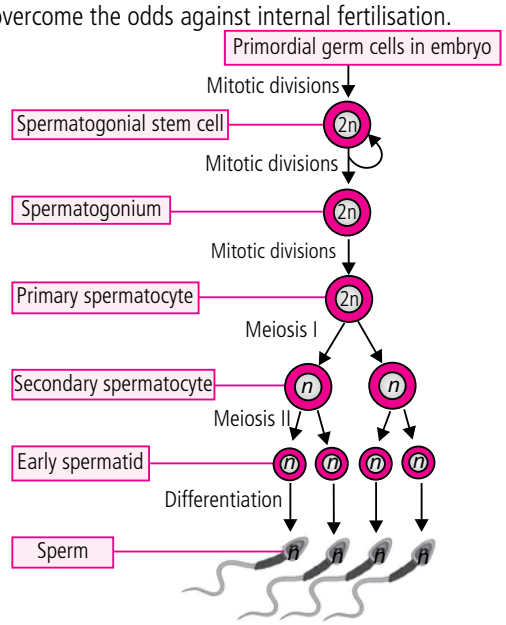


Fig.: Stages in spermatogenesis

- After their maturation, spermatozoa detach from Sertoli cells. The process is called **spermiation**. The released sperms are stored in epididymis and first portion of vasa deferentia for upto one month. Here they gain motility. Nutrition is provided by epithelium of epididymis.

Sperm or Spermatozoon

- Sperm is a microscopic structure composed of a head, neck, a middle piece and a tail. A plasma membrane envelops the whole body of sperm.
- The sperm head contains an elongated haploid nucleus, the anterior portion of which is covered by a cap-like structure, **acrosome**. It is derived from Golgi complex of the spermatid. Acrosome contains proteolytic and lysosomal enzymes popularly called **sperm lysins,** *e.g.*, hyaluronidase, proteases, acid phosphatase. The surface of head contains adhesions (decapacitation factors) which have to be removed before it becomes capable of fertilising an ovum.
- The middle piece possesses numerous mitochondria, which produce energy for the movement of tail that facilitate sperm motility essential for fertilisation.

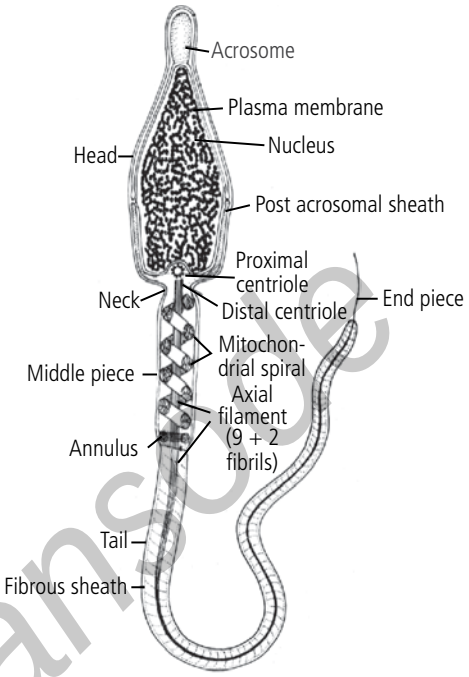


Fig.: A mammalian spermatozoon

Disorders of male reproductive system

Prostatitis
It is inflammation of prostate generally caused by infection. Prostatitis results in perineal or testicular discomfort, mild dysuria and symptoms of urinary obstruction.

Benign prostatic hypertrophy (BPH)
This is the enlargement of the prostate gland. It compresses the urethra, causing frequent night urination (nocturia) or difficult or painful micturition.

Hydrocoele
It is enlargement of testicle due to accumulation of fluid usually in tunica vaginalis.

Inguinal hernia
Tearing of inguinal tissue may result in protrusion of a part of intestine into scrotum.

Prostate carcinoma
It is cancer of prostate. Some symptoms are dysuria, difficulty in voiding, increased frequency of urination or urinary retention.

Impotence
It is the inability of the adult male to achieve penile erection. It can be due to physiological, psychological or neuromuscular defects.

Sterility
Sperms are unable to fertilise the ovum due to low count or less motility.

Cryptorchidism
It is a failure of one or both of the testicles to descend into the scrotum. Cryptorchidism is caused by deficient secretion of testosterone by foetal testes. If spontaneous descent does not occur by the age of one year, hormonal injection is given. Retention of testes in the abdomen results in sterility.

- Ca^{2+} rise initiated by fertilising sperm results in degradation of regulatory unit of MPF through **Anaphase Promoting Complex (APC)** thus promoting completion of cell cycle.
- The first polar body may divide to form two-second polar bodies. Thus from **one oogonium, one ovum** and **three polar bodies are formed**.
- The ovum, is the actual female gamete. The polar bodies take no part in reproduction and soon degenerate due to lack of cytoplasm and food. The formation of non-functional polar bodies enables the egg to get rid of excess chromosomes.

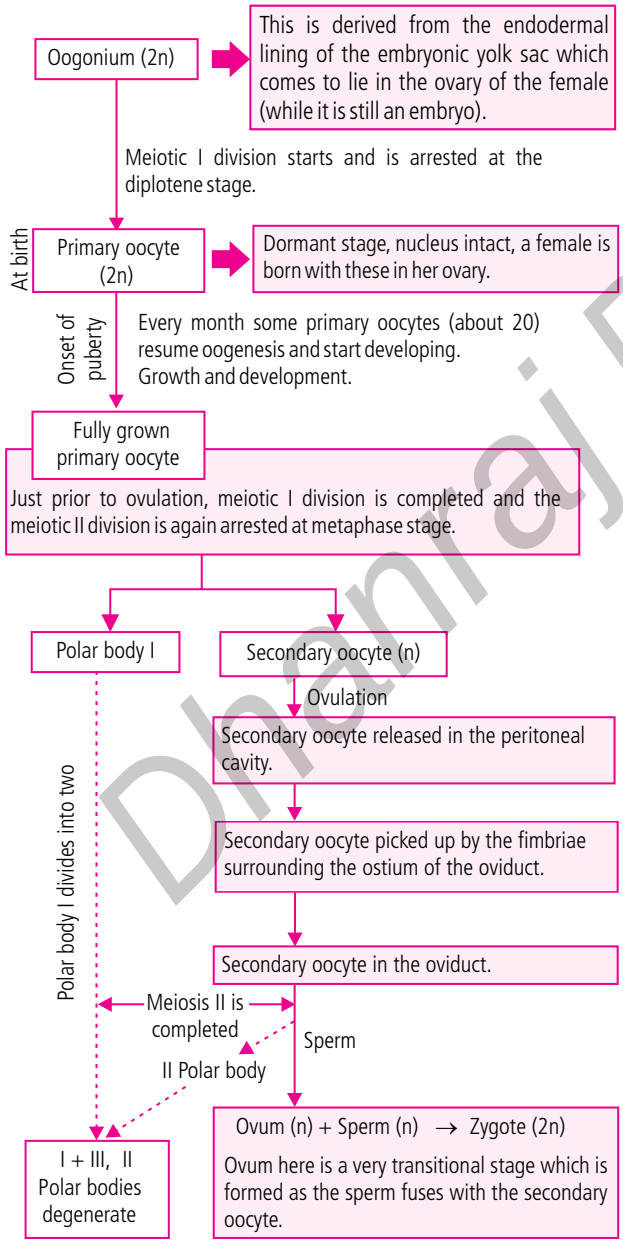


Fig.: Flow chart depicting gametogenesis in females.

Why is the timing of gametogenesis different in males and females?

After primordial germ cells enter genital ridge (the area in vertebrate embryo that develops into gonads), they stop migration, undergo 2-3 further rounds of mitosis and enter a pre-meiotic stage. In the male genital ridge, sperms reverse this process and arrest. But in the female genital ridge, they enter meiotic prophase as primary oocyte and progress through meiosis until diplotene stage, at this time, they arrest. It is suggested that all germ cells, regardless of their chromosomal constitution, are programmed to develop as oocytes and the timing of meiosis seems to be a cell-autonomous property. However, in males, the genital ridge prevents prenatal entry into meiosis. This can be because of a male meiosis inhibitor produced by Sertoli cells.

Menstrual cycle

- The first menstruation begins at puberty and is called **menarche**. In human females, menstruation is repeated at an average interval of about **28/29 days,** and the cycle of events starting from one menstruation till the next one is called **menstrual cycle**.
- The menstrual cycle can be functionally divided into four phases.

Menstrual phase

- It lasts for roughly five days. The first day of menstruation marks day one of new cycle.
- Following the peak of activity on about Day 21, the corpus luteum regresses so that by Day 1 its hormonal production is greatly reduced.
- This rapid estradiol and progesterone (secreted by corpus luteum) withdrawl induces changes in endometrium.
- Blood vessels rupture, causing bleeding. The cast off uterine tissues, blood that oozes from the ruptured endometrial blood vessels, and tissue fluid from the endometrial surface pass out through the vaginal opening. This process is called **menstruation**, or menstrual flow which continues for 3-5 days.
- Lowered levels of progesterone and estradiol also cause release of FSH from the anterior pituitary. This initiates a new cycle.

Follicular phase or proliferative phase

- Reduced concentration of ovarian and gonadotropin hormones, stimulate the hypothalamus to produce GnRH.
- It activates anterior pituitary to produce gonadotropins. In the presence of FSH 6–12 ovarian follicles begin enlargement

to respond or may be resistant to FSH. In this case FSH levels are very high and the estrogen level very low. It occurs between 45 to 55 years (In some individuals it is between 40 to 50 years).

Table : Phases of menstrual cycle

Phases	Days	Events
Menstrual phase	1^{st}-5^{th}	Endometrium breaks down, menstruation begins. The cells of endometrium, secretions, blood and the unfertilised ovum constitute the menstrual flow. Progesterone production is reduced.
Follicular phase (Proliferative phase)	6^{th}-13^{th}	Endometrium rebuilds, FSH secretion and estrogen's secretion increase.
Ovulatory phase	14^{th}	Both LH and FSH attain a peak level. Concentration of estrogen in the blood is also high and reaches its peak. Ovulation occurs.
Luteal phase (Secretory phase)	15^{th}-28^{th}	Corpus luteum secretes progesterone. Endometrium thickens and uterine glands become secretory.

- Since there are no developing follicles, the supply of estrogen and progesterone is reduced. This may lead to temporary depression, hot flushes and other physiological and psychological problems in menopause.
- Other common symptoms are fatigue, vaginal dryness and softening of bones due to loss of minerals particularly calcium.

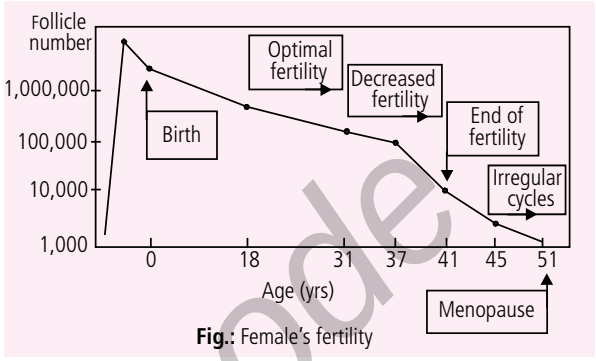


Fig.: Female's fertility

- Menstrual cycle is controlled by **FSH, LH, estrogen** and **progesterone**.
- **Dysmenorrhoea** is painful menses.
- **Menorrhagia** is excessive menstruation.
- **Oligomenorrhoea** is sparse or infrequent menstruation.
- *Amenorrhoea* is non-occurrence of menses.
- *Oestrus cycle* is a series of cyclic changes that are found in the ovaries, reproductive tract and hormones of female nonprimate mammals, *e.g.*, cows, dogs, cats, horse, buffalo. During this period the female receives the male. At the end of oestrus, the lining of reproductive tract is sloughed off. However, there is no menstruation. The sloughed off tissues are absorbed. Oestrus is followed by a passive period called anoestrus.

Disorders of female reproductive system

Breast cancer
Breast cancer is rarely seen before the age of thirty. Its incidence increases after menopause.

Cervical cancer
It is relatively slow-growing cancer. Its main risk is that it is unnoticed until it has invaded other tissues.

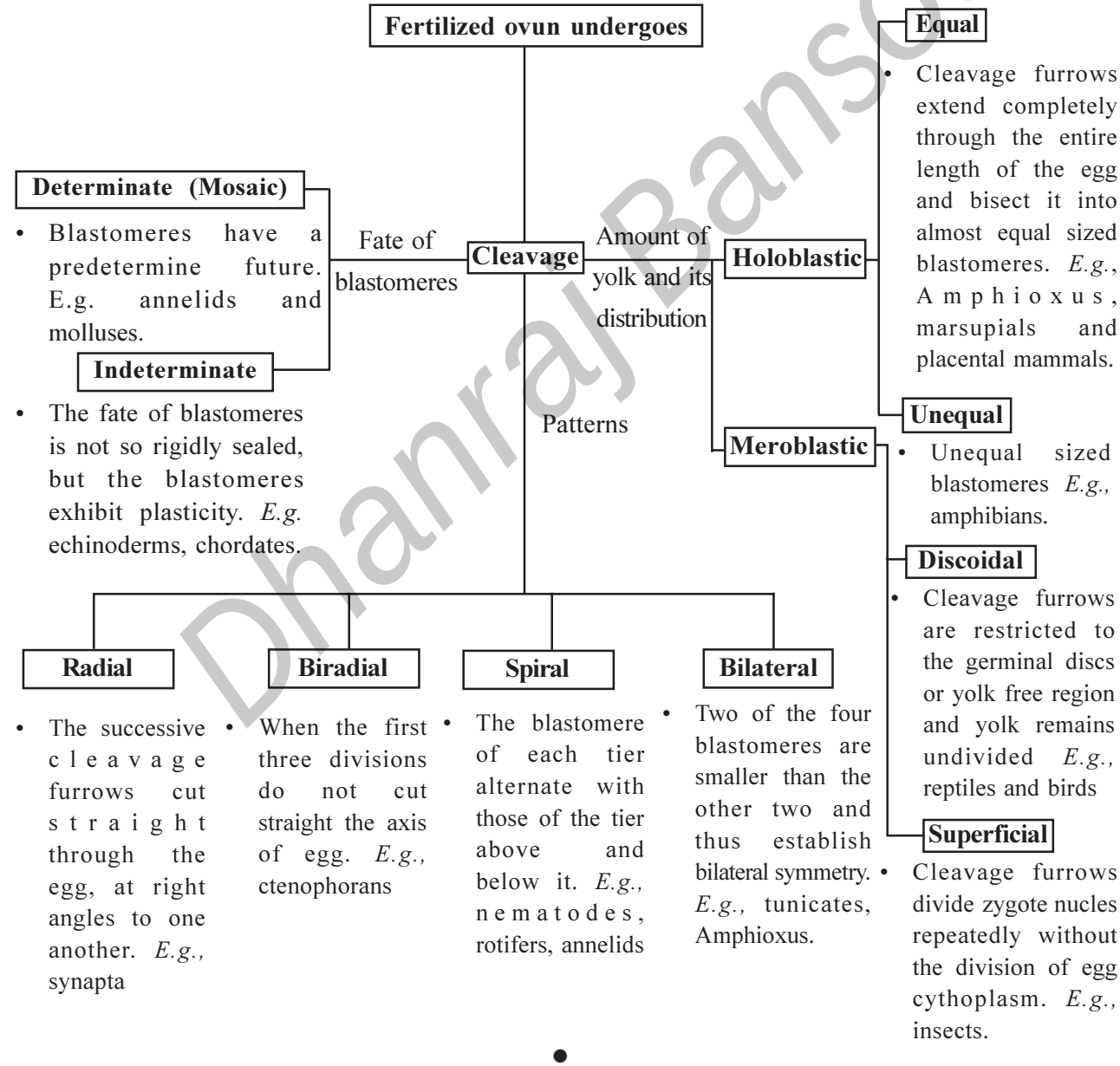
Infertility
Infertility in women is the inability to become pregnant. It may be due to failure to ovulate or to some anatomical factor that prevents the union of egg and sperm.

Oophorocystosis (Ovarian cysts)
Ovarian cysts are fluid filled tumours of the ovary. Such cysts sometimes rupture and regress (get smaller) during pregnancy.

Endometriosis
It is the growth of endometrial tissue outside the uterus. Symptoms include premenstrual pain or unusual menstrual pain.

Ectopic pregnancy
It is implantation of embryo at a place other than uterus, generally in the oviduct.

Oophoritis
It is inflammation of ovary, usually caused by an infection.



CONCEPT MAP

Reproductive Health

Strategies of reproductive health

- It is counselling and creating awareness among people about :
  - → Reproductive organs
  - → Adolescence and associated changes
  - → Safe and hygienic sexual practices
  - → Sexually transmitted diseases
- AIDS, syphilis, genital herpes, genital warts, gonorrhoea, hepatities B etc are some of the diseases transmitted through sexual intercourses with infected person.
- It can be prevented by :
  - Avoiding sex with unknown/ multiple partners.
  - Using condoms during coitus.
  - Early detection and complete treatment if diagnosed with disease.
- Programmes undertaken regarding this are :
  - → Child immunisation
  - → Ban on amniocentesis to legally check female foeticides
  - → Maternity and child health and family planning.

Polulation explosion and birth control

- All around develoment, increased health facilities, better living conditions, these all has resulted in population explosion.
- This can be overcome by motivating smaller families by using contraceptive methods-measures.

Types of contraceptive measures

Temporary methods

- Coitus interruptus
- Lactational amenorrhea
- Condoms, cervical caps etc.
- Foam tablets, jellies, creams etc.
- IUCD
- Pills, norplant etc.

→ **Permanent methods**

- Vasectomy
- Tubectomy

Medical termination of pregnancy

Infertility

- It is inability to conceive or produce children inspite of umprotected sexual cohabitation.
- It can be caused by physical, congenital, immunological or even psychological disorders.
- Specialized **infertility clinics** can help in the diagnosis and proper treatment of some of these disorders.
- However, where such diagnosis and treatment are not possible, the couples can be assisted to have children through certain special techniques called Assisted Reproductive Technologies (ART).
- Assisted Reproductive Technologies (ART) assist infertile couple to have children.
- Some important techniques of ART are :
  - Test tube baby programme
  - Artificial Insemination Techniques (AIT)
  - Gamete Intra Fallopian Transfer (GIFT)
  - Intra Cytoplasmic Sperm Injection (ICSI)

Reproductive Health

POPULATION EXPLOSION AND BIRTH CONTROL METHODS

According to WHO, reproductive health refers to the state of physical, emotional, behavioural and social fitness for leading a reproductive life.

Strategies to Improve Reproductive Health

- Number of programmes have been launched by Govt. of India under the name 'Reproductive and Child Health Care' (RCH).
- Awareness programmes are conducted among people about reproduction related aspects and STD's.
- Providing facilities and support to build up a healthy reproductive society.
- Family planning programmes were launched in 1951 so as to stabilise the population.
- Statutory ban on amniocentesis so as to prevent female foeticide and introduction of child immunisation programmes.

Population Explosion and Birth Control

- The increase in size and growth of human population is called **population explosion.**
- The reasons for high population growth are:
  (i) Rapid decline in death rate.
  (ii) Decline in Maternal Mortality Rate (MMR).
  (iii) Decline in Infant Mortality Rate (IMR).
  (iv) Lack of reproductive health knowledge.
  (v) Some religious belief against birth control.

Some steps to overcome population explosion

- Motivate smaller families by using contraceptive methods.
- Awareness through media, posters/bills–Hum Do Hamare Do.
- Raising marriageable age of girls to 18 years and of boys to 21 years.

Birth Control and Contraception

Birth control refers to the regulation of conception by preventive methods or devices to limit the number of offsprings, while contraception refers to devices or medications followed so as to prevent the likelihood of pregnancy.

Methods of Contraception and Birth Control

Methods	Basis of Action	Note on Uses	Relative Disadvantages
Barrier Methods			
Condom	A thin, strong rubber sheath, prevents the sperm from entering the vagina.	Placed over erect penis just before sexual intercourse.	Not as reliable as the pill. Relies on the male. May tear or slip off.
Femidom	Female condom, a thin rubber or polyurethane tube with a closed end, which fits inside vagina and open end has two fixable rings, one on each end, to keep it in place.	Inserted before intercourse and removed any time later.	Difficult to insert. Can break or leak. Expensive than male condom.
Diaphragm/ Cap	A flexible rubber dome which fits over the cervix and prevents entry of sperm to uterus. Used with a spermicidal cream or jelly (a spermicide is a chemical which kills sperms).	Inserted before intercourse. Must be left in place at least 6 hours after the intercourse.	Suggestion of doctor is must for proper size selection. It requires training to fit. Occasionally causes abdominal pain. It should not be left for more than 30 hours as it may cause toxic shock syndrome. Examination required after every 6 months that cap is of right size.
Spermicide	Chemical which kills sperm.	Placed in vagina to cover the lining of vagina and cervix. Effective for about 1 hour.	High failure rate.
Sponge	Polyurethane sponge impregnated with spermicide, fits over cervix, disposable.	Fits up to 24 hours before intercourse. Leave in place for at least 6 hours after intercourse.	High failure rate.
Hormonal Methods			
Pill	Contains the female sex homones i.e. oestrogen and progesterone. Prevents development of eggs and ovulation by inhibiting the secretion of FSH. Act on cervical mucus to prevent the penetration of sperm. Prevent the blastocyst implantation.	One taken orally each day, during first 3 weeks of cycle. After week 4, menstruation starts and the pill is started again.	Short-term side effects, may include nausea, fluid retention and weight gain. Long-term side effects not fully understood, but increased risk of blood clotting may occur in some women. Not recommended for older women.

Genetics

Branch of biology that deals with study of heredity and variations.

Heredity

Study of inheritance of characters from parents to offsprings

Variations

Difference in traits shown by individual of a species

Caused due to

- Crossing over
- Reshuffling of genes
- Chance combination of chromosomes during maiosis and fertilization

Types

Somatic varition

Variations that occur in somatic cell due to environmental factors or use and disuse of organ or conscious efforts

Germinal variation

variations that occur mostly in germinal cells are inheritable

Causes

Recomobination (crossing over)

Shuffling of genes that occurs as a result of interchange of corresponding parts between the chromatids of homologous chromosomes

Mutations

Sudden inheritable change. They can be spontaneous or induced. Basically mutations are three types.

- **Chromosomal mutations**
- **Genomic mutations**
- **Gene mutations**

Traits

Features (similarities or differences) of an individual

Aquired traits

Non-genetic and non-heritable

Inherited traits

Genetic and heritable

Sex determination

Mechanism by which sex of new born is determined sex of an individual affects inheritance of some traits

Deciding Factors

- Environmental
- Genetic/ Chromosomal

- XX-XY method
- XX-XO method
- ZW-ZZ method
- Haploid Diploid method

Effect on inheritance of traits

- Sex-linked traits
- Sex-limited traits
- Sex influenced traits

Genetic disorders

- Mendelian disorders
- Chromosomal disorders

Inheritance of traits

Inheritance of Traits

Pedigree Analysis

Analysis of a family pedigree to find the movement and distribution of certain genetic traits. It helps to find out dominance or recessive etc., nature of certain genes

Mendelism

Factors = genes are the carriers of traits. Their inheritance follow 3 laws.

Low of Dominance

The allele of a gene shows dominance over other

Law of segregation (or) purity of gametes

Alleles present in a generation retain their purity (do not mix up) and segregate in next generation

Law of Independent Assortment

Alleles of genes for two different characters can assort independent of each other

Chromosomal theory of inheritance

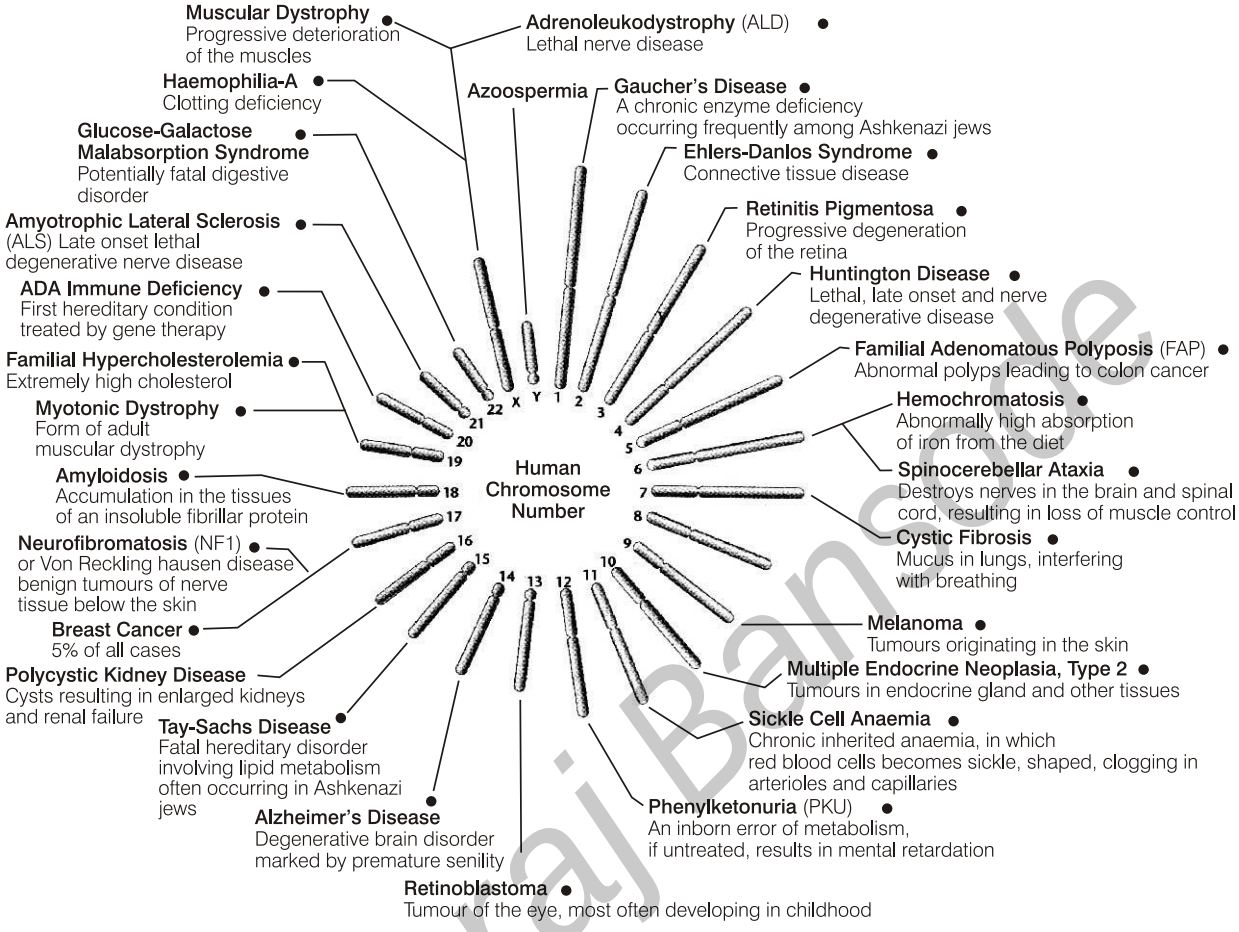
Sutton and Boveri (1902) proposed this theory which states that mendelion factors or genes are located at specific loci on chromosomes and it is the chromosome that segregates and assort indepenently during meiosis

Linkage

Phenomenon of certain genes staying together and their enblock inheritance from one generation to another. This affects in heritance of traits and interferes with independent assortment

- Complete linkage
- Incomplete linkage

Some genetic disorders due to genic abnormalities

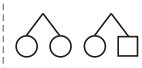
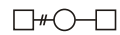
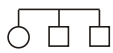


The chromosomes of a human being, showing the location of genes whose abnormal forms cause some of the well known hereditary diseases.

Some of the Major Chromosomal Disorders

Disorder	Autosomal/Sex linked	Symptom	Effect
Down's syndrome	Autosomal, aneuploidy (21-trisomy)	Mongolian eyefold (epicanthus), open mouth, protruded tongue, projected lower lip, many loop on finger tips and palm crease.	Retarded mental development, IQ below 40.
Patau's syndrome	Autosomal, aneuploidy (13-trisomy)	Left palate and lip, polydactyly, anomalies in dermal pattern, abnormalities of face, eye, deformed ears, small chin and cleft lip.	Life span of four months.
Edward syndrome	Autosomal aneuploidy (18-trisomy)	Long narrow skull, small face, short digits, webbed neck, corneal opacity and person keeps fingers tightly clenched against the palm of the hand.	Mentally retarded
Turner's syndrome	Sex chromosomal monosomy 44 + XO	Short stature females (< 5′), webbed neck, body hair absent, menstrual cycle absent, sparse pubic hair, under developed breasts, narrow lips and puffy fingers.	Sterile and hearing problem.
Klinefelter's syndrome	Sex chromosomal aneuploidy (Tri/tetrasomy of X chromosome) 44 + XXY, 44 + XX-XY	These males are tall with long legs, testes small, sparse body hair, Barr body present and breast enlargement.	Gynaecomastia, azospermia, sterile.

Some common symbols used in pedigree analysis

Symbol	Use	Symbol	Use
□	Male		Dizygotic twins
○	Female		
◇	Sex designated or unspecified		Monozygotic twins/Identical twins
	Adopted		No offspring
	Pregnancy		Patient initating genetic workup (proband, index case and consultant)
	Deceased		Two matings
	Affected with trait		Normal trait
	Carrier for trait		Recessive allele
	Carrier for X-linked trait		Death
	Mating		Heterozygous condition is sometimes shown by solid or darkening in half of the symbol
	Consanguineous mating		
	Siblings		
	Number of children		
	Divorced or separated		
	Miscarriage, SAB		Still death

Roman numerals–Generation, English numerals–Different members of one generation, Horizontal line between symbols–parents, Horizontal line above the symbols–Offspring, Vertical line–Progeny

Human Genetic Disorders

- Genetic disorders are all genomic mutations.
- In humans, genetic disorders can be categorised as :
  (i) Human genetic disorders due to chromosomal abnormality (chromosomal disorders).
  (ii) Human genetic disorder due to genic abnormality.
- Chromosomal disorders are due to absence or excess of abnormal number of chromosomes.

Human Chromosome

- In 1956 **Tijo** and **Levan** reported correct number of human chromosomes, i.e. $2n = 46 = 23$ pairs (22 pairs of autosomes and 1 pair of sex chromosome). In females, sex chromosomes are XX and in males are XY.
- The Y-chromosome in human determines maleness. It carries a gene *Cry* (sex determining region of Y-chromosome) which codes for TDF (Testis Determining Factor).
- The study was based on karyotype, i.e. diploid complement of chromosomes, obtained at mitotic metaphase.
- When the chromosomes are arranged on the basis of decreasing order of length and position of centromere, this arrangement is called **karyogram** or **idiogram**.

Genetic Suppression

The genetic suppressions involve
(a) True reversion i.e. reversal of original genetic change due to back mutation.
(b) If the effect of mutation is decreased due to a change at the different site then the process is called **suppression.** This genetic suppression can be of two types namely
(i) Intragenic suppression, i.e. the suppression involving the changes within the same gene.
(ii) Intergenic or extragenic suppression, i.e. those involving the changes in other genes.
The intragenic suppressions can be:
Intercodon suppressions, i.e. those involving two different changes within the same codon, e.g.

GCU (Alanine, active enzyme) —Mutation→ GAU (Aspartate, inactive enzyme) —2nd Mutation→ GUU (Valine, active enzyme)

Reading frame suppression, i.e. which involve suppressions in the same reading frame due to additions and deletions within the same gene.
By an amino acid substitution some distance away from the site of primary mutation. e.g. In the trytophan synthetase (A gene of *E.coli*) a primary mutation, i.e. glycine → glutamic acid, resulted in a non functional enzyme. The effect of this mutation was corrected by a second mutation (tyrosine → cysteine) taking place at 36 amino acid residues away. This second mutation restored the activity of enzyme.
Under **extragenic or intergenic suppressions** the effect of a mutation in one gene is overcome by a mutation in another gene. In strict sense, the term suppressor mutation refers to intergenic suppressions only. The two genes involved here may even be located on different chromosomes. The second gene in these cases, which produces suppression is called suppressor gene. There are suppressor genes for each of the three termination codons namely **Amber mutants** for UAG. **Ochre** mutants for UAA and **Opal** mutants for UGA.
The suppression of UAG and UGA is 50% while that of UAA is only 1-5%.

Chromosomes

'Carries of heredity'. They are thread like structures composed of chromatin that carry the genes in linear sequence. They determine the individual characteristics of an organism.

Gene

Unit of heredity that is composed of DNA. Gene is visulalised as s discrete particle that determines particular characteristics.

Expression

Gene expression is the mechanism at the molecular level by which a gene is able to express itself in the phenotype of an organism. In the process the information in DNA is transformed into proteins via following sequential process.

Regulation

The mechanism of switching off and switching on of the genes depending upon the requirement of the cells and the state of development. In prokaryotes, operon system is responsible for gene regulation.

DNA

DNA is a long polymer of deoxyribonucleotides that consists of deoxyribose sugar, phosphoric acid and nitrogenous bases (A,T,C,G). DNA contains hereditary information in the form of sequence of nitrogenous bases. Three bases together constitute a codon and the whole may of these codons is teremed genetic code.

Replication

Formation of new exact copy of the DNA is a semiconservative and semidiscontinuous process. DNA replication is essential for maintaining quantity and quality of genetic material in every new cell generation.

Types

Positive regulation
Positive regulation is the one in which the genes remain unexpressed unless they are induced to do it. It is therefore inducible regulation.

Negative regulation
Negative regulation is the one in which the genes continue to express till their activity is repressed. It is also called repressible regulation.

Exerted at five levels

- Transcriptional level when primary transcript is formed.
- Processing level of primary transcript
- Translational level
- Post translational level
- During transport of *m*RNA

Transcription

Genetic information of DNA is transferred to RNA (*m*RNA) via transcription. RNA polymerase enzyme in presence of several other factors prepares single stranded RNA that is complementary to DNA with the substitution of thymine by uracil.

RNA

Single stranded, unbranched nucleic acid molecule consisting of ribose sugar, phosphoric acid and nitrogenous bases (A,U,C,G). They perform various functions in cells.

hnRNA

The orimary transcript that consists of both introns (interrupting sequence) and exons (expressing sequences) is called heteronuclear RNA . It undergoes procesing to produce *m*RNA.

tRNA

*t*RNA or transfer RNA works as the adapter molecule during protein synthesis (gene expression). It brings amino acids present in cytoplasm to the *m*RNA strand corresponding to the sequence of codons on the mRNA and facilities protein synthesis.

rRNA

*r*RNA (ribosomal RNA) are the component of ribosomes. Ribosomes are essential for protein synthesis.

Processing

hnRNA splicing occurs to remove introns. Besides, poly A tail and a methyl guanosine triphosphate cap is added in order to increase its stability and to facilitate transportation of resulting *m*RNA.

***m*RNA**

*m*RNA or messanger RNA carries the genetic information present in DNA inside nucleus to the cytoplasm where proteins are synthesized in accordance to the genetic code.

Translation

Translation is the process during which the genetic information stored in the sequence of nucleotide in an *m*RNA molecule are translated into proteins.

Proteins

Proteins are polymers of amino acids that are essential for body organization. They also act as enzymes for various biochemical processes.

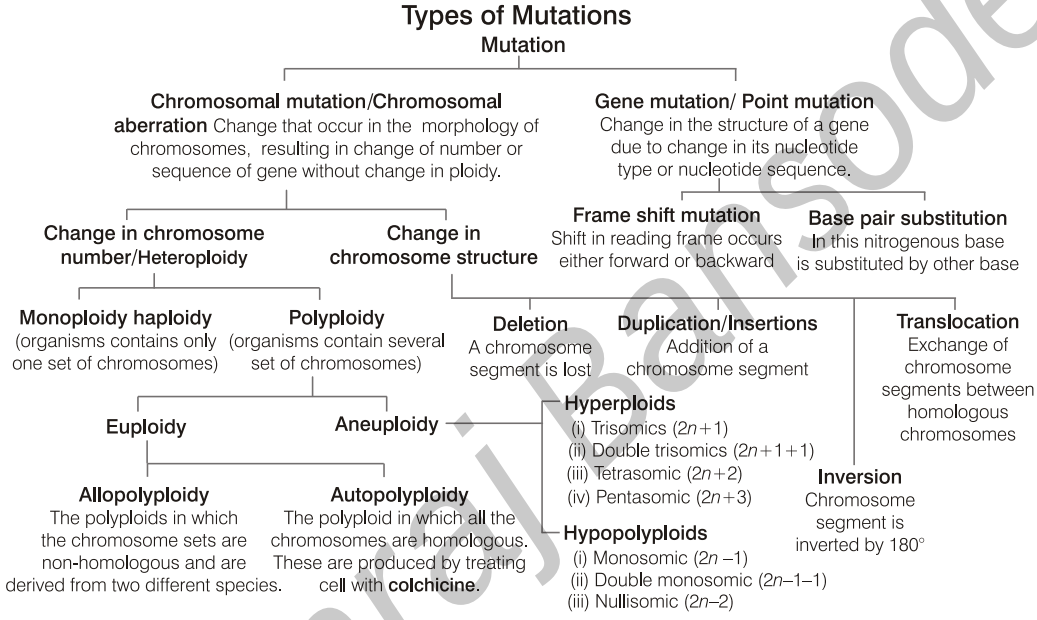
Phenotypic expression

If proteins that catalyze a particular process are produced more, than that process will occur more efficiently causing changes in phenotype.

MUTATIONS AND GENETIC DISORDER

Mutations

- Mutation is a sudden change in the genetic material of an organism.
- It causes permanent change in the organism's genotype and phenotype.
- Mutagens like UV rays, chemical, etc., causes mutations.
- Certain chemicals when tested individually are not mutagenic but when applied together these increase the frequency of mutations. Such chemicals are called as **co-mutagens**. Co-mutagens are also called **ratio potentials** as these increase the mutation frequency and this phenomenon is called as **potentiation**.



Frequency of Mutations

Mutations occur much more frequently in certain regions of genome. These regions are called as 'hot spots'. The frequency of spontaneous mutations is generally low, ranging from 10^{-7} to 10^{-12} per organism. The rate of detectable mutations in average gene is 1 in 10^6. The mutation rate can be calculated under two heads namely:

(a) Mutation rate at individual loci, i.e. chances of mutation for an individual locus.
(b) Mutation rate per genome, i.e. chances of mutation to be taken collectively for a complete genome.

Human Genetics

- The basic principles of inheritance are applicable to all living organisms including human.
- **Sir Archibald Garrod** (1909) was the first person to study human genetics.
- He is called as **Father of Biochemical Genetics** and **Father of Human Genetics**.
- Study of human genetics is based on pedigree analysis, population genetics, study of twins karyotype, etc.

Pedigree Analysis

Pedigree is a chart showing the record of inheritance of certain genetic traits for two or more ancestral generations of an individual. Pedigree analysis is used for studying inheritance of human traits.

Silent Mutations

Any gene mutation which does not result in phenotypic expression is called a **silent mutation**. These mutations may arise due to the following reasons.

(a) As more than one codon specify same amino acid (due to degeneracy of code) Hence, the change in codon may not result to change in amino acid thus, change in trait is not visible.
(b) The change in codon may result to change in amino acid and so also in polypeptide chain. But this change is insufficient to modify the function of protein appreciably.
(c) The mutation occurs in a gene which is no longer functional or the protein, which is not required by the organism for rest of his life.
(d) Simultaneous presence of suppressor mutations may cause a mutation to be silent.

Evolution

(Latin evolvere-to unroll) Multicellular organisms evolved from tiny eukayryotic unicellular ones.

Evidence of evolution

Morphological and anatomical

Comparaive studies of morphology and anatomy, homology of organisms provide evolutionary proofs, e.g. vestigial organs, atavism etc.

Embryological

Comparative study of embryonic development of various organisms shows various similarities and resemblance to embryos of lower organisms indicating evolution (Biogenetic law of Haeckel)

Pateontological

Paleontology is the study of fossils (preserved remains of dead organisms). It provides most direst and reliable evidence of evolution.

Connecting Back

Connecting links are living organisms with characteristics intermediate between two groups, e.g., Euglena (link between plants and animals)

Molecular and phystological

various physiological processes, cellular structure, biochemistry, genetic composition, etc. also provide evolutioonary evidence e.g., blood plasma proteins.

Theories of evolutions

Lamark's Theory

It says that "The changes in structure or function of any organ are acquired during the lifetime of an individual by use of disuse of that organ and are inherited" causing evolution.

Darwain's Theory

It says that variation occur in organisms and useful amoung them are selected by nature (i.e., natural selection) and get accumulated in the organism. This leads to evolution.

Mutation Theory

This theory put forward by Hugo de Vries says that evolution is a discontinuous, saltatory process that occurs due to sudden inheritable variations.

Modern Synthetic Theory

According to it five factor : genetic variations, heredity, natural selection, reproductive isolation and speciation lead to evolution

Mechanism of evolution

Evolution starts with generation of variations, Variations in a population may occur by mutations, genetic drift, gene migration, hybridization, etc. Out of these variations inheritable variations undergo natural selection and the individual with highest survival value in the present environmental conditions evolve.

Human evolution

All human beings present today belong to a simple species Homo sapines which has evolved bipedal locomotion high cranial capacity, opposable thumbs and etc. dominates in today's life forms.

Geological Time Scale

Era	Period	Epochs	Duration	Animal Sequence	Plant Sequence (vegetation)
Coenozoic (age of mammals and angiosperms)	Quaternary	Holocene of recent (age of man)	Continuing till date	**Mental age**, supremacy of **man**.	Plants evolution of monocots, dominance of herbs.
		Pleistocene	7.0 lakh years	Appearance of **human beings** and their **social life**. Decline of giant mammals.	Increase of herbs and grasses.
	Tertiary	Pliocene	1.32 crore years	Ape-like ancestor of human appeared.	Evolution of herbaceous plants.
		Miocene (golden age of mammals)	1.1 crore years	Mammals at height of evolution, evolution of man like apes and other mammals like sheep, goat, dogs, elephant.	Land or terrestrial plants evolved.
		Oliocene	1.9 crore years	**Anthropoid apes** evolved from monkeys, crocodiles.	Rise of **monocots**.
		Eocene	1.2 crore years	Evolution of **diversified placentals**, ancestors of hoofed carnivores, marine mammals and birds.	Beginning of **grassy plant**, **flowering plants** spread into forests.
		Palaeocene	8.0 lakh years	Evolution of **insectivorous** smaller mammals, carnivorous mammals.	Forests of **angiosperms**.
				Rocky Mountain Revolution	
Mesozoic (age of reptiles and gymnosperms)	Cretaceous		7.1 crore years	Extinction of **dinosaurs** and **primitive birds**. First modern birds appeared. Primitive placental mammals like insectivorous shrews originated.	Beginning the evolution of dicots. **Angiosperms appeared**.
	Jurassic		5.4 to 5.9 crore years	Giant reptiles like dinosaurs were at peak, evolution of **toothed birds** like *Archaeopteryx*, marsupials evolved from prototherians.	Evolution of **gymnosperms** was at peak.
	Triassic		3.5 crore years	Origin of first **oviparous prototheria** mammals, dinosaurs, flying reptiles.	Forests of **conifers**, **cycads** and other gymnosperms.
				Appalachian Revolution	
Palaeozoic (age of ancient life)	Permian		5 crore years	Extinction of **trilobites**, origin of **mammal like reptiles**. Decline of amphibians.	Among gymnosperms evolution of **conifer trees**.
	Carboniferous (Mississippian)		6.5 crore years	Abundance of **sharks** and **amphibians,** origin of reptiles like seymauria. Spiders and insects declined.	**Ancestral gymnosperms** and **ferns** dominating bryophytes originated. Origin of **first seed plant**.
	Devonian (age of fishes)		5 crore years	Origin and evolution of **sharks,** bony fishes and lung fishes. Appearances of **first amphibians**.	Giant **club moss**.
	Silurian		3 to 4 crore years	Evolution of **arthropods**, **insects**, **jawless primitive fishes** evolved.	Bryophytes and land ferns were in large number. Origin of **vascular plants**.
	Ordovician		6 to 7 crore years	Origin of **jawless fishes** in fresh water. Abundance of giant molluscs brachiopods, trilobites, echinoderms. **First vertebrates**.	Plants reached freshwater. Marine plants abundant.
	Cambrian		7 crore years	Trilobites and brachiopods were dominant. Echinoderms were also present, no life on land.	Marine **bacteria** colonial, multicellular filamentous algae evolved in oceans.
				Second Great Geological Revolution	
Proterozoic (era of early life)			1.93 billion years	Invertebrates like **Protozoa**, **Coelenterata**, **sponges, Annelida** and **Mollusca** evolved.	**Single-celled bacteria** and **blue-green algae** evolved in sea.
				First Great Geological Revolution	
Archaeozoic (era of invisible life)			1.5 billion years	Origin of life in sea from organic materials, **prokaryotes** (Monera) and **eukaryotes** (Protista) evolved and diversified.	Prokaryotic form of life formed blue-green algae originated.
Azoic (era of no life)			1.0 billion years	No life. Only chemical evolution took place.	

Origin of Life

Theories of origin of unitvers

Nebular Hypotbesis

It was propsed by Kant-Leplace according to which earth originated about 4.5-5 billion years ago from a gaseous cloud solar nebula.

Big bang Theory

According to this theory of Abbe Lemaitre univers formed by a big bang (thermonuclear expansion) of a dense entilty.

Chemical Theory of orogin of lice

- Oparin- Haldane's of chemical origin theory is most widely accepted theory of origin of life. It involves some basic stpes that are :
- **Formation of inorganic molecules**
- From the gases present in early earth's atmosphere.
- **Formation of simple organic compounds**
- From the inorganic compounds formed in previous step.
- Spontaneous formation of complex organic molecules
- Simple organic molecules combined to from large organic complex biomolecules like starch, proteins, fatty acids.
- **Spontaenous formation of molecular aggregates, concervates, eobionts and first living cell**
- Complex organic compounds synthesized on primise earth grouned togeths spontaneously and due to intermolecular attraction formed large colloidal aggregates called coacervates or Micropheres which tuned into eobionts (controlled by nucleic acids). These developed cel membrane and formed first living cells or prokayotes.

Eukaryotes (Unicellular)

Human Health and Disease

- Health defined as a state of complete physical, mental and social well being and not merely the absence of disease or infirmity.
- When the functioning of one or more organs or systems of the body is adversely affected, we say that we are not healthy, i.e., we have a disease.

Congenital diseases

These are inborn diseases present from the birth.

Acquired diseases

- These are diseases contracted after birth.
- It is of two types :

Communicable diseases

- These can pass from one infected person to a healthy one.

Non-Communicable diseases

- These remain confined to the persons who develop them and do not spread to others.

Cancer

- Cancer is a disease of uncontrolled proliferation of cells without any differentiation. It is of two types (i) Benign tumour, (ii) Malignant tumour.
- Cancer is neither hereditary not a contagious disease Chemical and physical agents that can cause cancer are called careinogens e.g. X-rays, UV rays, caffeine, steroid, arsenic air, soot, diethylstilbestrol (DES), vinyl chloride (VC), cadmium oxide.
- Several genes in the host called cellular oncogenes or proto-oncogenes have been identified which under certain conditions on getting activated could lead to oneogenic transformation of cells.
- Tumor suppressor genes normally keep mitosis in check and prevent cancer from occurring.

Bacterial diseases

- **Typhoid**
  Caused by Salmonella typhi
- **Pneumonia**
  Caused by Streptococcus pneumoniae or Diplococcus pneumoniae
- **Dysentery (Bacillary)**
  Caused by bacteria of the genus shigella
- **Plague**
  Caused by Pasteurella/ Yersinea
- **Diphtheria**
  Caused by Corynebacterium diphtheriae
- **Chlera**
  Caused by Vibrio cholerae
- **Tetanus**
  Caused by Clostridium tetani
- **Tuberculosis**
  Caused by Mycobacterium tuberculosis

Viral diseases

- **Common cold**
  Caused by Rhino virus
- **Mumps**
  Caused by Paramyxo virus
- **Measles**
  Caused by rubella virus
- **Dengue fever**
  Caused by arbo virus
- **Chikungunya**
  Caused by alpha virus
- **Chicken pox**
  Caused by Varicellazoster
- **Poliomyelitis**
  Caued by poliovirus (enterovirus)
- **Viral hepatitis**

Protozoan diseases

- **African sleeping sickness or trypanosomiasis**
  Caused by Trypanosoma gambiense
- **Kala-azar**
  Caused by Leishmania donovani
- **Amoebic dysentery or Amoebiasis**
  Caused by Entamoeba histolytica
- **Malaria**
- Caused by Plasmodium
- There are 4 species of Plasmodium with causes 4 types of malaria. These are :
  - **Plasmodium**
  - Plasmodium vivax or P. vivax (benign tertian malaria)
  - P. malariae (quartan malaria)
  - P. falciparum (cerebral malaria or malignant tertian malaria)
  - P.ovale (mild tertian malaria)

Helminthic disease

- **Ascariasis**
  Caused by Ascaris lumbricoides
- **Filariasis or elephantiasis**
  Caused by Wuchereria (W.bancrofii & W.malayi)

COMMUNICABLE DISEASES

- Communicable diseases are classified into nine types according to the nature of pathogen *i.e.*, the disease causing agent.

Viral Diseases

Viral hepatitis

- Viral hepatitis is commonly called **jaundice**.
- In early stage, the liver is enlarged and congested. In later stage, the liver becomes smaller, yellowish or greenish.
- The symptoms in early phase include – fever, anorexia, nausea, vomiting, epigastric discomfort, pains in muscles and joints.
- The urine is dark in colour. Leukopenia (reduction in the number of WBCs) is followed by lymphocytosis (increase in the number of lymphocytes). Splenic enlargement is sometimes present.

Table: Other viral diseases

	Disease	Pathogen	Mode of transmission/ Incubation period	Symptoms	Prevention
1.	Dengue fever	*Flaviribo* virus	By bite of *Aedes aegypti* mosquito/3-8 days	Fever, headache, muscles and joint pains, rashes, nausea, vomiting, excessive thirst, bleeding from nose, mouth, gums	Eliminating mosquito breeding places and applying mosquito repellents.
2.	Common cold	Rhinovirus	Droplet contact/ 3-7 days	Nasal congestion, running nose, sneezing, sore throat, cough, fever, headache	Washing hands frequently and using face masks.
3.	Mumps	Paramyxovirus	Droplet contact/ 7-18 days	Fever, painful swelling of parotid glands	Avoiding contact with the sick; MMR vaccine is available.
4.	Measles	Rubeola virus	Droplet contact/ 8-15 days	Fever, rash, itching, inflammation of respiratory passage	*Same as that of mumps*.
5.	Chicken pox	*Varicella zoster virus*	Direct contact and droplet contact/ 14-21 days	Fever, rash which changes into vesicles, pustules and then brown scab which falls off	Scabs should be collected and burnt, soiled articles should be washed and boiled. Vaccine is available.
6.	Smallpox (Eradicated from earth)	*Variola* virus	Direct contact and droplet contact/ 12 days	High fever, chill, headache, vomiting, rash that turn into scabs that fall off	*Same as that of chickenpox*.
7.	Poliomyelitis	Polio virus	Contaminated food and water/ 7-14 days	Stiffness of neck, paralysis of skeletal muscles, fever, headache, pain	Avoiding contaminated food and water. Salk vaccine and OPV vaccine available.
8.	Swine flu	Swine influenza (H_1N_1) viruses	Droplet contact	Fever, cough, bodyaches, headache, chills	Avoiding close contact with the sick. Vaccine is available.
9.	SARS (Severe Acute Respiratory Syndrome)	Corona virus	Droplet contact/ 2-7 days	Fever, chills, muscleache, cough, dizziness, running nose, vomiting, diarrhoea	Avoiding contact with the sick.

Pneumonia	*Streptococcus pneumoniae, Haemophilus influenzae*	Direct contact / 1 - 3 days	Cough, fever, pain in the lungs	PCV13 vaccine / Erythromycin, tetracycline
Diphtheria	*Corynebacterium diphtheriae*	Droplet infection/ 2-5 days	Fever, sore throat	DPT vaccine / Erythromycin
Whooping cough or pertussis	*Bordetella pertussis*	Direct contact / 10 - 16 days	Cough, breathlessness and vomiting	DPT vaccine/Erythromycin
Tuberculosis	*Mycobacterium tuberculosis*	Droplet infection and contaminated food and drinks / 3 - 6 weeks	Constant cough, pain in chest, loss of weight and appetite	BCG/streptomycin, PAS rifampicin
Tetanus (Lock jaw)	*Clostridium tetani*	Spores enter the wounds / 3 - 25 days	Painful muscular spasms, fever, lock jaw	DPT / Antitetanus serum (ATS), tetanus toxoid
Plague (Black death)	*Pasteurella/Yersinia pestis*	Bite of infected rat flea *Xenopsylla cheopis* / 2 - 6 days	Painful buboes, fever, haemorrhages	Streptomycin, oral tetracycline, Antiplague vaccine
Leprosy (Hansen's disease)	*Mycobacterium leprae*	Prolonged direct contact / 2 - 5 years	Infection of skin, wasting of body parts, deformities of fingers, toes, hypopigmentation.	Rifampicin, dapsone, clofazimine

Protozoan Diseases

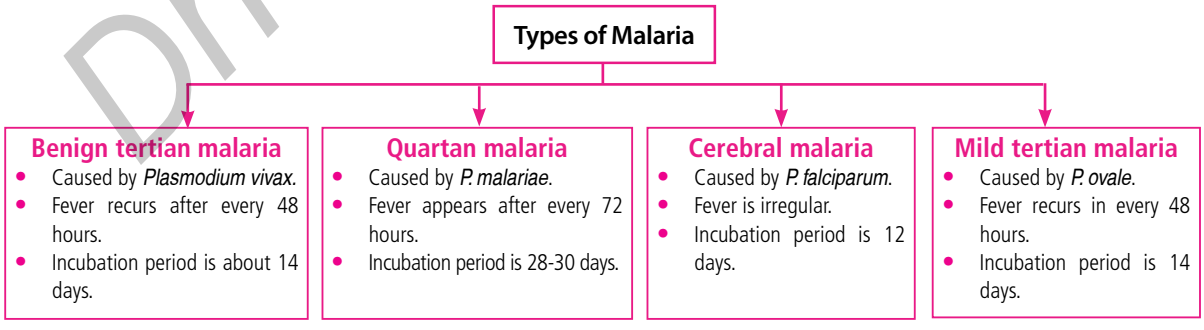
- Protozoans are diverse group of eukaryotic, unicellular organisms.
- Human diseases caused by protozoa are relatively few, but are individually of devastating consequences.

Malaria

- Malaria is caused by a digenetic (have two hosts to complete its life cycle) protozoan parasite known as *Plasmodium*.
- The primary host is female Anopheles mosquito and secondary host is man.
- Sir Ronald Ross established that malarial parasite is transmitted by the bite of a female *Anopheles* mosquito for which he got Nobel Prize in 1902.

Mode of transmission

- The malarial parasite, *Plasmodium* enters the human body as **sporozoites** (infectious form) through the bite of infected female *Anopheles* mosquito.
- There are four species of *Plasmodium* which causes four main types of malaria in human.



Symptoms

- Malaria is characterised by fever at intervals, sudden acute chillness (cold or rigor stage) accompanied by shivering followed by rise in temperature.
- Peak fever (hot or febrile stage) is 41.1°C or 106°F which persists for 3-6 hours. After 2-4 hours of fever, there is profuse sweating (sweating or defervescent stage) which lowers the body temperature to near normal.
- Malaria is also accompanied by nausea, headache, laziness and muscular pains. It also results in anaemia and splenomegaly.

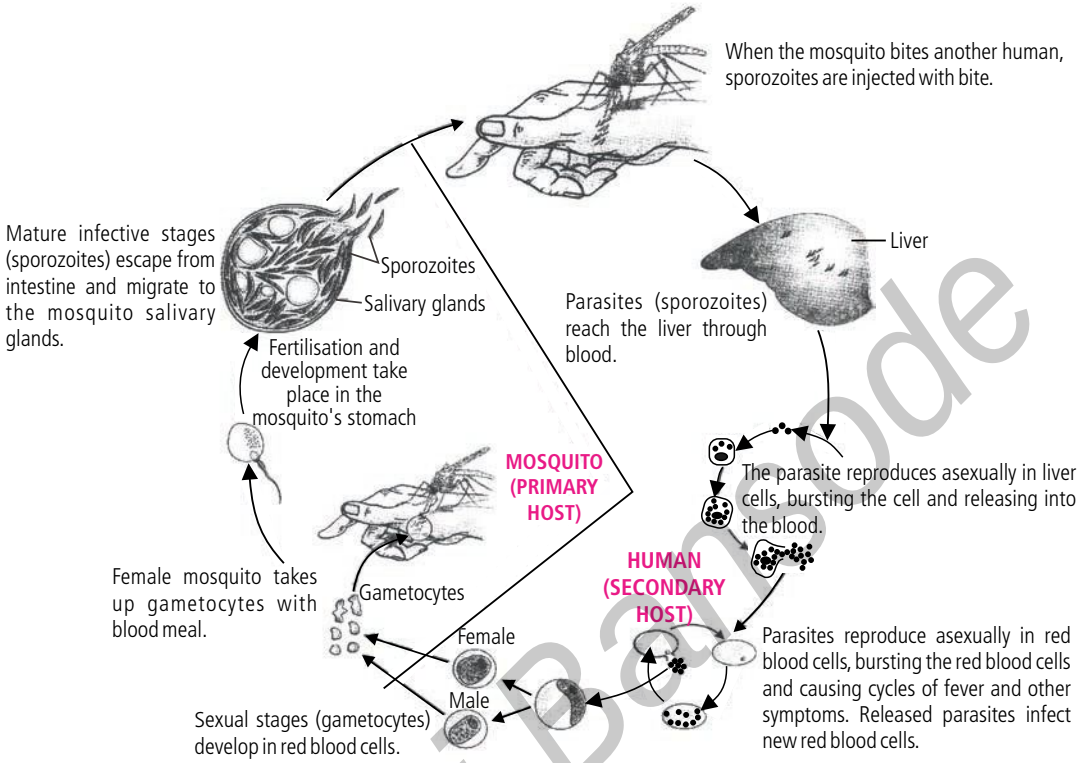


Fig.: Life cycle of *Plasmodium*

Prevention and Treatment

- Spraying DDT, BHC and other insecticides
- Fitting doors and windows with wire nets
- Using mosquito nets and repellants
- Use of drugs like chloroquine, quinine, primaquine etc.

Table : Other protozoan diseases

Disease	Pathogen	Mode of transmission/ Incubation period	Symptoms	Control measures /Treatment
Amoebiasis	*Entamoeba histolytica*	Faecal - oral route, sexual contact, vectors *e.g.*,flies. / 2-4 weeks	Abdominal pain, diarrhoea, blood in faeces.	Sanitary disposal of faecal matter / Emetine, stremetine, metronidazole and tinidazole.
Giardiasis	*Giardia intestinalis*	Contaminated food and water / 1-3 weeks.	Epigastric pain, headache, diarrhoea.	Clean food and water/Metronidazole, tinidazole.
African sleeping sickness or Trypanosomiasis	*Trypanosoma sp.*	Biting of tse tse fly *Glossina* sp./ Weeks or months.	Swelling of lymphatic glands, recurrent fever, anaemia, patient falls asleep.	Pentamidine, atoxyl, tryparsamide, germanin.
Kala-azar or Dum-dum fever	*Leishmania donovani*	Bite of sandfly *Phlebotomus argentipes* / 3-6 months.	High fever, spleen enlargement, anaemia, darkening of skin.	Sodium antimony tartrate, glyconate, urea stebamine, neostibosan.

Helminthic Diseases

- Helminths are animals that belong to the Phylum **Platyhelminthes** (flatworms) and **Nematoda** (roundworms).
- Many parasitic forms of this group, popularly known as **parasitic worms**, are endoparasites of gut and blood in human body and cause various diseases called as **helminthiasis**.

Immunity

It is body's ability to destroy pathogens or other foreign materials and to prevent further cases of certain infectious diseases.

Types of Immunity

Innate Immunity/Inborn

- Non-specific defence mechanisms.

- It is present at the time of birth.
- It is of two types : external defence and internal defence.

External defence first line defense

It comprises physical and chemical barriers to the entry of pathogens into the body.

Internal defense second line defense

It occurs when the first line of defenses fail to prevent access of pathogens to the tissues. The body's internal defenses is carried out by WBC (neutrophils and monocytes) macrophages, natural killer (NK) cells, inflammatory reactions, fever, interferons and complement system.

Acquired immunity / Specific defense mechanism

(Third line of defenses)

- Response of immune system to specific pathogens.

Active immunity

- It is produced due to contact with pathogen or its antigen and subsequent production of antibodies.

Passive immunity

It occurs when readymade antibodies are directly given to protect the body against foreign agents. Colostrum (Contains abundant IgA) and foetus receiving antibodies from mother are some examples of passive immunity.

Antigen Presenting Cells

- These are specialized cells which include macrophages (monocytes as blood macrophages and histocytes as tissue macrophages) B-Lymphocytes and dendrite cells (e.g., Langerhans cells of epidermis of skin)

Lymphocytes

T-Lymphocytes, T-Cells

- T-Cells are involved in cell mediated immune response.

B-Lymphocytes, B-Cells

- B-cells are involved in antibody mediated or humoral immune response.
- They give rise to plasma cells (produce Antibodies) and memory B-cells on activation by antigen specific T-cells.

Immunity

Antigens / Antibodies

- Antigens are substances which when introduced into the body, stimulate the production of antibodies.
- The specific reactivity induced in a host by an antigenic stimulus is known as immune response. It is of two types - (1) Primary and (2) Secondary immune response.
- Antibodies (Abs) are glycoproteins, called immunoglobulins, made up of four peptide chains, two small called light chains and two longer called heavy chains.
- Different types of antibodies such as IgA (heaviest and second most abundant), IgM (Largest and first reach the site of infection) IgG (Most abundant, only Ab that crosses placenta), IgD and IgG produced in our body.

Immune System

- It consists of Lymphoid organs, tissues, cells and soluble molecules such as antibody.
- Lymphoid organs are of two types - (1) Primary lyumphoid organ and (2) Secondary lymphoid organs. Thymus, bone marrow are primary lymphoid organs.
- Lymph nodes, spleen, tonsils, payer's patches, appendix and MALT (Mucosal Associated Lymphoid Tissue) are Secondary Lymphoid Organs.

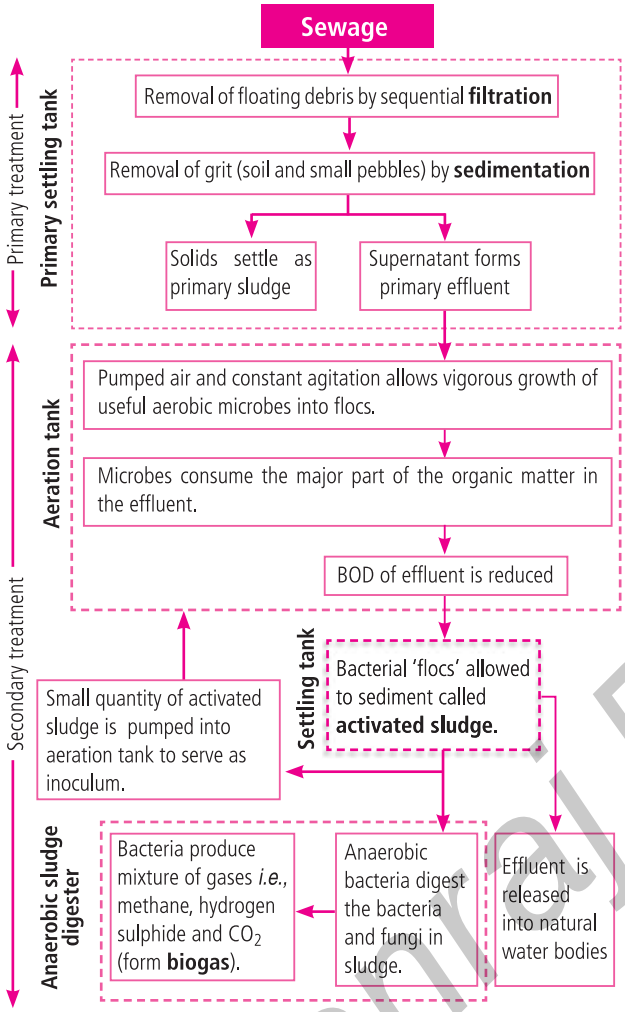
Vaccination & Immunisation

- Vaccination is the process of development of immunisation against a particular disease by inoculation of harmless antigenic material like attenuated pathogen or its toxoid in the form of vaccine into a healthy person.
- Vaccine is of 3 types - First generation vaccines, Second generation vaccines and Third generation vaccines.

Immunological Disorders

Failure of host defense results into immunological disorders, which falls into 3 different categories.

- Immuno Deficiency
- Auto Immunity
- Hyper Sensitivity



- **Flocs** are the masses of bacteria associated with fungal filaments to form a mesh-like structure.
- **Biological oxygen demand** (BOD) is the amount of oxygen that would be consumed by the bacteria to oxidise all organic matter present in one litre of water.
- The BOD test measures the rate of uptake of oxygen by microbes in a water sample and thus the amount of organic matter present in water is indirectly calculated.
- More polluted water has greater BOD.

Tertiary Treatment

- Tertiary treatment is usually not employed except where necessary. It further purifies the effluent of secondary treatment before discharging it into water bodies.
- Chlorination is performed inside chlorine contact tank to eliminate pathogens like bacteria and viruses. Concerns about harmful disinfection by-products led to replace chlorination by UV radiation treatment or ozonation.
- Tertiary treatment is particularly important for the removal of nitrogen and phosphorus compounds from water. It is an expensive step of treatment.

The Ministry of Environment and Forests has initiated Ganga Action Plan and Yamuna Action Plan to prevent the discharge of untreated sewage into these rivers. The number of STPs are not enough to manage the increasing quantity of sewage due to urbanisation. These plans proposed to build a large number of new STPs so that rivers receive only treated sewage.

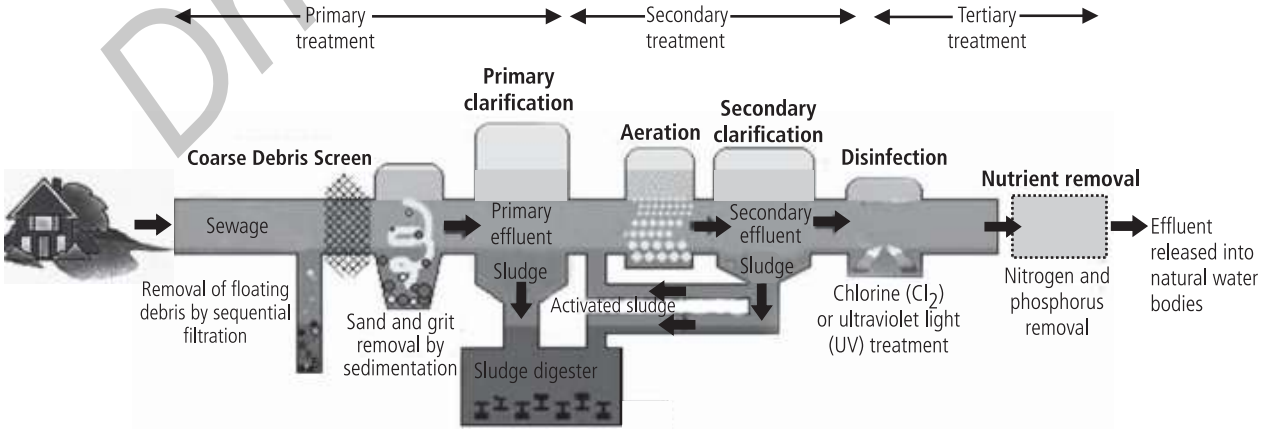


Fig. : Sewage Treatment Plant

Traditional views

- Brotechnology (Erey' 1917) is the technological employment of microganisms, plant cells, animal cells, their components or biological process to generate products and services useful to human beings.

Modern view

- Modern biotechnological is the use of genetically modified organisms (GMOs) or generally engineered plant and animal cells in developing protection technologies that not only enhance their productivity but also give rise to new products.

Biotechnology

Principles of Biotechnology → **Chemical engineering**

Genetic engineering

- Techniques to alter the chemistry of genetic material (DNA and RNA), to introduce these into host organisms and thus change the phenotype of the host organism.
- The techniques of genetic engineering include creation of recombinant DNA (rRNA).

Tools recombinant DNA technologies

Restruction enzymes

- Restruction eazymes belong in a larger class of enzymes called nucleases. These are of three kinds. exonucleases. endonucleases and restriction endonucleases. Exaleases remove nucleotides from the ends of the DNA. whreas endonucleases make cuts at specific positions within the DNA.
- Each restriction endonuclease recognises a specific palindromic nucleotide sequences in the DNA.
- For R1, Bam !!, 1, Hin d III are some of the example of restriction endonucleases.

Gerl electrophoresis

- It is a technique to seperate and isolate DNA fragments.

Cloning vectors

- They are carriers or vehicles of desired DNA fragments passenger DNA) which can undergo independent replication to increase copies of desired genes.
- Cleaning vectors are of four type - plasmids, viruses, cosmids and artificial chromosomes.

Competent host

(For transformation with recombinant DNA)

- It involves vector transfer and direct or vectorless transfer.
- Vector transfer involves transformation with cloning vectors.
- Vectories transfer involves.

(i) Microinjection (ii) Particle gene gun or biolistic
(iii) Electroporation (iv) Direct DNA injections

Processes of rDNA technologies

Isolation of genetic material

- To isolate the DNA from the bacterial cells plant or animal tissue it is treated with enzymes such as lysozyme (bacteria), cellulase and pectinase (plant cells), chitinase (fungus).
- The treated cells are homogenised and centrifuged.
- Hormogenised product is then treated with proteases (for digesting histones and other proteins). ribonucleases (digestion of RNAs). amylases and lipases.
- DNA remains intact. It is precipitated by the addition of chalked ethylalcohol.

Amplification of gene of interest using PCR

- PCR or polymicrase chain reaction is the in vitro synthesis of multiple copies of a gene or DNA segment.
- Amplified DNA segment can be used to ligate with the vector for formation of rDNA and its cloning.

Otbatining the desirable gene product

- When rDNA is transferred into a bacterial, plant or animal cell, the foreign DNA gets multiplited.
- The foreign gene gets espressed under appropriate conditions.
- If any protein encolding gene is expressed in a heterologous host, it is called a recombinant protein. The cells harbouring cloned genes of interest may be grown on a small scale in the laboratory. The cultures may be used for extracting the desired protein and then purifying it by using different separation techniques.
- Small scheme culture can not yield appreciate quantities of products. To produce in large quantities, the development of bioreactors where large volumes of (100-1000 litres) of culture can be processed is used.

Cutting of DNA at specific locations

- Restruction enzyme digestions are performed by incubating purified DNA molecules with the restriction enzyme.
- The process is repeated with the vector DNA also.
- After having cut the source DNA as well as the vector DNA with a specific restriction enzyme. The cut our gene of interest from the source DNA and the cut vector with space are mixed and ligase is added.
- This results in the preparation of recombinant DNA.

Insertion of recombinant DNA into the host cell / organism

- The rDNA is inserted into host bacterium by transformation using cold CaCl solution.
- The bacterial cell containing the desired rDNA is selected uing selective antibiotics in the culture medium.

Downstream processing

- Down stream processing is the recovery of product from the fully grown genetically modified cells, its purification and preservation.
- The procedure and vigour or downstream processing and quality control varies from product to product.

Applications of Biotechnology — Ethical issues

Biopiracy

- It is exploitation of bioresources of a country by organisations and multinationals for commercial exploitation with or without patent but without any Access and Benefit Sharing Agreement (ABA).
- Some nations are developing laws to prevent such unauthorised exploitation of their bioresources and traditional knowledge.

Biopatent

- It is an official licence to use a particular biological material for commercial exploitation like (i) A strain of microorganism (ii) GM plant animal (iii) DNA sequence (iv) Biotechnological procedure (v) Production process. (vi) Product and (vii) Product application.
- Biopatents are going to give not only increased economic benefits to holders, but will also provide a spurt in research.

Biotechnlogical application in agriculture

- Genetically modified crops (GM crops) or Transgenic plants : GM crops contain and express one or more useful foreign genes or transgenes (e.g. Bt cotton, golden rice, Flaver Savr tomato)
- GM plants have been useful in many ways :
  - Growing GM crops can help to reduce the use of chemical pesticides.
  - GM crops are more tolerant to abiotic stresses (cold, drought, salt, heat etc.).
  - They have helped to reduce post-harvestlosses.
  - Increased efficiency of mineral usage by plants prevents early exhaustion of fertility of soil.
  - GM plants enhance nutritional value of food. e.g., vitamin A enriched rice.
  - Herbicides (weed killers) do not harm the GM crops.
  - Plant biologists are working to create genetically engineered plants having resistance to these deseases.
  - GM plants have been used to create alternative resources to industries in the form of starches, fuels and pharmaceuticals (molecular farming.)

Biotechnological application in medicine

- Recombinant DNA technology is engaged in production of newer and safer therapeutic drugs, called recombinant drugs. These drugs do not induce immunological reactions as some other drugs obtained from nonhuman sources (e.g., insulin from animals).
- A large number of human genes encoding pharmaceutically valuable proteins have been cloned and expressed in microorganisms.
- Gene theraphy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo. Here genes are inserted into a person's cells and tissues to treat a disease.

Production of transgenic animals

- These are animals which have been genetically modified by incorporating foreign and other specific genes through recombinant DNA technology. A number of animals have been genetically modified,e.g., rats, rabbits, pigs, sheep, cows, fish. 95% of them are transgenic mice.
- Some of the important uses of transgenic animals are as follows :
  - Transgenic animals enable scientists to study the working of genes, their regulation, effect on normal body functions and development.
  - Transgenic animals are used to study how genes take part in development of diseases.
  - The important bilogical products being harvested by this method are protein α-1 antitrypsin for treating emphysema, tissue, plasminogen activator (goat), blood clotting factors VIII and IX (sheep) and loctoferrin (cow).
  - Transgenic animals are the best for checking the safety of vaccines before their use in humans.
  - Trasgenic animals are used in studying the effect of toxic chemicals.

Biotechnological application in industry

Mostly microorganisms are used in many industries to produce alcohol, enzymes, vaccines, vitamins, antibiotics, organic acids etc.

Ecology

- Study of reciprocal relationship between organisms and their environment.

Organisms

- Basic unit of ecological hierarchy.
- Interaction with physical environment comprised of atmosphere, hydrosphere and lithosphere.
- **Adaptations** enable them to survive and reproduce in their habitats.
- **Environmental factors** (abiotic and biotic) influence the form and functioning of organisms.

Abiotic Factors

- **Climatic**
  - Light
  - Temperature
  - Wind
  - Rain (Precipitation)
  - Atmospheric humidity
- **Edaphic**
  - Mineral matter
  - Organic matter
  - Soil
- **Topographic**
  - Altitude
  - Steepness of slope
  - Direction of slope

Biotic factors

Bacteria, Algae, Fungi, Parasites, Saprophytes, Symbionts, Animals

Population

Organisms of the same kind form population. They are capable of interbreeding among themselves.

Characteristics of Population:
- Density
- Natality
- Mortality
- Dispersal
- Age distribution
  - Emigration
  - Immigration
- Biotic potential
  - J Shaped(Exponential)
  - S-Shaped(Logistic)
- Growth form

Community

Population of different species occurring in a habitat.

Ecosystem

It includes biological community, integrated with its physical environment.

Biosphere

Includes all ecosystems on the earth.

Features

Species composition

Different kinds of plants and other organisms present in a community.

Dominance

- Only one or few species in a community dominate and influence other species in terms of numbers and biomass production.

Species interaction

- **Positive**
  - Mutualism
  - Protocooperation
  - Commensalism
- **Negative**
  - Competition
  - Predation
  - Parasitism

Stratification

- Vertical layering of vegetation in which different layers are occupied by different species.

Concept Map

Ecosystem

Components

Abiotic
- Inorganic materials, soil, water, air, temperature, light etc.

Biotic
- Producers, consumers and decomposers

Types
- Forest ecosystem
- Grassland ecosystem
- Desert ecosystem
- Aquatic (freshwater and marine ecosystem)

Structure
- Species compositisn
- Stratification
- Trophic structure

Functional aspects

Based on

Ecological pyramids
- Graphical represen-tation of the trophic structuire

Trophic levels (T)
- Producers (T_1)
- Herbivores (T_2)
- Carnivores (T_3)

Pyramid of biomass
- Upright in terrestrial habitats, but inverted in aquatic habitats.

Pyramid of numbers
- Mostly upright but inverted in parasitic food-chain and spindle shaped in forest ecosystem.

Pyramid of energy
- Always upright.

Function

Gross primary productivity

Net primary productivity

Productivity
- Food production

Primary productivity

Secondary productivity

Net Productivity

Decomposition
- Breakdown of organic matter
- Occurs by fragmentation of detritus, leaching and catabolism.

Nutrient cycling
- Storage and transfer of nutrients through various components of ecosystem so that nutrients are repeatedly used.

Sedimentary
- Exists in the earth crust
- Examples : Phospho-rous and Sulphur cycle.

Gaseous
- Exists in atmosphere or hydrosphere.
- Examples :Water cycle, Nitrogen cycle, Carbon cycle etc.

Energy flow
- It is unidirectional.
- Involves conversion of light energy into food energy and transfer of enenrgy from one organism to another.
- Trophic levesl are connected by the trans-fer of food or energy along the food chain and food web (network of food chains).
- There is transfer of 10% energy from one trophic level to another (Raymond Lindemann).

Biodiversity and Conservation

• Biodiversity is defined as the vast array of species of microorganisms, algae, fungi, plants and animals occuring on the earth and the ecological complexes of which they are a part. This includes diversity within species, between species and of the ecosystem

Alpha diversity
Diversity in the given community of habitat.

Beta diversity
Diversity between community

Gamma diversity
It is regional diversity

Levels of biodiversity

Genetic diversity
It is the diversity in the numbers and types of genes as well as chromosomes present in different species and the variations in the genes and their alleles in the same species.

Species diversity
It is the diversity in the number and richness of species of a region

Community Ecosystem diversity
It is related to the differnt type of ecosystems/habitats eg., terrestrial and aquatic ecosystems

Patterns of Biodiversity

- Species Latitudinal and altiludinal gradient diversity on earth is not uniformly distributed but shows interesting patterns. It is generally highest in the tropics and decreases towards the poles.
- Important explanations for the species richness in tropics: Tropics had more evolutionary time; they provide a relatively constant environment and they receive more solar energy which contributes to greater productivity.

Species area relationships
It is a relationship between the area of habitat or part of a habitat and the number of specis within that area

Importance of Biodiversity

- stability of ecosystem
- sources of food and improved varieties
- sources of fibres
- provide variety of useful products such as gums, resins, dyes, perfumes, lubricants, rubber, latex, tea, dryfruits
- provide drugs and medicines
- scientific value
- ecosystem services

Loss of Biodiversity

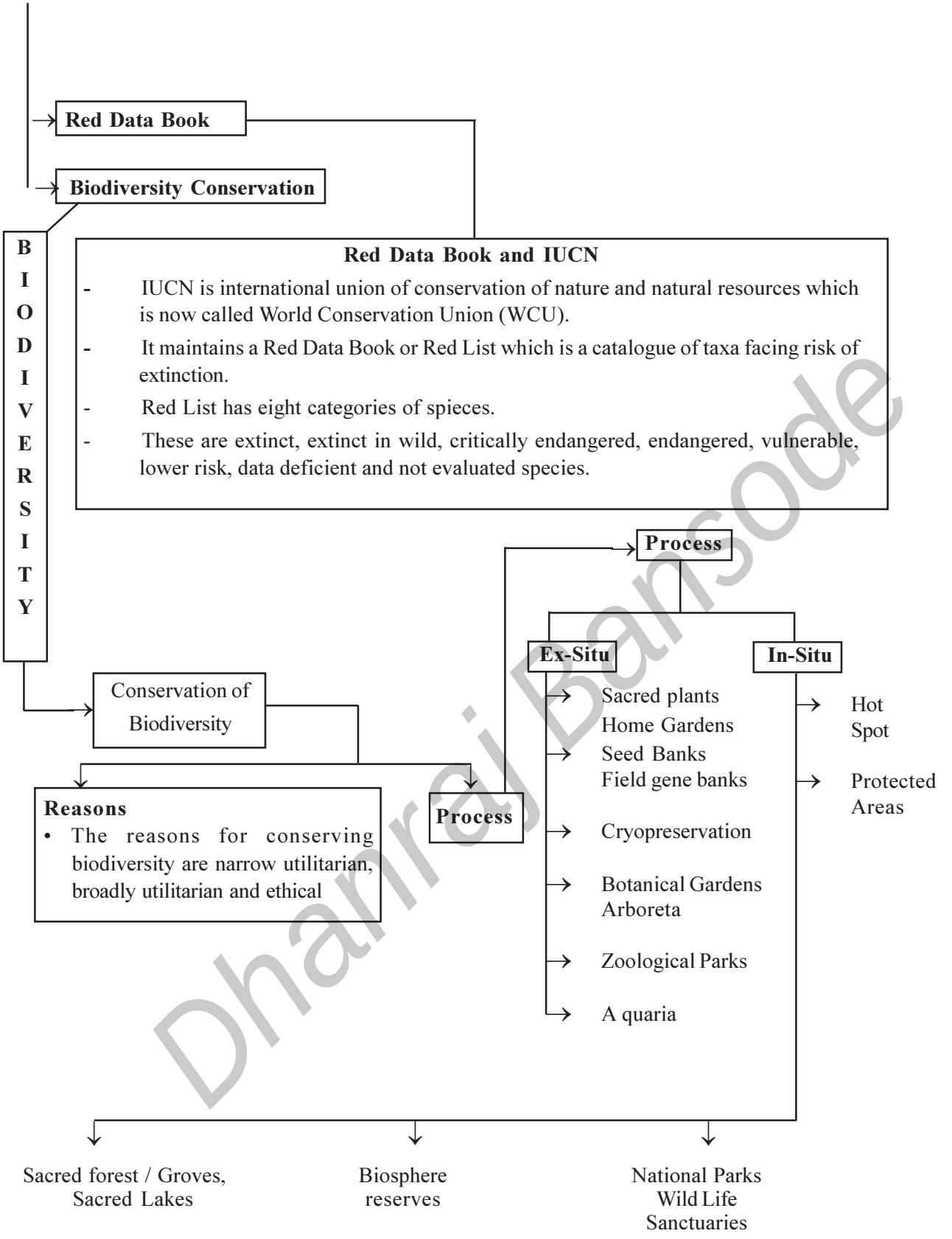
Most serious aspect of the loss of biodiversity is the extinction species

Types of extinction

- Natural extinction
- Mass extinction
- Antropogenic extinction

Factors contributing to extinction

- Habitat loss and fragmentation
- Over exploitation
- Alien species invasions
- Disturbance and Degradation
- Pollution
- Coextinctions
- Forestry
- Intensive Agriculture



Environmental Issues

Pollution

- It is 'undersirable change in physical, chemical and biological properties of air, water and soil, which directly or indirectly affect human beings.'

Air pollution

- Primarily results from burning of fossil in industries and automobiles.
- Effects include reduction in growth and yield of crops and their premature death. Affects respiratory system of humans and of animals.
- Devices such as setting chamber, cyclonic separators, bag filters, electrostatic precipitators etc. are used to control air pollution.
- Noise is also considered air pollutant.

Water pollution

- It is deterioration of water quality that makes it unfit for consumption.
- Causes are domestic sewage, industrial discharge, surface run off containing pesticides, detergents, fertilizers, silt etc., oil spills.
- Consequences of water pollution are :
  - decreased DO
  - increased BOD
  - eutrophication
  - biomagnification
  - thermal pollution
  - health hazards
- Water pollution can be controlled sewage treatment.

Solid waste management

- Solid waste refers to everything that goes out in trash.
- Sources of solid wastes are municipal wastes, industrial wastes, mining wastes, hazardous wastes, defunct ships and electronic wastes.
- Disposal of wastes consists of recovery and recycling, source reduction, burning and dumping (landfills).

Agrochemicals and their effects (Soil pollution)

- Pesticides, fertilizers, chemicals and radioactive wastes are the main source.
- Control measures include :
  - → Organic farming
  - → Solid waste disposal
  - → Soil conservation by terrace farming, growing grazing fields, afforestation, reforestation

Radioactive pollution

- Pollution of air, water and soil with radio-active materials.
- It is caused by atomic weapons and atomic explosions, atomic reactors and nuclear fuel, mining of radioactive materials.
- These waste should be changed into harm-less form and stored in safe place where they may gradually decay in a harmless manner.

Greenhouse effect and global warming

- Greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surfce and atmosphere.
- Increased level of greenhouse gases (N_2O, CFCs, methane, CO_2) has led to considerable heating of earth leading to global warming. This is resulting in odd climatic changes, melting of ice caps etc.
- Control measures include cutting down use of fossil fuels, improving efficiency of energy usage, reducing deforestation, planting trees and slowing down the growth of human population.

Ozone layer depletion

- Ozone layer (layer which protects life on earth from harmful effects of UV radiations) is being depleted by ozone depleting substances (ODS), such as chlorofluorocarbons, nitrogen oxides, hydrocarbons etc.
- Ozone depletion of thinned ozone layer (ozone hole) is particularly marked over Antarctic region.
- It causes aging of skin, damage to skin cells and various types of cancer, snow blindness, cataract etc.

Deforestation

- It is the conversion of forested areas to non-forested ones.
- It results in enhanced CO_2 concentration, loss of biodiversity, disturbed hydrological cycle, soil erosion, and desertification.

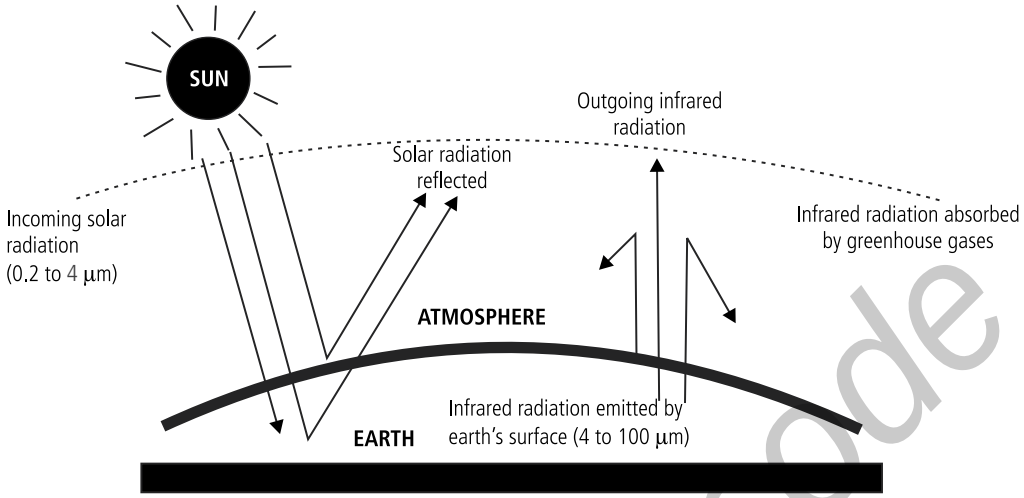


Fig. : Greenhouse effect

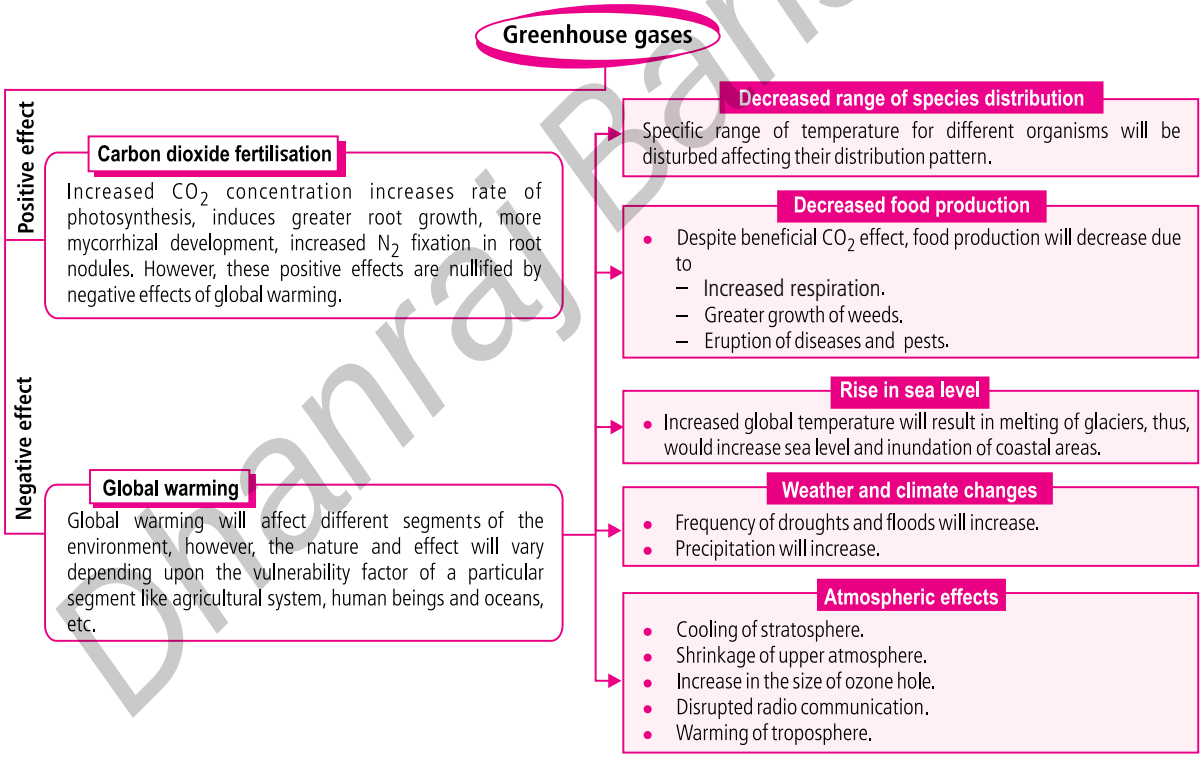


Fig.: Effects of greenhouse gases

- The various greenhouse gases are **CO_2 (warming effect 60%), CH_4 (20%), chlorofluorocarbons or CFCs (14%) and N_2O (6%).** Others of minor significance are **water vapours** and **ozone**.
- Scientists believe that increased input of CO_2 and other greenhouse gases into the atmosphere will increase the earth's natural greenhouse effect and raise the average global temperature of the atmosphere near the earth's surface. This enhanced greenhouse effect is called as **global warming**.

Methods to reduce greenhouse gas emissions

(i) Reduce, Reuse, Recycle. Buying products with minimal packaging will help to reduce waste.
(ii) Use less heat and air conditioning system.
(iii) Use more public transport system.
(iv) Plant more trees.
(v) Use more renewable sources of energy.