PLUS ONE ZOOLOGY

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edu help programme

STUDY MATERIAL

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HIGHER SECONDARY NATIONAL SERVICE SCHEME

CHAPTER : LIVING WORLD

Diversity in the living world

Biodiversity is the number and type of organisms in the world ; global biodiversity is estimated to be 1.7-1.8 million

Nomenclature

System of providing scientific names to organisms so that an organism is known by same name all over the world

International agencies of nomenclature

ICBN – International Code for Botanical Nomenclature

ICZN - International Code for Zoological Nomenclature

Binomial Nomenclature

System of naming where each name has two parts; proposed by **Carl Linnaeus**

Rules of Binomial Nomenclature

1. Each name has two parts; first part denotes genus name and second part denotes species name
2. Genus name must start with capital letter and specie name must start with small letter
3. Names are derived from Latin and must be written in italics
4. When hand written names must be underlined separately

Mangifera indica - Mango

Homo sapiens – Man

Musca domestica – Housefly

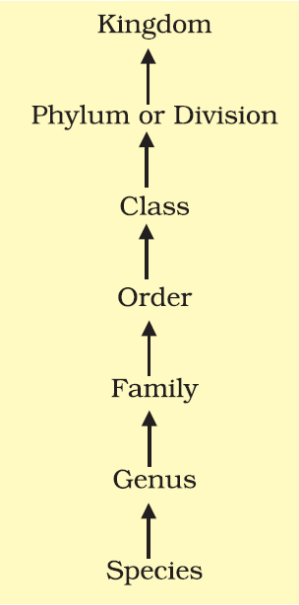
Mangifera indica Linn. Linn indicate name of author (Linnaeus)

Taxonomy is classification of organisms based on internal, external and cellular characters.

Each unit in taxonomy is called **taxa**.

Systematics – taxonomy considering evolutionary relationships; introduced by **Carl Linnaeus** in his book ***Systema Nature*.**

Taxonomic categories in ascending order



Organisms with their Taxonomic Categories

Common Name	Biological Name	Genus	Family	Order	Class
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta

Taxonomical Aids

Taxonomical Aids	Feature
1. **Herbarium**	**Dried and preserved plant parts**
2. **Botanical Garden**	**Living plants**
3. **Museum**	**Dead and preserved plants and animals**
4. **Zoo**	**Wild animals**
5. **Keys**	Identification of animals and plants based on their **similarities and dissimilarities**

Examples for Keys

Flora – account of habitat and distribution of plants of an area;

Monograph – information about any one taxon;

Manuals – provide information for identification of names of species found in an area

CHAPTER ANIMAL KINGDOM

Classification based on levels of organization

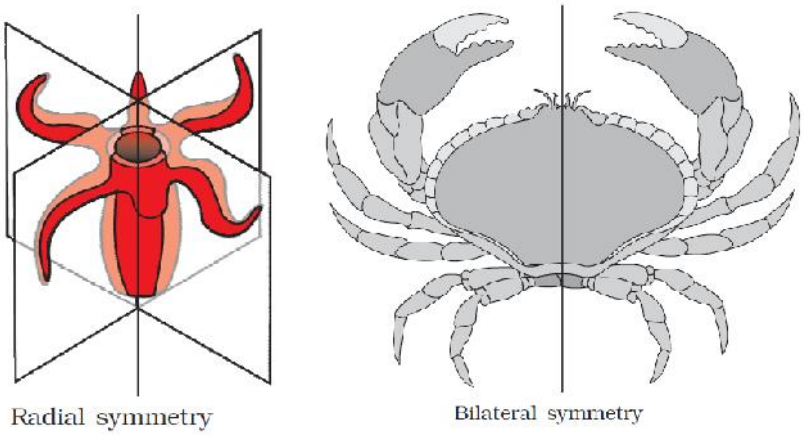
Level of organization	Examples
Cellular level	Porifera (Sponges)
Tissue level	Cnidaria (Hydra, Jelly fish)
Organ level	Platyhelminthes (Tape worm, liver fluke)
Organ system level	Aschelminthes, Annelida Chordate etc,

Closed circulation – presence of blood vessels for circulation. Eg. Earth worms, all higher animals

Open circulation – absence of blood vessels; blood flows through open spaces. Eg. Arthropods

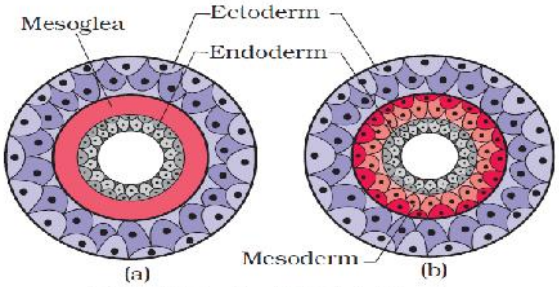
Classification based on symmetry

Asymmetry	Body cannot be divided into equal halves through any plane passing through the center Eg. Porifera - Sponges
Radial symmetry	Body can be divided into equal haves through any plane passing through the center Eg. Cnidaria – Hydra; Ctenophora
Bilateral symmetry	Body can be divided into equal right and left halves Eg. All higher animals



Classification based on Diploblastic and triploblastic organisation

Diploblastic	2 germ layers (ectoderm and endoderm)	(Cnidaria), Ctenophora
Triploblastic	3 germ layers(ectoderm, mesoderm and endoderm)	Flat worms (Platyhelminthes) Chordate



(a) Diploblastic (b) Triploblastic

Classification based on Coelom

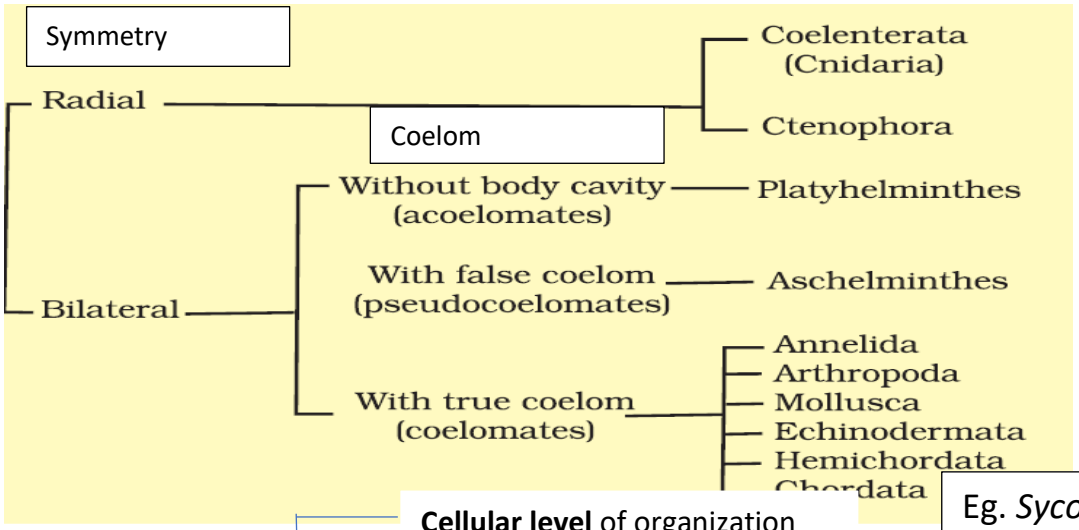
Nature of coelom	Character	Example
Acoelomate	No coelom	Platyhelminthes
Pseudocoelomate	Coelom as pouches	Aschelminths
Coelomate	True coelom lined by mesoderm	Annelids , Chordate

Metamerism – body divided into compartments eg. Earthworm (Annelida)

Notochord

Notochord is mesodermaly derived rod like structure seen on the dorsal side of embryo.

A. **Chordates** – possess notochord; Eg. Fish, Frog , Man etc
B. **Non chordates** – notochord absent eg. Arthropoda, Annelida etc.



Phylum Porifera

- **Cellular level** of organization
- **pores** on body
- **Asymmetric**
- **Canal system** (food collection, respiration and excretion)
- **Choanocytes (**special cells lining canals)
- **Spongin** fibers (support)

Eg. *Sycon, Euspongia* (Bath sponge), *Spongilla* (Fresh water sponge)

Phylum Cnidaria

- **Cnidoblasts**
- **Polyp and Medusa (**Two body forms)
- **Alternation of generation (Metagenesis)**
- Gastrovascular cavity opens by **hypostome** (mouth)

Eg. **Corals** (have calcium carbonate exoskeleton), ***Physalia*** (Portuguese Man of War), **Sea anemone** (*Adamsia*), ***Pennatula*** (Sea Pen), ***Gorgonia*** (Sea Fan), ***Meandrina*** (Brain Coral).

Cnidoblast

Functions; anchorage, defense and food collection

Medusa – free swimming, sexual, umbrella shaped

Two body forms (a) **Medusa** (Eg. Jelly fish) (b) **Polyp** (Eg. Hydra)

Alternation of generation (Metagenesis) - Eg. In *Obelia* colony polyps produce medusa asexually and medusa p

Phylum Ctenophora

- **Comb jellies**
- **Comb plates** for locomotion
- **Diploblastic , Tissue level** of organization
- **Bioluminescence** (property of emitting light)

Eg, *Ctenoplana, Ctenophora, Pleurobrachia*

Phylum Platyhelminthes

- Dorsoventrally **flattened body** (Flat worms)
- **Acoelomates**
- **Organ level** of organisation
- **Flame cells** for excretion and osmoregulation
- **Parasitic adaptations** – hooks and suckers for attachment, absorb digested food through body surface.

Examples *:Taenia* (Tape worm) , Liver fluke (*Fasciola*), *Planaria* (high power of regeneration

Phylum Aschelminthes

- Body **divided into segments** (**metameres)**;
- **Nephridia** for excretion and osmoregulation
- **Dioecious** (Male and female separate)
- **Male smaller than female**
- Digestive system is complete with **muscular pharynx**

Examples : *Ascaris* (round worm), *Wuchereria* (Filarial worm), *Ancylostoma* (Hook worm)

- ***Nereis*** move with the help of **parapodia**
- Locomotion with the help of circular and longitudinal muscles

Examples a. Earthworm, b. Leech, c. Nereis

Phylum Arthropoda

- **Jointed legs** (hence name Arthropoda)
- **Chitinous exoskeleton**
- Body divided into **head, thorax and abdomen**
- Respiration by **trachea/ gills / book gills / book lungs**
- Excretion by **Malpighian tubules**
- Sense organs are antennae, compound eyes and statocysts (Balance)

Examples

Phylum Mollusca

Soft bodied animals

Calcareous shell

Body divisions- **head, visceral hump and foot**

Mantle covers visceral hump

Examples: *Pila* (Apple Snail), *Pinctada* (Pearl Oyster), *Octopus* (Devil Fish), *Sepia* (Cuttle fish), *Dentalium* (Tusk Shell) etc.

Phylum Echinodermata

Spiny bodied

Adult radially symmetrical and larva bilaterally symmetrical

Mouth on lower (ventral) side and anus on upper(dorsal) side

water vascular system – food collection, transport, respiration

Examples: *Asterias* (Star fish), *Ophiura* (Brittle star), *Antedon* (Sea lily), *Cucumaria* (Sea cucumber), *Echinus* (Sea Urchin)

Phylum Hemichordata

Marine worm like animal

Body divisions **Proboscis, Collar and Trunk**

Excretion by **proboscis gland**

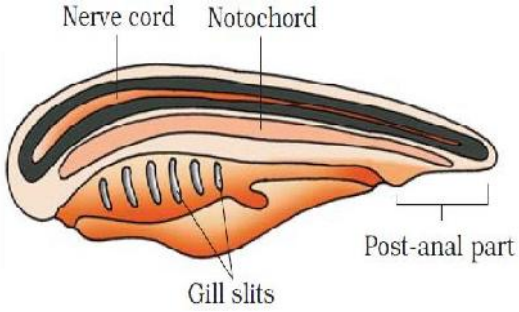
Open circulation

Examples: *Balanoglossus* and *Saccoglossus*

Phylum Chordata

Distinguished features of Phylum Chordata

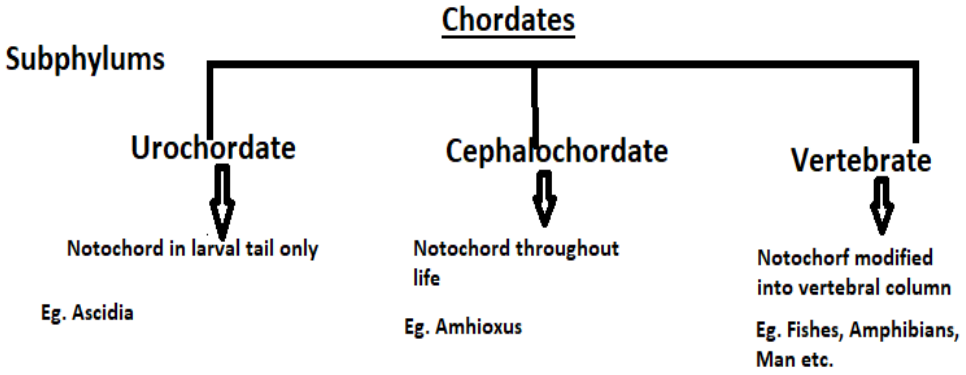
a. **Dorsal, hollow nerve chord**
b. **Notochord**
c. **Pharyngeal gill slits**
d. **Post anal tail**



Comparison of Chordates and non-chordates

S.No.	Chordates	Non-chordates
1.	Notochord present.	Notochord absent.
2.	Central nervous system is dorsal, hollow and single.	Central nervous system is ventral, solid and double.
3.	Pharynx perforated by gill slits.	Gill slits are absent.
4.	Heart is ventral.	Heart is dorsal (if present).
5.	A post-anal part (tail) is present.	Post-anal tail is absent.

Classification of chordates

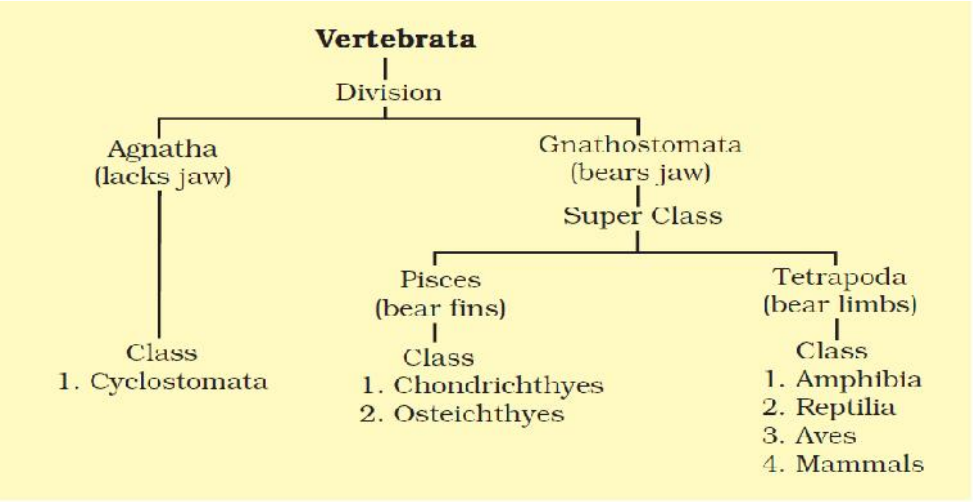


All vertebrates are chordates but all chordates are not vertebrates

Vertebrate is a subphylum under Chordate. There are other sub phylum like urochordate and cephalochordate under Chordate.

Protochordates – Urochordates and cephalochordates

Classification of subphylum Vertebrates



Class Cyclostomata

Ectoparasites on fishes;

6-15 gill slits;

Sucking and suctorial mouth without jaws;

No scales and paired fins;

Cartilaginous; closed circulation,

Examples : Petromyzon, Myxine (Hag fish)

A jawless vertebrate - *Petromyzon*

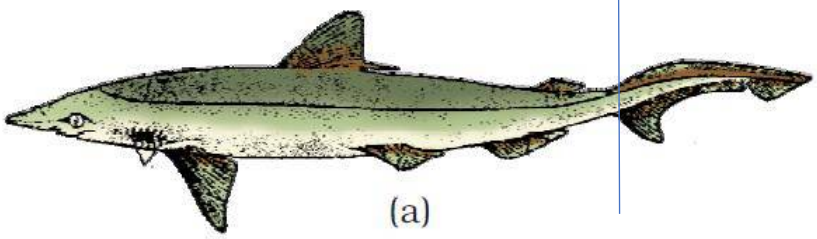
Super class Pisces

Presence of streamlined body; presence of gills and scales; cold blooded (**Poikilothermous**- do not have fixed body temperature), two chambered heart.

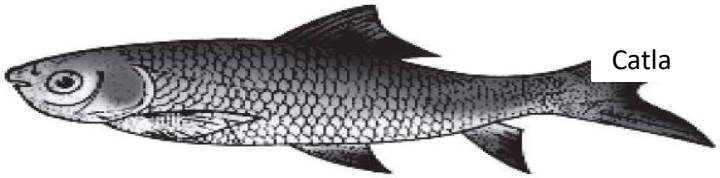
Comparison of cartilaginous fishes and Bony fishes

Class Chondrichthyes	**Class Osteichthyes**
Cartilaginous endoskeleton	Bony endoskeleton
No operculum	Operculum present
Placoid scales	Cycloid or ctenoid scales
Eg. Shark (Scoliodon), Pristis (Saw fish), Carcharodon (Great white shark) Trygon (Electric ray)	Eg. Exocoetus(Flying fish), Hippocampus (Sea Horse) Rohu, Catla, Angel fish

Scoliodon



(a)



Catla

(b)

Class Amphibia

Live both on land and water	Skin moist for **cutaneous respiration**
Body divided into **head and trunk**	**Tympanum** represents ear
External fertilisation	Respiration by **gills, lungs and skin**
3 chambered heart	Oviparous

Example : *Bufo* (Toad); *Frog* (Rana); *Hyla* (Tree fog); *Salamandra*; *Icthyophis* (Limbless amphibian)

Class Reptilia

Dry cornified skin with scales Crawling mode of locomotion

Poikilothermous **Skin cast** present on snakes

3 chambered heart except in Crocodiles

Examples : Snakes, Lizards, Chameleon, Tortoise, Turtle, Crocodiles, Alligators

Class Aves

Flight adaptations

Feathers, Wings, streamlined body, **Pneumatic bones** (Bones with air cavities), **Air sacs** associated with lungs (provide air during flight)

Homeothermous (warm blooded / constant body temperature)

Examples : Crow, Pigeon, Parrot, Ostrich (flightless birds)

Class Mammalia

Presence of **mammary glands** Viviparous

Presence of **pinnae** (external ear) Body hair present

Four chambered heart Homeothermous

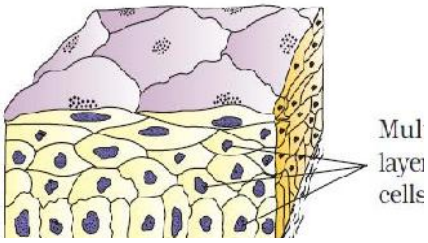
Examples : Man, Apes, Monkeys, Platypus (egg laying), Pteropus (Bat / flying); Whales and Dolphins (aquatic), Kangaroo (Marsupial)

CHAPTER STRUCTURAL ORGANISATION IN ANIMALS

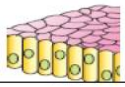
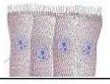
Epithelial tissue

Simple epithelium
Single layered, lines body cavities and ducts

Compound epithelium
Multi layered, protective, lines skin, buccal cavity etc.

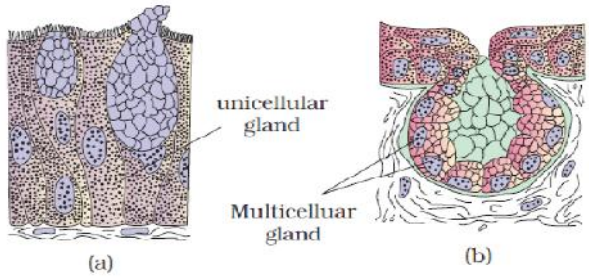


Types of simple epithelium

Name	Shape	Location	Function
Squamous	Flat, irregular 	Alveoli, Capillary	Diffusion
Cuboidal	Cube shaped 	Ducts of glands, Kidney tubules	Secretion and absorption
Columnar	Tall cylindrical 	Stomach and intestine	Secretion and absorption
Ciliated	Presence of cilia 	Fallopian tube, Bronchioles	Movement of particles

Types of glands – Based on number of cells

Unicellular gland	Multi cellular gland
Single cell act as gland Eg. Goblet cells secreting mucus	Gland with many cells Eg. Salivary glands



Types of glands – Based on mode of secretion

Exocrine gland	Endocrine gland
Secrete digestive juices	Secrete hormones
Presence of ducts	Ductless
Eg. Salivary glands	Eg. Thyroid, Pituitary

Cell junctions – provide structural and functional links between cells

1. **Tight junction –** do not allow particles to pass through
2. **Gap junction -** allow particles to pass through
3. **Adhering junction –** joining adjacent cells

CONNECTIVE TISSUE

Most abundant tissue; connecting supporting and linking of various organs;

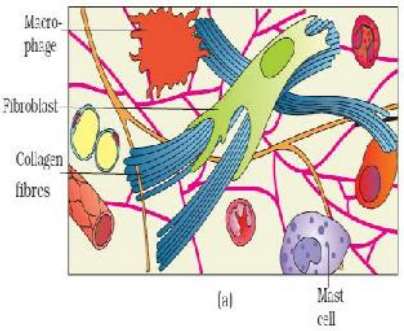
Connective Tissue

Loose Connect Tissue	Dense Connective Tissue	Special Connective
Eg. Areolar tissue	Eg. Tendon	Eg. Blood

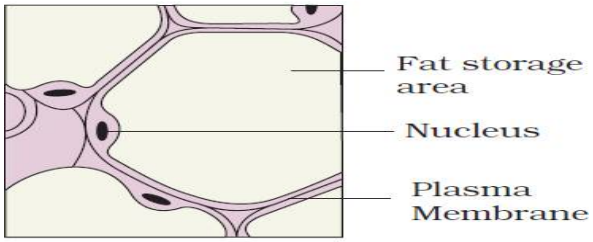
Adipose Tissue Ligament Bone

Loose Connect Tissue – cells and fibers are arranged loosely in a semifluid matrix

Eg. A**. Areolar tissue** -found under the skin and support skin;

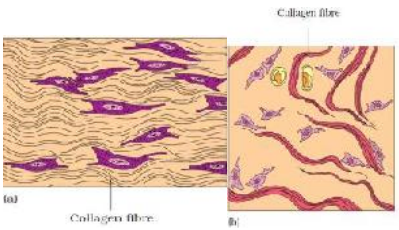


Adipose Tissue- found under the skin and store fat



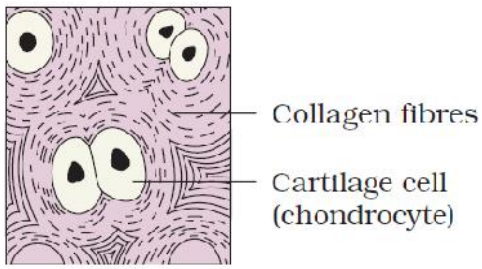
Dense Connective tissue – fibers and cells packed tightly in dense matrix

Dense regular – fibers arranged in regular pattern; Eg. **Tendons** – connect bones with muscles.
Ligaments – connect bones with bones



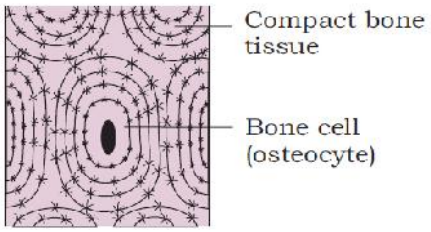
Dense connective tissue:
(a) Dense regular
(b) Dense irregular

Specialized connective tissues



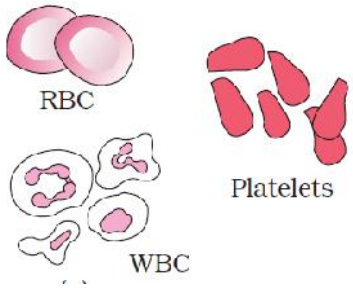
Cartilage – found in tip of nose, pinnae etc

Cartilage forming cells - **Chondrocytes**



Bone – hard matrix with calcium salts and collagen fibers

Bone forming cells – **Osteocytes**



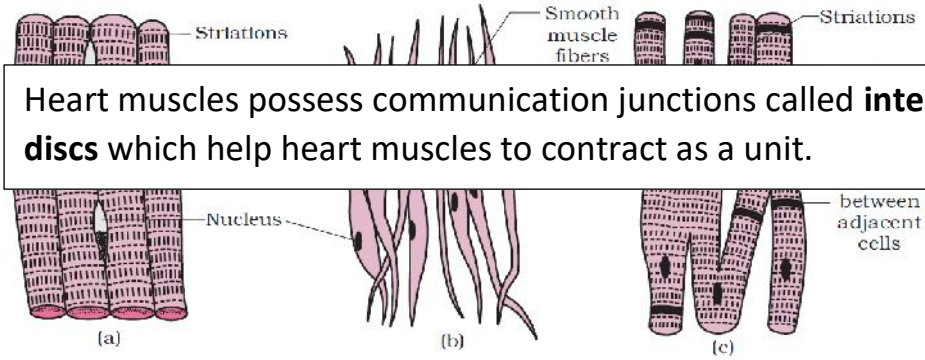
Blood

Fluid connective tissue

Muscular Tissue

Comparison of 3 types of muscles

Skeletal muscles	Smooth muscles	Cardiac muscles
Connected to skeleton (Hands, legs, biceps etc.)	Found in visceral (blood vessels, stomach, intestine)	Found in heart only
Striated	Nonstriated	Faint striations
Spindle shaped	Fusiform	Cylindrical
Voluntary	Involuntary	Involuntary



Muscle tissue : (a) Skeletal (striated) muscle tissue (b) Smooth muscle tissue (c) Cardiac muscle tissue

Heart muscles possess communication junctions called **intercalated discs** which help heart muscles to contract as a unit.

NEURAL TISSUE

Formed of neurons and neuroglia. **Neurons** are the functional units; **Neuroglia** are supporting cells which make up more than half of neural tissue.

Cockroach

Body divided into **head, thorax and abdomen**

Body covered with **chitinous exoskeleton**

Sclerites - hardened plates in exoskeleton

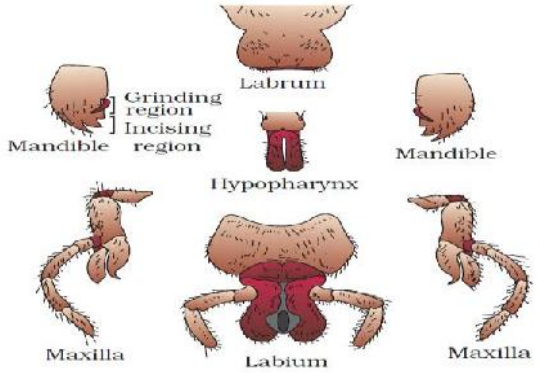
Tergites - Dorsal plates

Sternites - ventral plates

Arthrodial membrane – joins dorsal and ventral plates

Head - Formed of 6 fused segments; head bears a pair of compound eyes, a pair of antennae and mouth parts

Mouth parts are **biting and chewing type**



Thorax

Thorax has 3 segments. **Prothorax, mesothorax and metathorax**. Each thoracic segment bears a pair of walking legs. Mesothorax bear a pair of wings

Mesothoracic wings - dark, opaque, not used in flight, cover the hind wings and abdomen during flight.

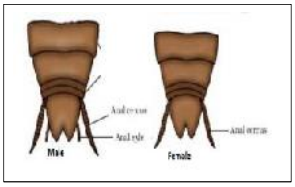
Metathoracic wings are transparent, membranous and used in flight

Abdomen

Abdomen has 10 segments. The last abdominal segment has a pair of **anal cerci** (sensory). Male has a pair of short thread like structure called **anal styles**.

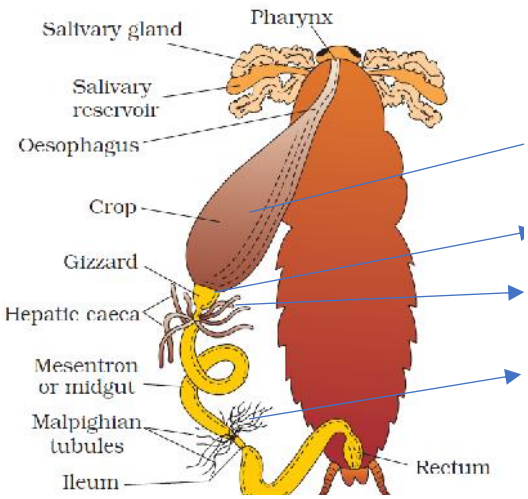
Differentiation of male and female cockroaches

Male	Female
Anal style present	Anal style absent
Abdomen pointed	Abdomen broad
7th sternum normal	7th sternum boat shaped



Anatomy

Digestive system



Crop store food

Grinding food.

Secrete digestive juices

Excretion

Respiratory system

Tracheal system perform respiration;air from outside enter trachea through 10 pairs of openings called spiracles.

Spiracles → **Trachea** → **Tracheole** → **Muscles** ;

Gas exchange take place at tracheoles ; blood has no role in gas transport.

Excretory system

Excretion is by **Malpighian tubules**; **fat body, nephrocytes and urecose glands** also help in excretion: excretory product is uric acid (**uricotelic**

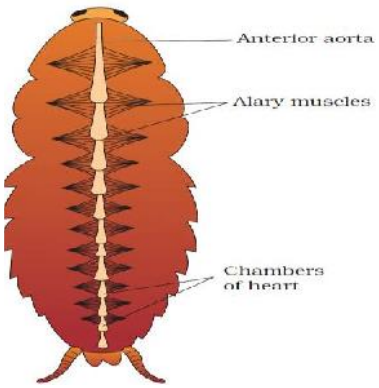
Blood vascular system

Open type circulation

Body cavity – **haemocoel**;

Body fluid – **haemolymph**

Hemocytes – Blood cells which are phagocytic



Muscular heart with funnels

Heart opens to sinuses through **ostia**

Ostia opened and closed by **alary muscles**

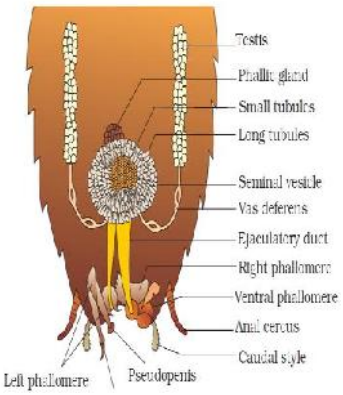
Nervous system

Nervous system include **segmentally arranged ganglia and ventral double nerve chord** ; brain is represented by **supra esophageal ganglion**; nervous system is spread throughout body; head bears only a bit of nervous system ; so cockroach can live for some more time even after the head is cut off

Sense organs – a pair of antennae, anal cerci, maxillary palp, labial palp and a pair of compound eyes;

Compound eye is formed of small units called **ommatidia;** vision using compound eye is called **mosaic vision**; mosaic vision has high sensitivity and less resolution

Reproductive system



Male reproductive system

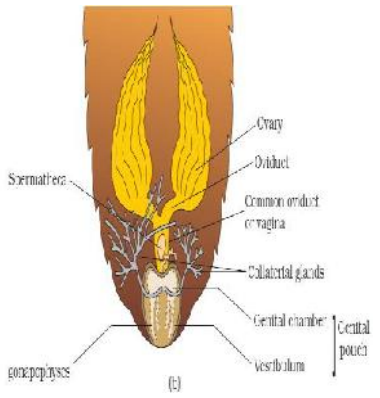
A pair of **testis** – produce sperms

A pair of **vas deference** – carry sperms

Mushroom gland and **phallic glands**– produce secretions

Phallomere – male gonapophysis/ external genitalia / help mating

Seminal vesicles – store sperms and make them into bundles called **Spermatophore**



Female reproductive system

A pair of **ovaries** – produce ovum; ovary has units called ovariole;

Oviducts – carry ovum; oviducts ioin to form common vagina

A pair of **spermathecae**

Colleterial glands – pro sperms active

Development is **paurometabolous** (development stage);nymph undergoes moulting 13 times.

Chapter Biomolecules

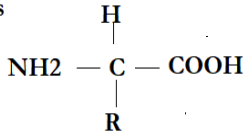
A Comparison of Elements Present in Non-living and Living Matter*

Element	% Weight of Earth's crust	% Weight of Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	negligible

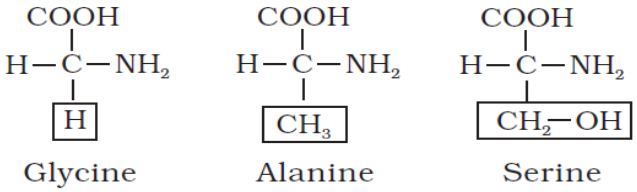
Living things and nonliving things can be identified from the proportion of elements Carbon, Hydrogen Oxygen and Nitrogen present in them. Living things have comparatively large quantities of these elements

Amino acids - substituted methane

Structural formula of amino acids



Based on R group amino acids vary; there are 20 amino acids in proteins



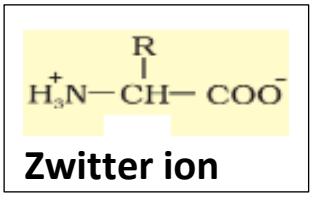
Amino acids

Acidic amino acid Eg. Glutamic acid

Basic amino acid Eg. Lysine

Neutral amino acid Eg. Valine

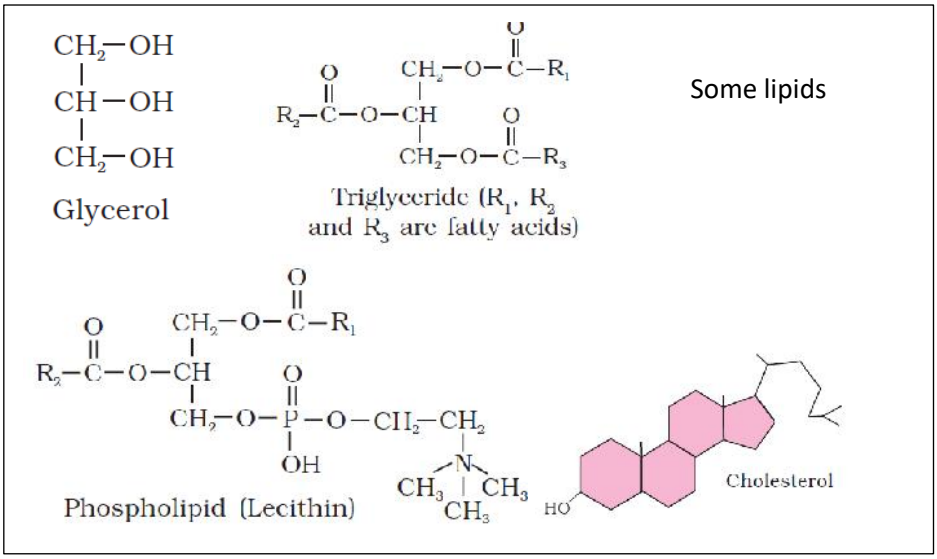
Aromatic amino acid Eg. Tyrosine, Tryptophan, Phenyl alanin



Zwitter ion – ionized form of amino acid

Lipids

Water insoluble biomolecule; **Palmitic** acid has 16 carbon chain and **Arachidonic acid** has 20 carbon chain



Fats – lipids with high melting point; remain solid in winter.

Oils - lipids with low melting point; remain liquid

Some lipids have phosphate group associated with them; they are called **phospholipids**; Eg. **Lecithin** found on **cell membrane**

In lipids fatty acids are esterified with glycerol

1 Glycerol + 1 fatty acids → Monoglyceride

1 Glycerol + 2 fatty acids → Diglyceride

1 Glycerol + 3 fatty acids → Triglyceride

Nitrogen Bases

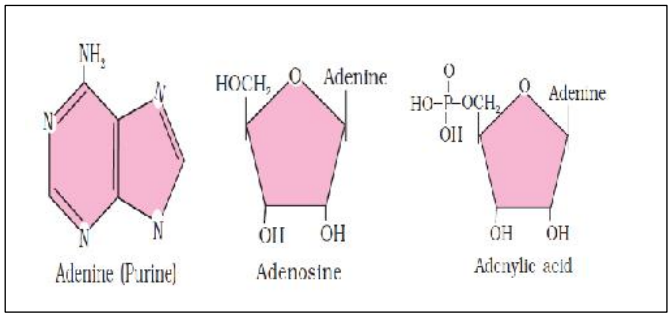
Carbon compounds with heterocyclic rings; they are classified int two categories;

Purines – with double rings; Eg. Adenine and Guanine

Pyrimidines -with single rings Eg. Cytosine, Thymine, Uracil

Nitrogen base + Sugar → Nucleoside

Nitrogen base + Sugar + Phosphate → Nucleotide



DNA and RNA which are the genetic material are polynucleotides

A, G, C T – found in DNA

A,G, C, U – found in RNA

Adenosine, Guanosine ,Cytidine, Uridine are Egs. Of nucleosides.

Adenylic acid, Guanylic acid, Cytidylic acid , Uridylic acid are nucleotides

Primary and secondary metabolites

Primary metabolites	Secondary metabolites
Present in both animal and plant cells	Present only in plant cells & Fungi
Have definite roles in metabolism	No definite role in cells ; important in human welfare.
Eg. Amino acids, glucose, Nitrogen bases etc	Eg. Pigments, alkaloids, gums, rubber etc

Some Secondary Metabolites

Pigments	Carotenoids, Anthocyanins, etc.
Alkaloids	Morphine, Codeine, etc.
Terpenoides	Monoterpenes, Diterpenes etc.
Essential oils	Lemon grass oil, etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin, etc.
Polymeric substances	Rubber, gums, cellulose

Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

Biomacromolecule; Eg. Polysaccharides, proteins, nucleic acids etc.

Lipids are not biomacromolecules but they appear in acid insoluble pool. This is because lipids are insoluble in water. When we grind them they form vesicles. Vesicles get separated along with acid insoluble pool.

Most abundant component of cell - **Water**

Most abundant c organic component of cell - **Protein**

Proteins

Proteins are polypeptides formed of linear chains of amino acids ; there are 21 types of amino acids in protein; **proteins are heteropolymers** because they are formed of different amino acids

Some Proteins and their Functions

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4	Enables glucose transport into cells

Essential amino acids – amino acids which cannot be synthesized in body; must be supplied through diet;

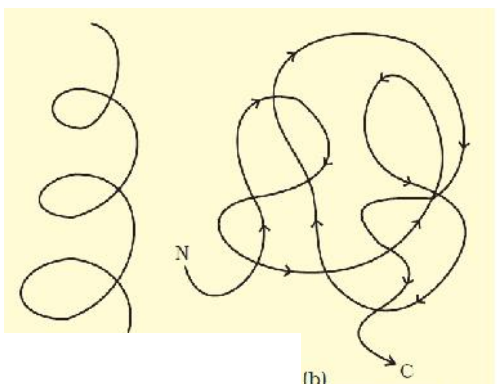
Non essential amino acids – can be synthesized in body

Most abundant protein in animals – **Collagen**

Most abundant protein in plants – **RUBISCO**

(Ribulose Biphosphate Carboxylase Oxygenase

Structure of proteins



Proteins exist in 4 structural forms;

Primary structure – linear arrangement of amino acids in polypeptides

Secondary structure- polypeptide chain is folded in the form of helices

Tertiary structure – polypeptide is folded upon itself like a woolen ball; important in biological activities

Quaternary structure – presence of more than one

Polysaccharides

Polysaccharides are long chains of sugars connected by glycosidic bonds

Cellulose – Homopolymer of glucose found in cell walls of plants (paper, coir, cotton)

Starch - Homopolymer of glucose , stored food in plants

Glycogen - Homopolymer of glucose, stored food in animals

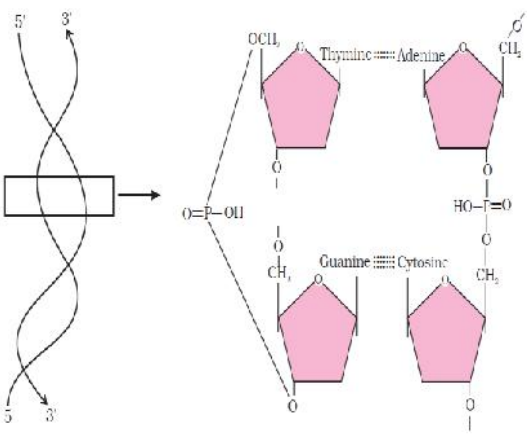
Inulin - Homopolymer of fructose

Chitin – heteropolymer present in exoskeleton of arthropods

Nucleic acids

DNA and RNA are polynucleotides; they act as genetic material

Structure of DNA



Double helix model of DNA was explained by **Watson and Crick**;

DNA has **sugar phosphate back bone**; Nitrogen base pairs project inside;

Two polynucleotide strand run in opposite direction hence they are said to be **antiparallel;**

Adenine always pair with Thymine by a double bond **(A=T);** Guanine always pair with Cytosine by a triple bond **(G ≡ C)**.

Pitch of DNA – 3.4nm or 34Å

Diameter – 20 Å

Distance between base pair - 3.4 Å

Number of base pairs per turn - 10

Right handed coiling DNA with these features is called **B DNA**

Nature of bond linking monomers in a polypeptide

Protein – Peptide bond

Polysaccharide - Glycosidic bond

Nucleic acid - 3^1-5^1 Phosphodiester bond

Dynamic state of body constituents - Concept of Metabolism

Biomolecules show chemical reactions inside the cell. All these reactions are together called **metabolism**). Metabolic reactions are catalyzed reactions, they are catalyzed by biological catalysts called **enzymes**.

Metabolic basis for living

Anabolic reactions – metabolic reactions which lead to synthesis of complex molecules. Eg. Synthesis of acetic acid from cholesterol

Catabolic reactions - metabolic reactions which lead to breaking down of complex molecules into simple units Eg. Glucose to lactic acid (glycolysis)

Metabolic reactions require energy. Energy is provided by **ATP (Adenosine Triphosphate), the energy currency of cell.**

Living state

Living state is a nonequilibrium steady state to be able to perform work

Enzymes

Enzymes are **biological catalysts**; all enzymes are proteins with few exceptions; In enzymes polypeptide has specific pockets called **active site** to which substrate binds; **Ribozymes** are RNA acting as enzyme.

Difference between enzymes and inorganic catalysts

Enzymes work well at a limited range of temperature; enzymes are destroyed at high temperature; inorganic catalysts work well at high temperature

Enzyme catalyzed reactions take place at a faster rate

Eg. Consider the reaction

$$CO_2 + H_2O \xrightarrow{\text{Carbonic anhydrase}} H_2CO_3$$

carbon dioxide — water — carbonic acid

In the absence of enzyme **carbonic anhydrase** this reaction take place at a slower rate; 200 molecules per hour are formed; in presence of enzyme carbonic anhydrase 6 lakh molecules are formed per sec.

Nature of enzymes action

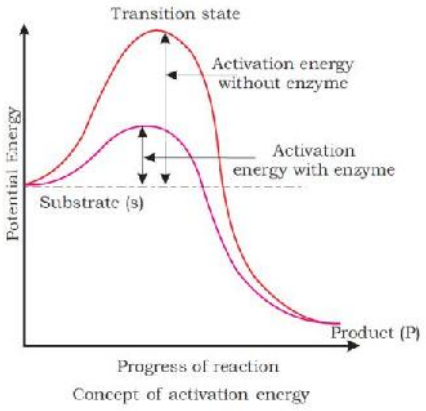
E + S → ES → EP → E + P

Enzyme combine with substrate and form enzyme substrate complex

Inside the complex substrate is converted to product

Enzyme product complex break releasing enzyme

Concept of Activation energy



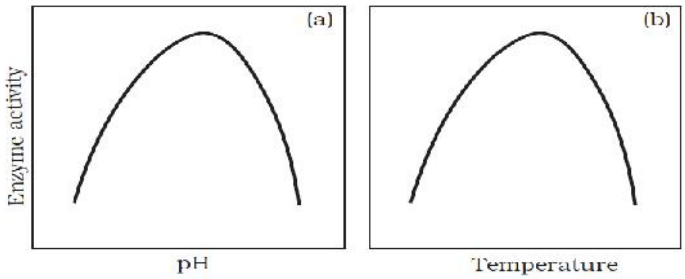
Concept of activation energy

Enzyme decreases activation energy and speed up conversion of "S" to "P"; activation energy is the energy needed to attain transition state

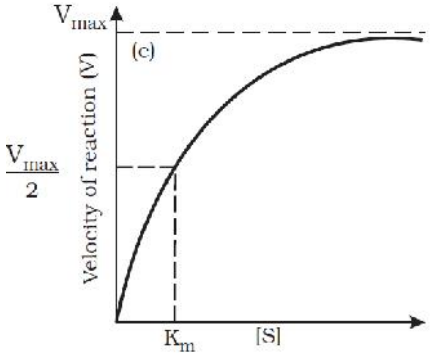
Factors affecting enzyme activity

1. **pH** –Enzyme activity increases with increase in pH up to a limit. Enzyme activity is maximum at **optimum pH.** After optimum pH further increase in pH will destroy enzyme activity.
2. **Temperature** - enzyme activity increases with increase in temperature up to a limit. Enzymes are inactive at low temperature and destroyed at high temperature. Enzyme activity is maximum at **optimum temperature.** After optimum temperature further increase in

temperature will destroy enzyme activity



3. **Substrate concentration** Enzyme activity increases with increase in substrate concentration up to a limit; further increase in substrate concentration does not bring any change in enzyme activity; this because all enzyme molecules are saturated with substrate molecules
V max – substrate concentration at which enzyme activity is maximum



Inhibition of enzyme activity

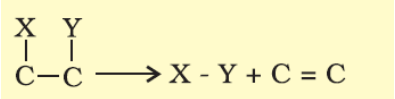
Binding os certain substances called **inhibitors** will retard or stop enzyme activity. Eg**. Competitive inhibition** - certain substances resembling substrate bind with enzyme and block its active site**.** Eg. For enzyme **succinic dehydrogenase**, the substrate is succinate; but is competitively inhibited by malonate.

Competitive inhibition is used in the control of bacterial pathogens**.**

Classification and Nomenclature of Enzymes

Enzymes are classified into 6 classes.

Sl. No.	Category	Nature of action
1.	Oxidoreductases/ Dehydrogenases	Oxidation/ reduction reactions **S** Reduced + **S**^{1} Oxidized ▸ **S** Oxidized + **S**^{1} Reduced
2.	Transferases	Transfer of a group

		S – G + S^1 → S + **S^1- G**
3.	Hydrolases	Hydrolysis of ester, peptide, glycosidic bonds etc.
4.	Lyases	Removal of groups 
5.	Isomerases	Interconversion of optic/ geometric isomers
6.	Ligases	Linking of two groups

Cofactors

Cofactors are nonprotein components connected to enzymes; they are essential to make enzymes catalytically active; enzymes have a protein part called **apoenzyme** and nonprotein part called **cofactor** ; if cofactors are removed from enzymes, enzymes become inactive.

Cofactors are of 3 types

1. **Prosthetic groups** – organic compounds tightly bound to enzymes; Eg. Haem is the prosthetic group for enzymes peroxidases and catalases
2. **Coenzymes** - organic compounds bound to enzymes only at the time of enzyme action; eg. NAD and NADP contain vitamin Niacin
3. **Metal ions** – in some enzymes metal ions act as cofactor. Eg. Zinc in enzyme carboxy peptidase

DIGESTION AND ABSORPTION

Dentition

Human dentition has 3 peculiarities

1. **Thecodont** – teeth are fixed in sockets of jaw
2. **Diphyodont** – 2 sets of teeth ; milk teeth and permanent teeth

Heterodont – 4 types of teeth; incisors, canines, premolars and molars

Teeth helps in **mastication**(chewing);

Tongue is connected to floor of oral cavity by **frenulum**; tongue bear taste buds ;

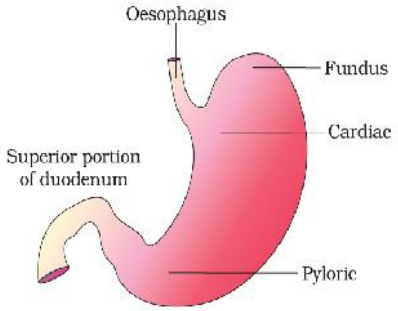
Pharynx – common passage for food and air

Laly S g of trachea at pharynx

Dental formula- – number and arrangement of teeth; It can be represented as

$\frac{2123}{2123}$ 2 incisors, 1 canine, 2 premolars 3 molars

Esophagus – muscular tube carrying food to stomach; no digestion in esophagus;



Stomach – J shaped muscular bag; has 3 regions; cardiac, fundus and pylorus

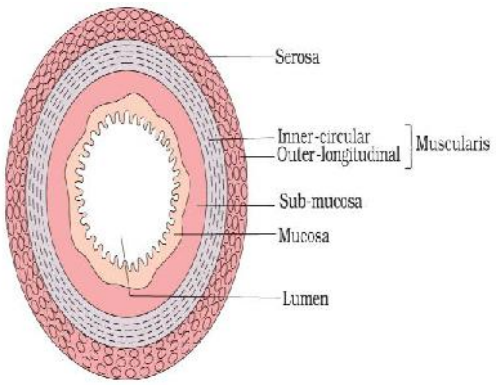
Gastroesophageal sphincter – guards the opening of esophagus to stomach

Pyloric sphincter – guards the opening of stomach to duodenum

Small intestine is divided into 3 regions caecum, colon and rectum

Caecum – first part; hosts symbiotic bacteria; vestigial organ called vermiform appendix; **colon** has 4 regions – ascending, descending transverse and sigmoid colons; **rectum** – last part; stores waste; reabsorbs water from waste and eliminate waste through anus

Anatomy of human gut



Serosa – outer layer of connective tissue

Muscularis – muscle layer; inner circular muscle layer and outer longitudinal muscle layer;

Submucosa – contain blood, nerves and glands like **Brunner's gland**

Mucosa – innermost layer; possess irregular folds in Stomach called **rugae** and **villi** in intestine **Rugae** – protect inner surface of stomach from HCl

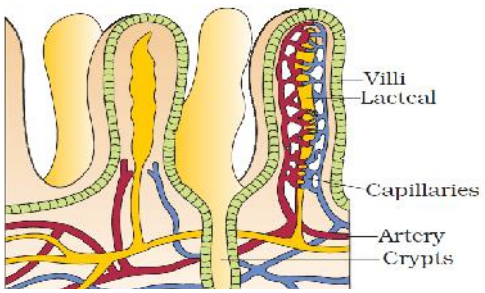
Villi – increase surface area for absorption

Laly

Mucosa forms glands in stomach (gastric glands)

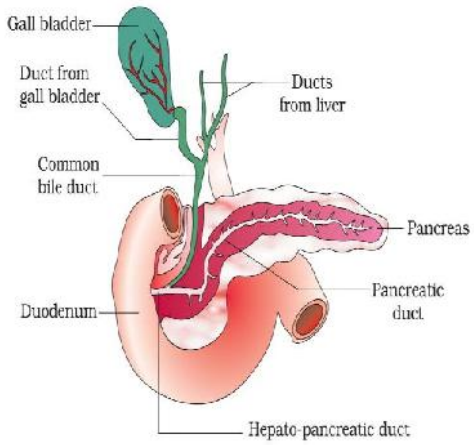
In between villi mucosal glands called **crypts of Lieberkühn** are present

Mucus cells in intestinal mucosa –



Digestive glands

1. **Salivary glands** – 3 pairs of salivary glands; **parotid**, **sublingual** and **submaxillary/submandibular** ; secrete saliva
   Liver – largest gland; has two lobes; structural and functional units are called **hepatic lobules**; hepatic lobules are covered by **Glisson's capsule**; liver secrete bile; bile is carried by hepatic duct; bile is stored in **gall bladder**; duct of gallbladder is called **cystic duct**; hepatic duct joins cystic duct to form common **bile duct**



Bile is carried by hepatic duct; bile is stored in **gall bladder**; duct of gallbladder is called **cystic duct**; hepatic duct joins cystic duct to form common **bile duct**; bile duct opens to duodenum along with pancreatic duct (**hepatopancreatic duct**) ; Hepatopancreatic duct carry bile and pancreatic juice

Sphincter of Oddi – valve at the opening of Hepatopancreatic duct to duodenum

3. Pancreas– second largest gland; situated at the U shaped part of duodenum; perform both exocrine and endocrine function(**Heterocrine gland**); exocrine part secrete pancreatic juice; endocrine part secrete hormones insulin and glucagon.

Digestion of food

Mechanical digestion – mastication in mouth and churning in stomach
Chemical digestion – digestion with the help of enzymes

Digestion in mouth

Mechanically digested food gets mixed with saliva; only starch is digested in mouth; saliva contains starch digesting enzyme called ptyalin/ salivary amylase.

$$\text{Starch} \xrightarrow[\text{pH 6.8}]{\text{Salivary Amylase}} \text{Maltose}$$

Partially digested food in mouth is converted into a ball (**Bolus**) and it is swallowed (**deglutition**); swallowed food moves down the digestive system by wave like contractions called **peristalsis**.

Lysozyme present in saliva act as antibacterial agent

Digestion in stomach

Stomach stores food for 4-5 hours; food is digested mechanically and chemically; Gastric glands have 3 types of cells

Mucus cells – secrete mucus

Chief cells/ Peptic cells – secrete pepsinogen

Parietal cells/ oxyntic cells – secrete HCl and intrinsic factor

$$\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin}$$

$$\text{Protein} \xrightarrow{\text{Pepsin}} \text{Peptones} + \text{Proteases}$$

Mucus and bicarbonate ions provide lubrication and protection of stomach wall;

Rennin present in gastric juice help digestion of milk protein in infants.

Digestion in small intestine

a. Digestion by pancreatic juice

Pancreatic juice contain **protein digesting enzymes** called trypsin, chymotrypsin and carboxy peptidase; **carbohydrate digesting enzyme** called pancreatic amylase; **fat digesting enzyme** called pancreatic lipase and **nucleic acid digesting enzyme** called nucleases. So it is called a **complete digestive juice**.

Enterokinase is a nondigestive enzyme produced by small intestine.

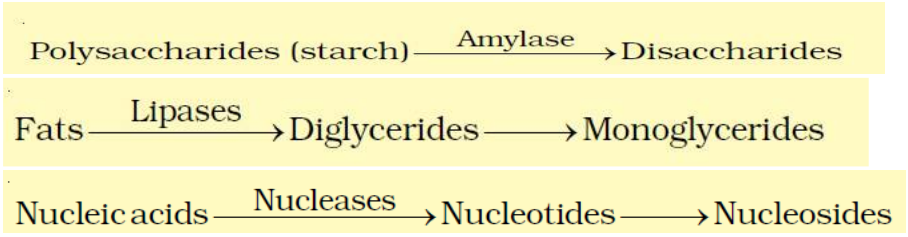
Protein digesting enzymes are secreted inactive and converted to active at the time of reaction; if they are secreted active they will digest proteins on the wall of intestine

$$\text{Trypsinogen} \xrightarrow{\text{Enterokinase}} \text{Trypsin}$$

$$\text{Chymotrypsinogen} \xrightarrow{\text{Trypsin}} \text{Chymotrypsin}$$

$$\text{Procarboxy peptidase} \xrightarrow{\text{Trypsin}} \text{Carboxypeptidase}$$

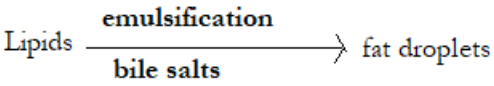
$$\left.\begin{matrix}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{matrix}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/Chymotrypsin}} \text{Dipeptides}$$



b. Digestion by Bile

Bile contain bile pigments (Bilirubin and Bilirubin), bile salts cholesterol and phospholipids . Bile does not contain any enzymes. But it is very important in digestion

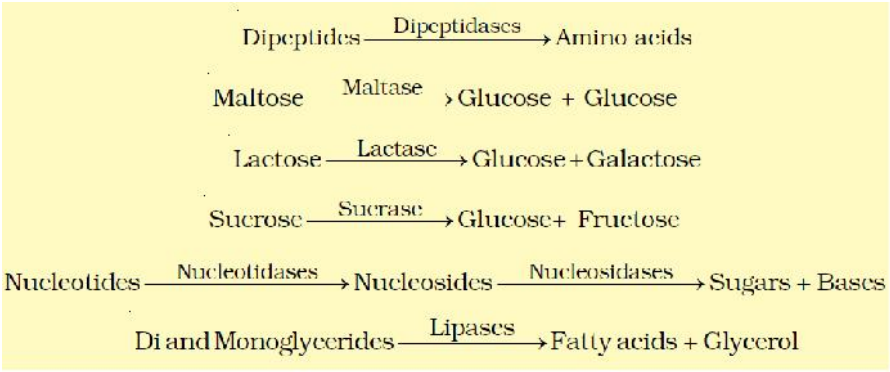
Bile salts present in bile help in **emulsification of fat**; lipases can act only upon emulsified fat



c. Digestion by intestinal juice (Succus entericus)

Succus entericus contain **protein digesting enzymes**, **carbohydrate digesting enzyme fat digesting enzyme** and nucleic acid digesting enzyme called nucleotidases and nucleosidases. So it is called a **complete digestive juice**.

Mucus and bicarbonates present in pancreatic juice protect intestinal surface from acidic secretions. Secretions of goblet cells, crypts and Brunner's gland help this process.



Functions of large intestine

No significant digestive activity for large intestine. But it perform functions like

1. Absorption of some water, minerals and drugs
2. Secretion of mucus, adhering of wastes and removal of faeces

Defaecation – removal of unabsorbed food (faeces)

Activities of digestive system is under the control of gastro intestinal tract hormones.

Absorption of digested food

Digested food are absorbed mainly by 3 methods

Simple diffusion – absorption without using energy; eg. Glucose, amino acids , Chloride ions

Active transport - absorption using energy; eg. Glucose, amino acids , Na^{++}

Facilitated transport – absorption with the help of carrier ions. Eg. Fructose, some amino acids

Absorption of fat

Fatty acids and glycerol are insoluble in water; so, they cannot be absorbed by above mentioned process.

Fatty acids and glycerol are converted into fat droplets called **micelles**; micelles are absorbed into intestinal mucosa; there they are reconstructed into protein coated droplets called **chylomicrons**; they are absorbed into lacteals; then they are absorbed into blood stream.

Absorption of digested food in different parts of digestive system

Mouth – certain drugs
Stomach – water, simple sugar, alcohol
Small intestine – amino acids, glucose, minerals, fatty acids ,lipids etc

Large intestine -water, minerals, drugs

Assimilation - utilization of absorbed food in cells

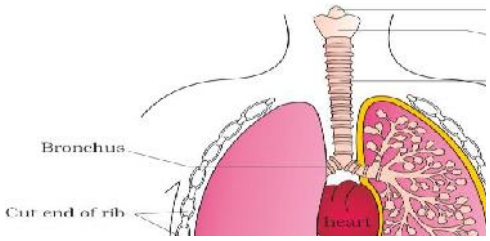
Disorders of digestive system

1. **Jaundice** – liver is affected, skin and eyes turn yellow
2. **Vomiting** – elimination of stomach content through mouth; controlled by vomit centre in medulla
3. **Diarrhea** – abnormal frequency of bowel movement; increased liquidity of faeces; reduced absorption of food
4. **Constipation** – faeces retained in rectum; bowel movements are irregular
5. **Indigestion** – food is not properly digested; mostly due to over eating, spicy food, anxiety, food poisoning, insufficient enzyme secretion etc.

CHAPTER BREATHING AND EXCHANGE OF GASES

Parts of human respiratory system

External nostrils → Nasal chamber → Nasopharynx → Trachea → Bronchi → Bronchioles → Alveoli



Larynx / Sound box – cartilaginous box at the beginning of trachea, helps in production of sound;

Trachea and bronchi are supported by cartilaginous rings.

Alveoli – thin vascular bags, functional units of lungs

Pleura – double layered wall protecting lungs

Conducting parts of respiratory system – Trachea, Bronchi , Primary bronchiole, Secondary bronchiole, Tertiary bronchiole , Terminal bronchiole. This part filters the air, warms it and humidifies it.

Exchange parts – Respiratory bronchiole, Alveoli. Exchange of gases takes place here.

Anatomical set up of lungs is suitable for breathing

Lungs are protected inside the **thoracic chamber**. Thoracic chamber is protected dorsally by vertebral column; ventrally by sternum; laterally by ribs and on lower side by diaphragm. Any change in thoracic volume will influence breathing

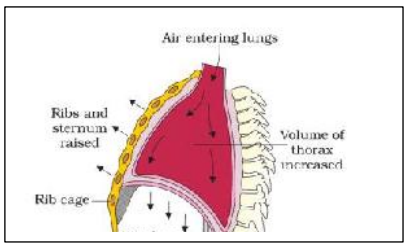
Steps in respiration

1. Breathing / Ventilation – inspiration and expiration

2. Gas exchange at lungs – O_2 taken in CO_2 given out
3. Transport of gases by blood
4. Diffusion at tissues
5. Utilization of oxygen in tissues (cellular respiration)

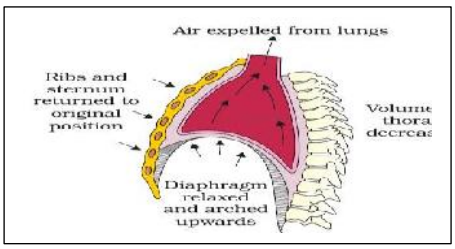
Mechanism of breathing

Inspiration



Diaphragm contract; intercostal muscles contract; thoracic volume increase; intrapulmonary pressure decrease, **Air enter into lungs**

Expiration



Diaphragm relax ; intercostal muscles relax; thoracic volume decrease; intrapulmonary pressure increase, **Air enter goes out of lungs**

Muscle involved in breathing - intercostal muscles and diaphragm

Forced breathing make use of abdominal muscles too

Rate of breathing 12-16 times/minute

Rate of respiration can be measured by **spirometer**

Respiratory volumes and capacities

Respiratory volumes

TV (Tidal Volume)	Volume of air inspired/expired during normal breathing	500ml
IRV (Inspiratory Reserve Volume)	Additional volume of air a person can inspire forcefully	2500- 3000ml
ERV (Expiratory Reserve Volume)	Additional volume of air a person can expire forcefully	1000ml – 1500ml
RV (Residual Volume)	Volume of air remaining in the lungs even after forcible expiration	1100- 1200ml

Respiratory capacities – clinical diagnosis of some diseases require a measure of respiratory capacities

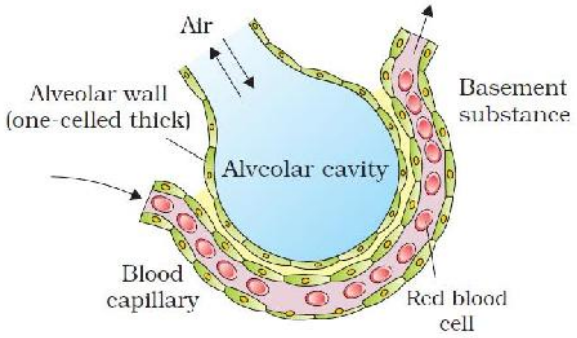
Inspiratory Capacity **(IC)**	Total volume of air a person can inspire after a normal expiration	TV + IRV
Expiratory Capacity **(EC)**	Total volume of air a person can expire after a normal inspiration	TV + ERV
Functional Residual Capacity **(FRC)**	Volume of air remaining in the lungs after normal expiration	ERV + RV
Vital Capacity **(VC)**	Maximum volume of air a person can breath in after a forced expiration/ maximum volume of air a person can breathe out after a forced inspiration	IRV + ERV + TV
Total Lung Capacity (**TLC**)	Total volume of air accommodated in the lungs after a forced inspiration	IRV + ERV + TV + RV

Exchange of Gases

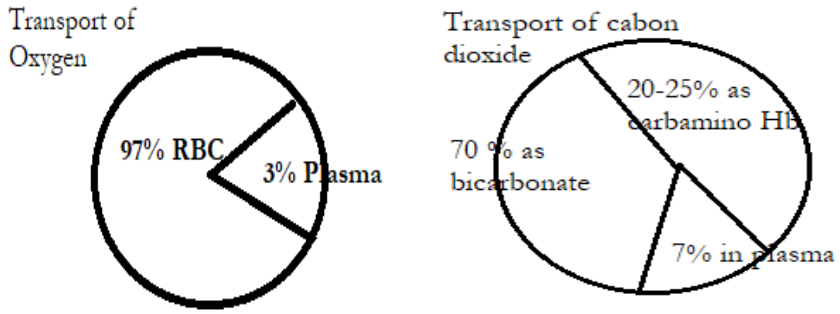
Gas exchange take place by **diffusion**; primary site of gas exchange is alveolus; gas exchange takes place between blood and cells also.

Factors influencing diffusion of gases

1. Difference in partial pressure of gases- gases diffuse from region of higher partial pressure to lower partial pressure
2. Solubility of gases- CO_2 is 25% more soluble than O_2.
3. Thickness of diffusion membrane – diffusion membrane has 3 layers squamous epithelium of alveoli, basement substance and endothelium of capillary; total thickness is less than 1 mm



Transport of gases

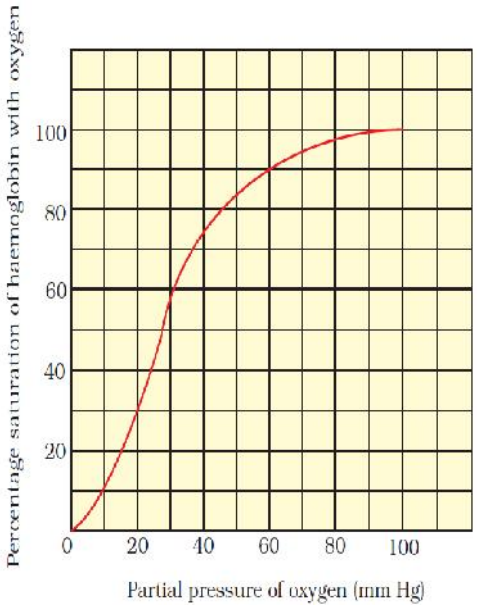


Transport of Oxygen

Oxygen is transported by 2 mechanisms; 97% Oxygen is transported by hemoglobin and 3% carried by plasma; **in lungs all factors are suitable for formation of oxy Hb**; ie High pO_2, low pCO_2, low temperature and low pH; **in tissues all factors are suitable for release of O_2**; ie low pO_2 high pCO_2 , high temperature high pH

Haemoglobin + Oxygen ⇌ Oxyhaemoglobin (Alveoli →, ← Tissue)

Oxy hemoglobin Dissociation curve



Oxy Hb Dissociation curve represent the relation between partial pressure of oxygen and percentage of saturation of Hb with Oxygen

Shape of graph – sigmoid

Factors influencing graph – pO_2, pCO_2, temperature, pH

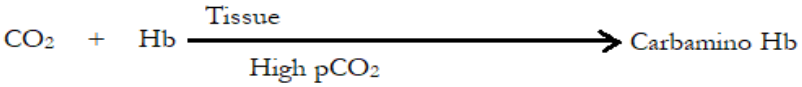
Significance – to study the role of pO_2, pCO_2, temperature, pH on binding Oxygen with Hb

100ml oxygenated blood can deliver 5ml O_2 to tissues

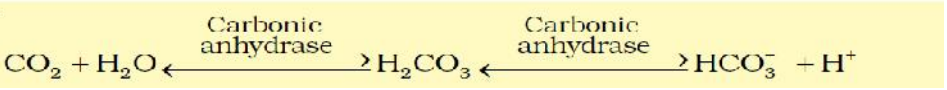
Transport of CO_2

CO_2 is transported by 3 mechanisms; 70% CO2 is transported by RBC as

bicarbonate , 7% carried by plasma and 20-25% as carbamino Hb



Transport as bicarbonate require the presence of enzyme **carbonic anhydrase** in the RBC



100ml oxygenated blood can deliver 5ml O_2 to tissues

Control of respiration

Respiration is controlled by neural mechanisms;

a. By respiratory rhythm Centre- located in medulla; primary control of respiration

b. By Pneumotaxic Centre – located in pons; moderate the functions of respiratory rhythm center; can regulate the rate of respiration

c. Chemo sensitive area- near rhythm center; sensitive to CO_2 and hydrogen ions

d. Chemoreceptors in aortic arch and carotid artery – sensitive to CO_2 and hydrogen ions

Increase in the level of CO_2 and hydrogen ions in blood can stimulate these areas and increase the rate of respiration;

Disorders of respiratory system

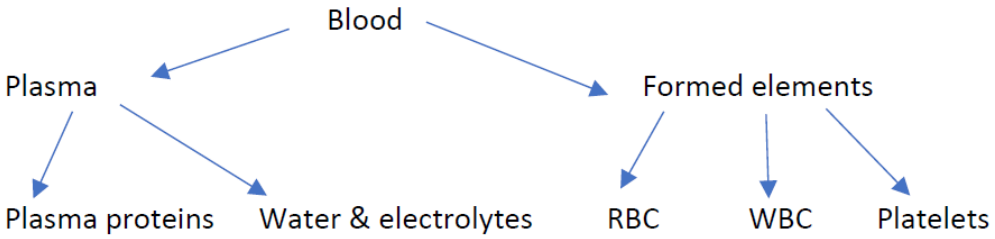
Asthma – difficulty in breathing due to inflammation of bronchi and bronchiole

Emphysema – damage of alveolar walls and reduction of respiratory surface ; mainly due to cigarette smoking

Occupational respiratory disorders- long exposure to dust and other materials in work place will damage lungs; this can be avoided by wearing masks.

CHAPTER BODY FLUIDS AND CIRCULATION

Structure of blood



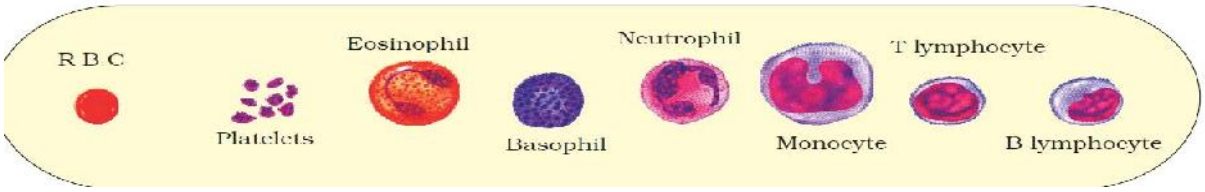
Plasma proteins and their functions

Albumin – osmotic balance

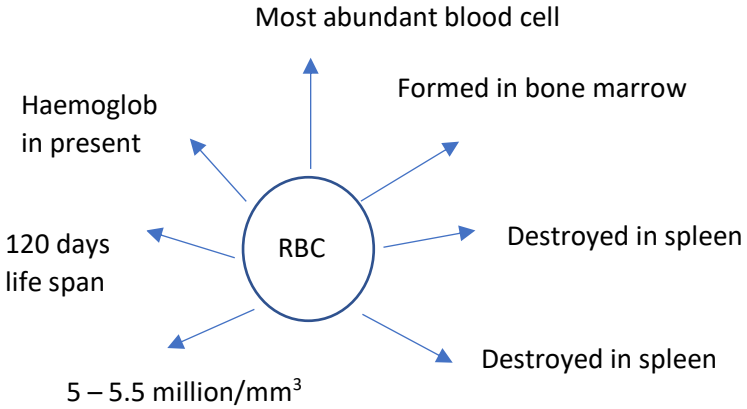
Globulin – immunity

Fibrinogen – blood clotting

Serum – plasma without clotting factors



Red Blood cells / Erythrocytes



Hemoglobin – Iron containing pigment carrying respiratory gases

12 – 16 gm/100ml blood;

Spleen – Graveyard of RBC

White Blood cells / Leucocytes

Granulocytes	Agranulocytes
Neutrophils; 60- 65% Phagocytic	**Lymphocytes**; 20- 25% ; secrete antibodies

Eosinophils; 2-3%; resist infections related to allergy

Monocytes; 6-8%; phagocytic

Basophils; 0- o.5%; inflammatory response, secrete histamine, serotonin etc

Platelets/ Thrombocytes

- Blood clotting
- 1.50000- 3.50000/mm^3
- Produced from megakaryocytes of bone marrow

Blood grouping

Human have **ABO** and **Rh** blood grouping

ABO grouping is based on the presence or absence of surface antigens named A and B on RBC. Corresponding antibodies are present in plasma.

TABLE 18.1 Blood Groups and Donor Compatibility

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

Significance of blood groups – blood groups must be matching while blood transfusion; receiving mismatched blood will cause destruction(clumping) of RBC of recipients.

Persons with O group can donate blood to all other groups because O group does not have any antigen; hence O group is called **universal donor**.

Persons with AB group can receive blood from all other groups because AB group does not have any antibody; hence AB group is called **universal recipient.**

Rh grouping

Rh antigen is also present on the surface of RBC; this antigen is first identified in RBC of Rhesus monkey; persons with Rh antigen are Rh^+; persons without Rh antigen are Rh^-. Rh group also must be considered while blood transfusion.

Erythroblastosis fetalis

Rh incompatibility disease of new born

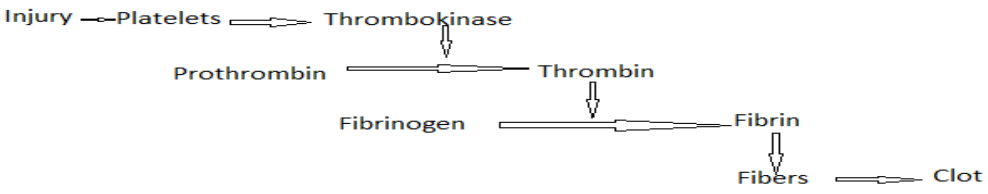
Mother Rh - ve; Father Rh +ve; first child Rh +ve and is born safe but second child is affected; baby will be affected with **anemia and jaundice**; the situation can be avoided by administering anti Rh antibody injection immediately after the delivery of first child.

Lymph (Tissue Fluid)

Lymph is interstitial fluid formed from blood and flowing through lymph vessels.

Functions of lymph - **Exchange** of nutrients, waste materials, hormones and respiratory gases between blood and cells; Lymphocytes present in lymph help **immunity**; Lymph helps in **fat absorption** (Lacteal)

Blood clotting



Calcium ions play important role in blood clotting.

Circulatory pathways

Open circulation - blood flows through open spaces called sinuses; eg. Arthropods

Closed circulation - blood flows through heart and blood vessels; eg. All higher animals

Single circulation- Eg. Fishes; Fishes have only one atria and ventricle; only deoxygenated blood passes through heart; blood is oxygenated in gills.

Incomplete double circulation – Eg. Amphibians and reptiles; 3 chambers in heart; possess two atria and one ventricle; blood gets mixed in ventricles; blood is oxygenated in lungs

Complete double circulation – Eg. Birds, mammals; 4 chambers in heart: no mixing of pure and impure blood; separate circulatory pathways for pure and impure blood.

Human circulatory system

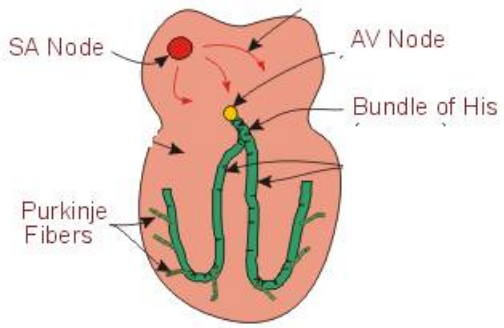
Heart – mesodermally derived muscular organ; located in thoracic chamber; protected by a double layered membrane called **pericardium**; left and right atria separated by inter atrial septum; left and right ventricles separated by inter ventricular septum; Heart is formed of **cardiac muscles.**

Tricuspid valve- guards the opening of right atrium to right ventricle; **Bicuspid valve / Mitral valve**- guards the opening of left atrium to left ventricle. **Semilunar valves** – guards the opening of aorta to left ventricle and pulmonary artery to right ventricle; **valves prevent back flow of blood**.

Nodal tissues in heart

In human heart, heartbeat is controlled by heart muscles itself; hence human heart is said to be **myogenic heart**; heart beat is originated and conducted by specialized cardiac muscles called **nodal tissues**.

SA Node (Sinu atrial node)- located on right atrial wall; originate and regulate heart beat; hence called **pace maker** of heart. SA node produces 70 - 75 cardiac impulses per minute; this action potential is picked up by **AV Node (Atrio ventricular Node**), in atrio- ventricular septum; then it passes through **Bundle of His / AV bundle** and reach ventricular wall via **Purkinje fibers**.

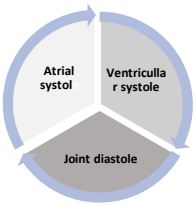


Route of cardiac impulse **(Conducting systems of human heart)** can be represented as

SA Node → AV Node → Bundle of His / AV bundle → Purkinje fibers → Ventricular wall

Heart rate is 72 / min.

Cardiac cycle – cyclic events in heartbeat. Duration of cardiac cycle – 0.8 secs.



Atrial systole – contraction of atrium

Ventricular systole - contraction of ventricles

Joint diastole – both atria and ventricles relax;

Stroke volume – volume of blood pumped by heart during a cardiac cycle; it is 70ml

Cardiac output - volume of blood pumped by heart in a minute; it is 5000ml;

Heart sounds – heart sounds are produced during closure of heart valves;

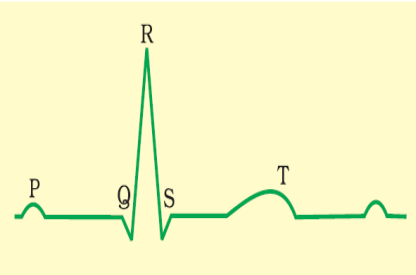
Lub sound – closure of AV valve ;

Dub sound – during closure of semilunar valve;

Heart sounds have clinical importance; it is used to diagnose heart diseases; it can be heard with stethoscope.

ECG – Electro Cardiogram

ECG is graphical representation of electrical activity of heart;



P wave – depolarization of atria

QRS wave - depolarization of ventricle

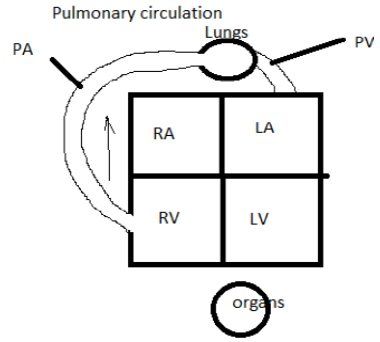
T wave – repolarization of ventricles

By counting QRS complex we can calculate heart rate; **clinical importance** - any variation in any wave indicate heart disease

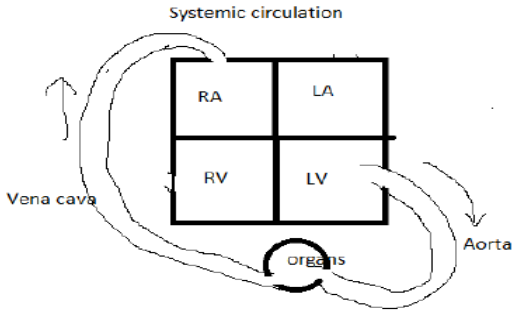
Double circulation

Mammals and birds have 4 chambered heart; pure and impure blood has separate pathways for circulation; pure blood circulate through pulmonary pathway and impure blood circulate through systemic pathway.

Pulmonary circulation



Systemic circulation



Pulmonary circulation

Circulation between heart and lungs;
purpose – purification/ oxygenation of blood;

RV → PA → Lungs → PV → LA

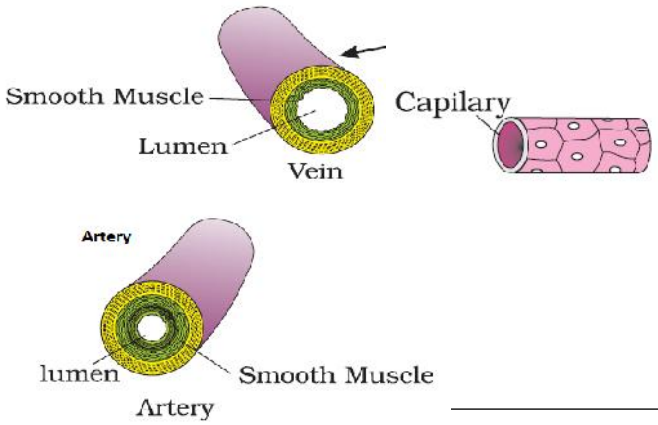
Systemic circulation

Circulation between heart and organs; for supplying pure blood and nutrients to organs and removal of Co2 and harmful substances

LV → Aorta → Organs → VC → RA

Coronary circulation – circulation of blood in heart muscles;

Hepatic Portal Circulation – special vascular connection between digestive tract and liver;



Artery – narrow lumen, thick muscular wall

Vein – wide lumen, thin wall

Capillary – narrow lumen, wall made only of squamous epithelium

Regulation of cardiac activity

Cardiac activity is auto regulated (**Myogenic**); cardiac functions are regulated by **a cardiac center in medulla** oblongata through autonomous nervous system (ANS); Sympathetic nervous system increases heart rate and cardiac output. Parasympathetic system decreases heart rate and cardiac output. Heart rate is also increased by **adrenaline** and brought back to normal by noradrenalin.

Disorders of circulatory system

1. **Hyper tension**- a persisting blood pressure of 140/90mmHg. is called hyper tension. hyper tension can cause damage of heart, brain, kidney etc.
2. **Coronary Artery Disease (CAD) or atherosclerosis**- deposition of fat, cholesterol and fibrous tissue on the inner wall of coronary artery; lumen of coronary artery become narrow and blood circulation to heart muscles becomes slow; this will destroy heart muscles.
3. **Angina pectoris** – acute chest pain due to insufficient supply of oxygen to heart muscles; common in middle aged and old people.
4. **Heart failure** – heart is not pumping enough blood to tissues; congestion of lungs is main symptom. **Cardiac arrest** – heart stops beating; **heart attack** – sudden damage of heart muscles due to insufficient blood supply.

EXCRETORY PRODUCTS AND THEIR ELIMINATION

Excretion is elimination of nitrogenous waste products.
Main nitrogenous wastes are **ammonia, urea and uric acid**; ammonia is the most toxic and require large amount of water for elimination; uric acid is the least toxic and require least amount of water for elimination.

Excretory organs in various animals

Platyhelminthes – Protonephridia/ flame cells
Annelids – Nephridia
Insects – Malpighian tubules

Crustaceans – Antennal glands / green glands
Hemichordates – Proboscis gland

Excretory organs are also concerned with osmoregulation (maintenance of electrolyte balance in body fluids)

Classification of animals based on excretion

Ammonotelic	Uricotelic	Ureotelic
Excrete ammonia; Ammonia is eliminated through body surface or gills; **Require large amount of water** for elimination; **Aquatic adaptation**. Eg. Fishes, tadpole, aquatic amphibians and aquatic insects	Excrete uric acid; excreted as pellets **using least amount of water; terrestrial adaptation**; Eg. Reptiles, birds, land snails	Excrete urea; require less amount of water for elimination; ammonia formed in the liver is converted to urea and eliminated through kidneys; Eg. Mammals, cartilaginous fishes; terrestrial amphiians

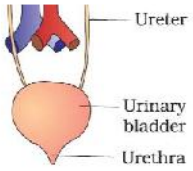
Adrenal gland

Human excretory system

A pair of kidneys – filter

Me

A pair of **ureters** - carry



A **urinary bladder** – storage of urine;
A **urethra** – carries urine out;
Renal artery – brings urea rich blood to kidneys;
Renal vein – carries purified blood from kidneys;

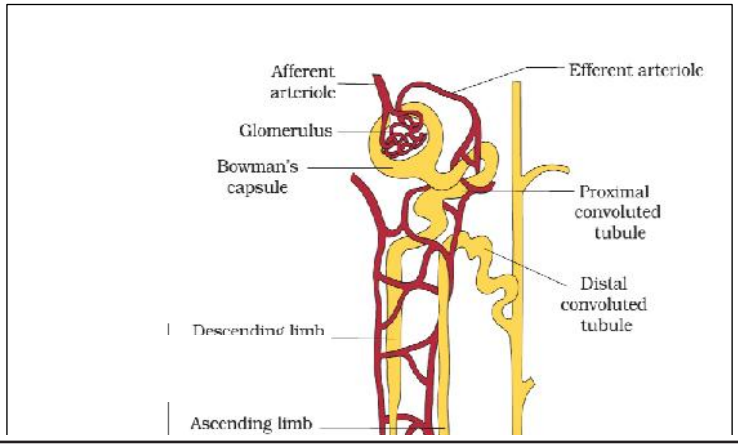
Hilum – a notch in the inner concave part of kidney; Renal artery , renal veins and ureter enter kidney through hilum;

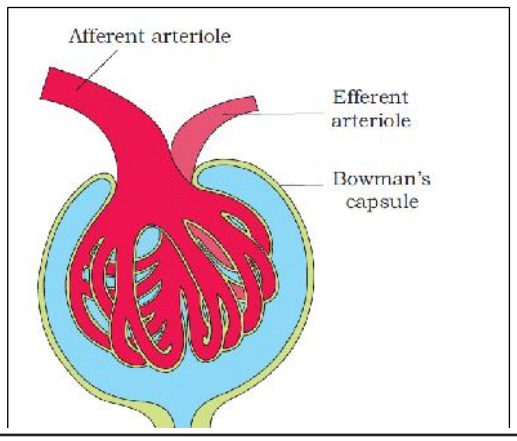
Renal pelvis – funnel shaped part inside hilum;

Renal cortex – outer zone of kidney;

Renal Medulla – inner zone of kidney; Renal medulla is raised into renal pyramids;

Columns of Bertini/ Renal columns – renal cortex extending in between renal pyramids.





Bowmans's capsule – double walled cup like structure in which glomerulus is located;

Glomerulus – a tuft of capillaries inside Bowmans's capsule; Glomerulus is formed by a branch of renal artery called **afferent arteriole**; blood is filtered in glomerulus to remove nitrogenous waste materials; purified blood comes out of glomerulus through **efferent arteriole**;

Renal tubule has 3 distinct regions

Proximal Convoluted tubule (PCT) – highly coiled first part;

Henle's loop – has descending and ascending limb;

Distal Convoluted Tubule (DCT) – highly coiled last part

DCTs of many nephrons open into **collecting duct** which open into renal pelvis of kidney.

Malpighian corpuscle, PCT and DCT are mostly located in renal cortex and Henle's loop extends deep into medulla.

Cortical nephrons – have short Henle's loop which extends very little into medulla.

Juxtamedullary nephrons – have long Henle's loop which extends deeply into medulla.

Peritubular capillaries – capillary network around renal tubule formed by efferent arteriole.

Vasa recta – part of Peritubular capillaries running parallel to Henle's loop. Cortical nephrons have reduced vasa recta.

Urine formation

Urine formation takes place in 3 steps

1. **Glomerular filtration** – When blood flows through glomerulus almost all constituents of plasma except plasma proteins get filtered into capsular space (Ultra **filtration**);

   GFR - Glomerular Filtration rate is amount of filtrate formed per minute in kidney; it is 125ml/ minute or 180 L / day; GFR is regulated by a mechanism under the control of **JGA (Juxta Glomerular Apparatus**; it is a special sensitive area at the junction of DCT and afferent arteriole
2. **Tubular reabsorption –** though 180 L filtrate is formed per day only 1.5 L urine is excreted per day; this is because 99 % of filtrate is reabsorbed in renal tubules. Water, glucose, amino acids, Na^+ etc. are mainly reabsorbed. Reabsorption takes place by passive or active mechanisms.
3. **Tubular secretion –** epithelial cells of renal tubule secrete substances like H+ and K+ into filtrate. This is essential to maintain ionic and acid balance in body fluids.

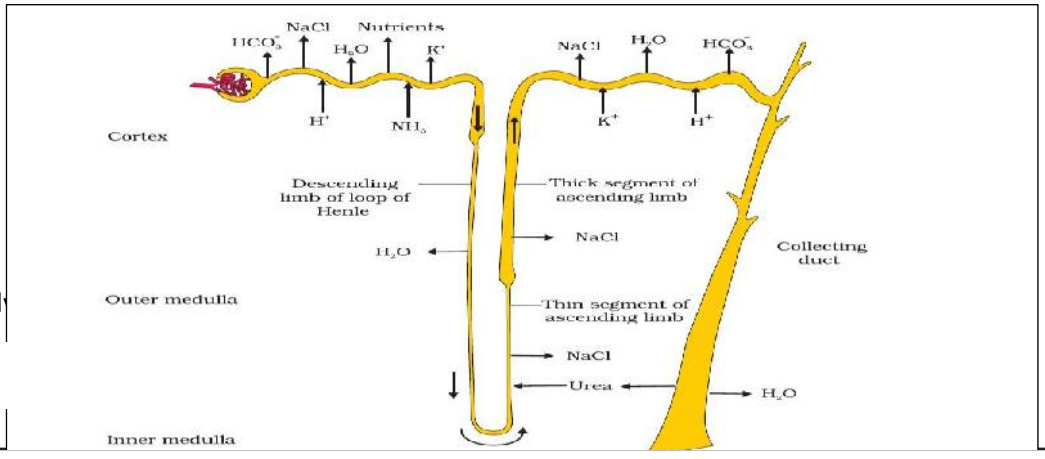
Functions of tubules

PCT – reabsorption of nearly all nutrients, 70-80% water and electrolytes (HCO_3^-) are reabsorbed here

Henle's loop – minimum reabsorption; maintain high osmolarity of medullary interstitial fluid; descending limb is permeable to water and impermeable to ions; here water is reabsorbed; so filtrate gets concentrated; ascending limb is permeable to ions and impermeable to water; here NaCl is reabsorbed; so filtrate gets diluted

DCT – conditional reabsorption of water and electrolytes;

Collecting duct – reabsorption of water; maintains osmolarity by tubular secretion of H^+, K^+. Some amount of urea is also absorbed to maintain high osmolarity of medulla .



Mechanism of concentrating the URINE

Human kidneys can produce urine 4 times concentrated than glomerular filtrate; this is ensured by **counter current mechanism**; this mechanism operates by ***vasa recta*** **and Henle's loop**.

NaCl and urea are the two solutes which maintain high osmolarity in renal medulla

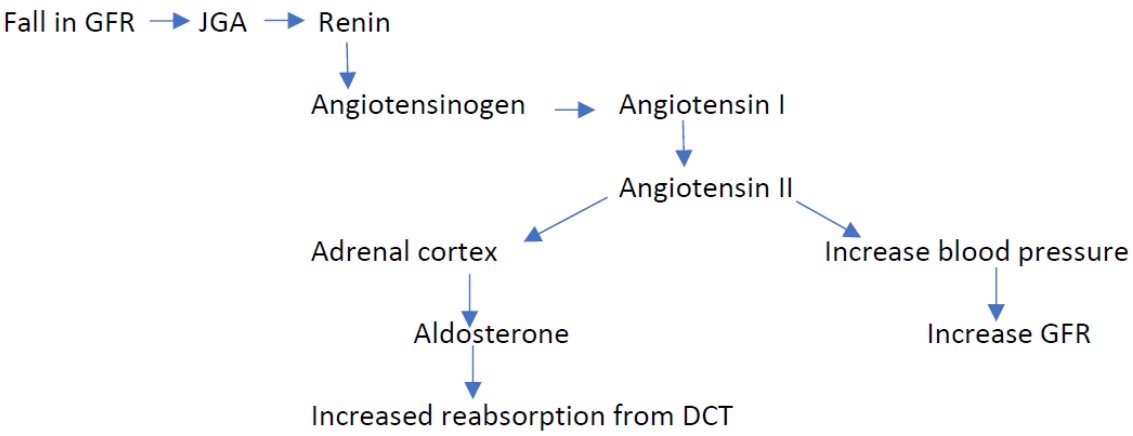
Regulation of kidney function

Kidney function is regulated by hormone feedback mechanisms.

By ADH

When water in body is insufficient → Hypothalamus → ADH (Antidiuretic hormone) / Vasopressin → Increase water reabsorption at DCT

By JGA



By ANF (Atrial natriuretic factor)

Increased GFR → Release ANF → Vasodilation

Decrease in blood pressure → Decrease GFR

This mechanism acts as a check on Renin Angiotensin Aldosterone system

Micturition - elimination of urine; initiated by neural mechanism called micturition reflex

Urinary bladder filled with urine → Stretch receptors on wall of urinary bladder stimulated → Signal received by CNS → Motor signals to bladder muscles → Contraction of smooth muscles on bladder → relaxation of urethral sphincter → release of urine

Amount of urine excreted per day 1-1.5 L

Amount of urea excreted per day 25-30 gm

Analysis of urine is of clinical importance - by analyzing urine we can identify diseases like diabetes mellitus. Urine of diabetic patients contain abnormal levels of glucose(Glycosuria) and ketone bodies(Ketonuria).

Role of other organs in excretion

Skin as accessory excretory organ – skin excrete water, NaCl, urea and lactic acid through sweat and sterols, hydrocarbons and waxes through sebum.

Lungs as accessory excretory organ - lungs remove water vapour and CO_2 (18 L / day)

Liver as accessory excretory organ- liver excrete bile pigments (Bilirubin and biliverdin), cholesterol, degraded steroid hormones, vitamins, drugs etc.

Disorders of excretory system

1. **Uremia** – accumulation of urea in blood due to kidney failure; this is a dangerous condition; uremic patients can save life by **hemodialysis** or kidney transplantation.

Hemodialysis/ artificial kidney – blood taken from a convenient artery and mixed with anticoagulant (heparin). Then it is passed through dialyzing

machine which contain dialyzing fluid whose composition is same as that of blood except that it does not contain nitrogenous wastes; in the machine blood and fluid is separated by a cellophane paper; nitrogenous wastes gets filtered into fluid and blood is purified ; purified blood is returned into a vein after removing anticoagulant .

Kidney transplantation is the best method to cure kidney diseases; a functional kidney can be received from a donor, most preferably a close relative to avoid graft rejection.

2. **Renal calculi/ Kidney stones** - crystals of calcium oxalates formed in the kidney causing severe pain
3. **Glomerulonephritis** – inflammation of glomerulus

LOCOMOTION AND MOVEMENT

Types of movement shown by human body cells

Amoeboid movement- macrophages and WBC

Ciliary movement – trachea, fallopian tube

Flagellar movement- sperms

Muscular movement – arms and legs

Structure of skeletal muscles

Muscle fibers are arranged in bundles called muscle bundles or **fascicle;** fascicles are covered with connective tissue called fascia;

Sarcolemma – plasma membrane lining muscle fiber;

Sarcoplasm – cytoplasm of muscle fiber;

Sarcoplasmic reticulum – stores calcium ions

Structure of Myofibril

Each muscle fiber contains parallelly arranged myofilaments; myofilaments are formed of **contractile proteins like actin and myosin**; Each myofibril has alternate dark and light bands; **dark band is called A band**;

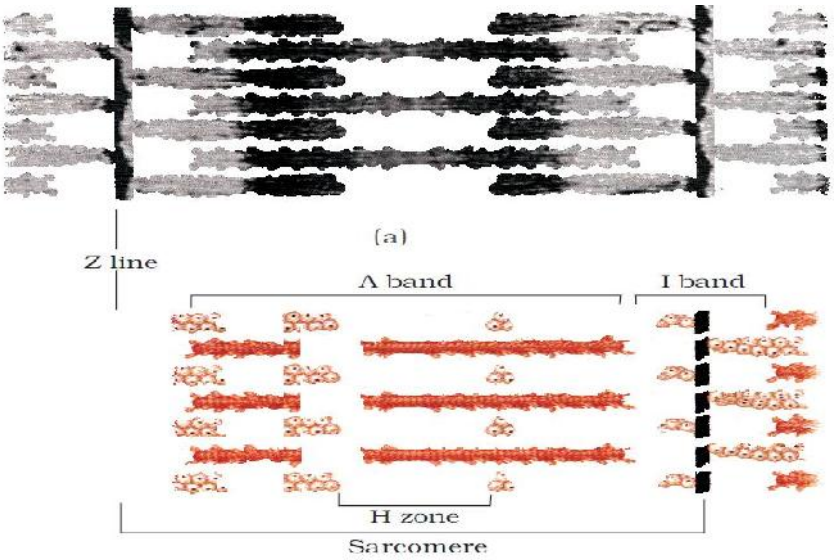
Light band is called I band;

Actin filaments are thinner and Myosin filaments are thicker;

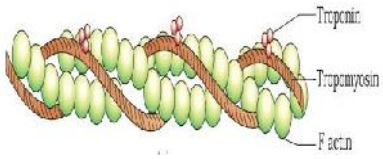
Myosin filaments have cross bridges or hooks on them;

At the center of I band there is a fiber called Z line;

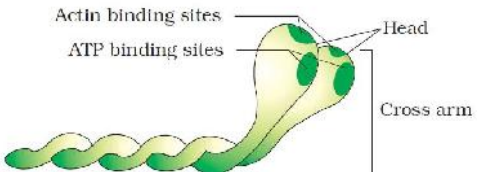
<u>Space between two Z lines is called sarcomere; Sarcomere is the functional unit of muscle fiber.</u>



Structure of contractile proteins (Actin, myosin, Tropomyosin, Troponin)



Actin – Actin is formed of two filaments (F actins, helically wound to each other
Troponin – filamentous protein running close to F actin
Troponin – 3 small proteins placed at regular intervals on tropomyosin

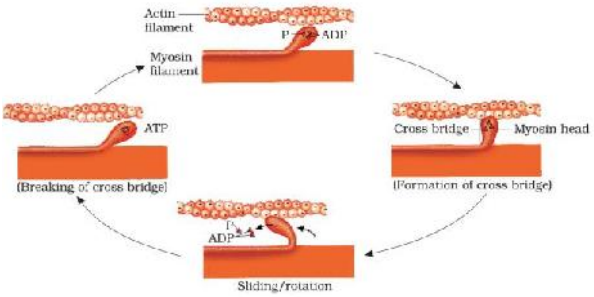


Myosin is a polymer of **meromyosin**; each meromyosin has a tail part called **LMM** (light meromyosin) and head part called HMM (Heavy meromyosin); HMM forms cross arms; HMM has **Actin binding part** and **ATP binding site**

Mechanism of muscle contraction

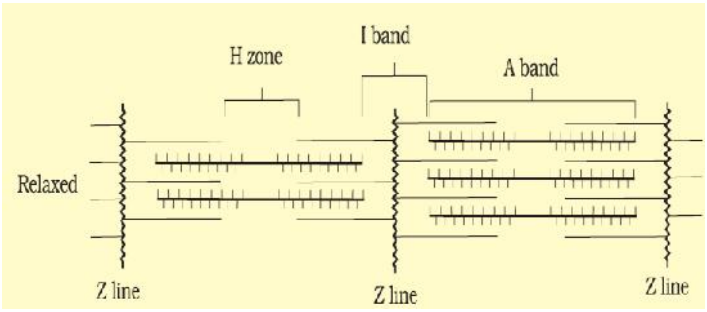
Mechanism of muscle contraction is explained by **sliding filament theory**; during muscle contraction <u>actin filaments slides over myosin filaments</u>.

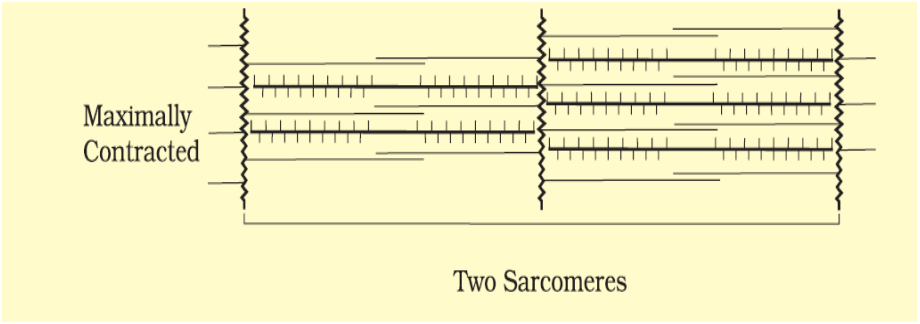
Impulse → Neuromuscular junction → Release of nurotransmitter(acetyl cholin) Action potential generated in sarcolemma → Release of calcium ions from sarcoplasmic reticulum → Calcium bind with troponin → Troponin removed from actin binding site of myosin → Energy released from ATP → Myosin head form cross bridge with actin → Actin filaments pulled towards center of A band → Sarcomere shortens → Muscle contracted.



During muscle contraction I band reduce; Z lines comes closer; Sarcomere shortens

Role of Calcium ion- Calcium ion removes troponin from actin binding site of myosin





Myoglobin – red coloured pigment present in muscles which store oxygen

Red muscles – contain more myoglobin and hence reddish in appearance; aerobic muscles; contain plenty of mitochondria;

White muscles - contain less myoglobin and hence whitish in appearance; anaerobic muscles; contain less number of mitochondria; contain more sarcoplasmic reticulum;

Fatigue – repeated activation of muscles can lead to accumulation of lactic acid and pain in muscles.

Skeletal System

Skeletal system is formed of bones and cartilages.

Skeletal System

Axial Skeleton (80)		**Appendicular Skeleton**
Skull (22)	Cranial (8)	1. Bones of arms (60)
	Facial (14)	2. Bones of legs (60)
7	Hyoid (1)	3. Pectoral Girdle (4)
	Ear ossicles (6)	a. Scapula -2 b. Clavicle -2
Vertebral column (26)		4. Pelvic Girdle (2) Coxal bones (Ilium, Ischium, Pubis)
Ribs (24)		
Sternum (1)		

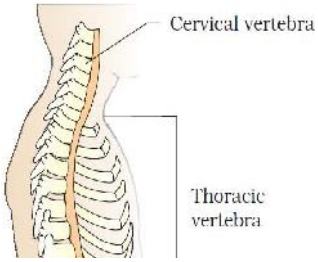
Axial skeleton

Cranium – bones protecting brain
Hyoid – U shaped bone at the base of buccal cavity supporting tongue
Ear ossicles – 3 small bone in middle ear; malleus, incus and stapes
Sternum – flat bone on ventral side of thoracic chamber to which ribs are attached ventrally

Vertebral column – formed of 26 bones called vertebrae vertebral column is connected to skull by wo bones called **occipital condyles**; (Fig.20.6)

ifferentiated into 5 regions

- Cervical (7); Thoracic (12); Lumbar (5); Sacral



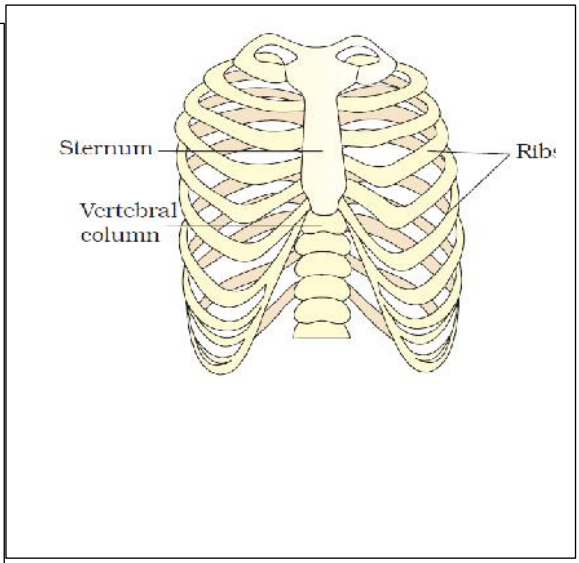
Ribs– 12 pairs of ribs present ; based on their attachment to sternum they are classified as

True ribs – 1st – 7th pair; directly connected to sternum

False ribs/ Vertebrochondral ribs – 8th , 9th , & 10th ; connected to sternum through 7th rib

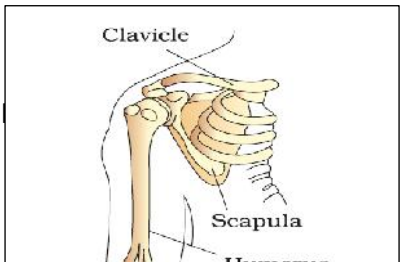
Floating ribs -11th and 12th ; not connected to sternum

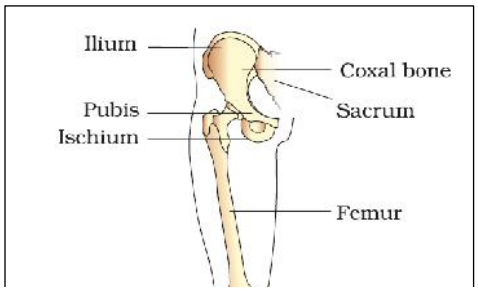
Rib cage is formed of ribs, thoracic vertebrae and sternum



Appendicular skeleton

Bones of arms (30)	Bones of legs (30)
Humerus (1)	Femur (1)
Radius & Ulna (2)	Tibia & Fibula (2)
	Patella (Knee cap) (1)
Carpels (8)	Tarsals (7)
Metacarpals (5)	Metatarsals (5)
Phalanges (14)	**Phalanges (14)**





Laly Sel

Pectoral girdle – connect arm with axial skeleton; it has 2 bones on each side; Scapula and Clavicle; shoulder joint is formed at glenoid cavity at the junction of pectoral girdle and humerus

Pelvic girdle – connect leg with axial skeleton; it has two Coxal bones on each side; each coxal bone is formed of 3 fused bones called ilium, ischium and pubis; femur articulates with pelvic girdle at a cavity called acetabulum.

Joints – joints are points of contact between two bones or bone and cartilage; joints allow movement with the help of muscles.

Joints are of 3 types.

Fibrous joints – bones are connected firmly with the help of dense fibrous connective tissue; joint does not allow any movement; eg. Joint between skull bones.

Cartilaginous joints – bones joined with the help of a cartilage; permits limited movement; found in vertebral column.

Synovial joints – at the point of articulation of bones there is a fluid filled cavity called synovial cavity; synovial fluid allows considerable movement at the joint; found in arms and legs.

Examples of Synovial joint

Ball and socket – shoulder joint and hip joint

Hinge joint – knee joint, elbow joint

Pivot joint – neck (between atlas and axis)

Gliding joint – fingers (between carpels)

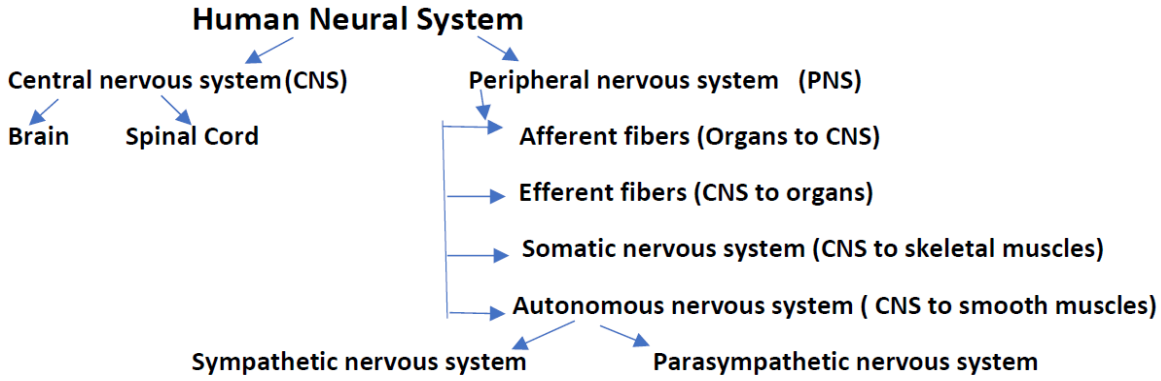
Saddle joint – between carpel and meta carpel of thumb

Disorders of muscular and skeletal system

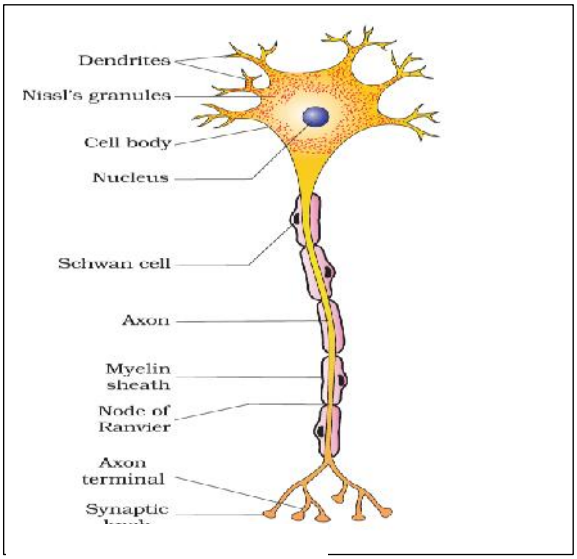
Myasthenia gravis – auto immune disorder affecting neuromuscular junction;
Muscular dystrophy – progressive degeneration of skeletal muscles due to genetic disorder.
Tetany – rapid spasms(wild contractions) in muscles due to low calcium levels in body fluids.
Arthritis – inflammation of joints.
Osteoporosis – age related; decreased bone mass and increased chance of fracture; can be caused due to decreased estrogen level in women.
Gout – inflammation of joints due to deposition of uric acid in joints.

NEURAL CONTROL AND COORDINATION

Neurons are the functional units of nervous system



Structure of Neuron



3 major divisions of neurons are **Cell body**/ Cytone, **Axon** and **Dendron**; **Cell body** – central part with nucleus and Nissl's granules; **Axon** - long cytoplasmic process carrying impulses away from cell body; **Dendrons** – many cytoplasmic process with Nissl's granules and bring impulse towards cell body;

Distal end of axon has branches which end up in **synaptic knobs**; synaptic knobs contain **synaptic vesicles** with **neurotransmitters**;

Unipolar Neuron – possess one axon only; found in embryos only

Bipolar Neuron – possess one axon and one dendron only; found in retina

Multipolar Neuron – possess one axon and many dendrons; found in cerebral cortex

Myelinated neuron – possess myeline sheath; found in spinal and cranial nerves

Nonmyelinated neuron – myeline sheath absent; axon covered with Schwann cells only; found in ANS and SNS

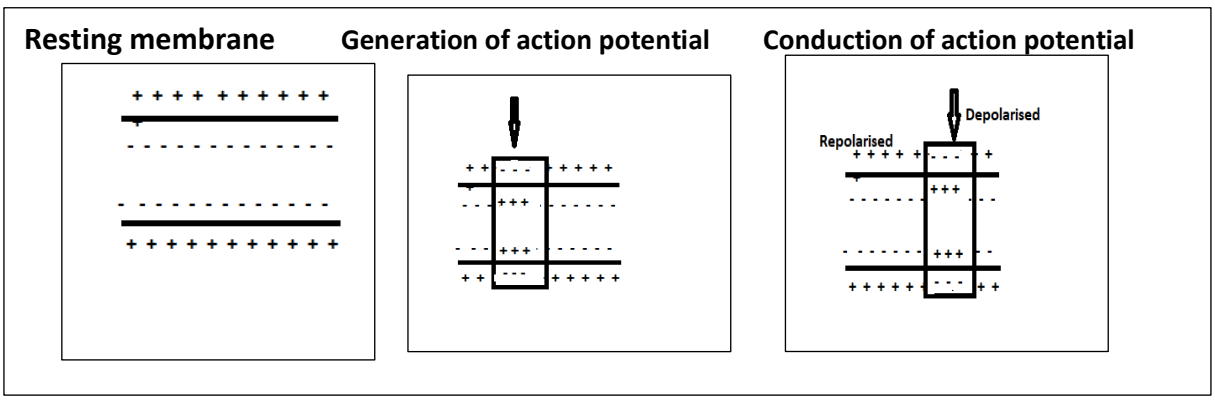
Generation and conduction of nerve impulse

Resting neuron

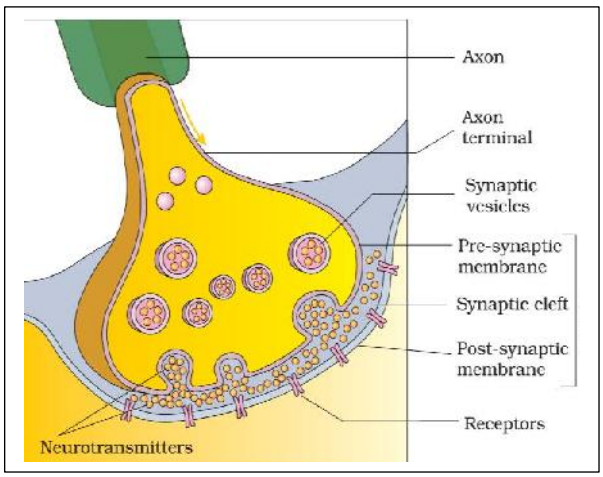
Resting neuron has potential which is generated by **sodium potassium pump**. Outside of the membrane is positive and inside of the membrane is negative; this is called **resting membrane potential.**

When an impulse come to a particular area of neuron, Na^+ - K^+ pump stops at that region; Na^+ ions rushes inside and K^+ ions rush outside; so temporarily inside of that area become positive and outside become negative. That area is said to be **depolarized**

Na^+ - K^+ pump immediately start functioning; depolarized area soon gets repolarized; the next adjacent area gets depolarized; this depolarization and repolarization moves along the entire length of axon; this is called action potential



Transmission of Nerve impulse - Synaptic transmission



Nerve impulses are transmitted through nerve to nerve connections called **synapse**.

Neuron bringing impulse is called presynaptic neuron; it is an axon terminal;

Neuron taking impulse away is called postsynaptic neuron; it is a dendrite.

Synaptic cleft – space between membranes of pre and post synaptic neuron.

When an action potential reaches synaptic knob of presynaptic neuron

↓

Synaptic vesicles move towards synaptic membrane and fuse with it

↓

Synaptic vesicles break releasing neurotransmitters to synaptic cleft

↓

Receptors in post synaptic membrane stimulated

↓

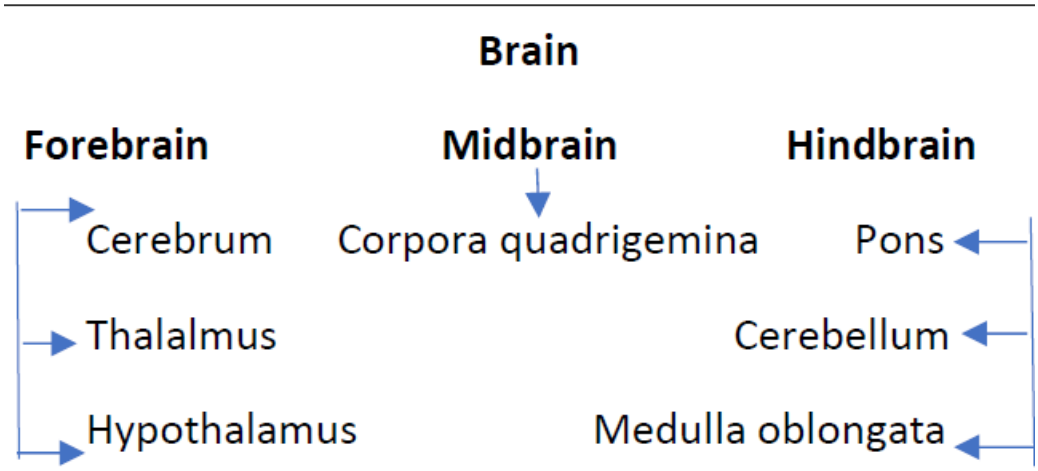
Action potential generated in post synaptic membrane.

Electrical synapse – no synaptic cleft; impulse transmitted without the help of neurotransmitter. Faster transmission take place in electrical synapses

In chemical synapse axon terminal contain **synaptic vesicles neurotransmitters** are present in **synaptic vesicles.**

Central Neural System

Human brain is protected by skull and 3 layers of **meninges**. Meninges are duramater (outer), arachnoid membrane(middle) and piamater (inner).



Cerebrum – largest part of brain; divided longitudinally into two halves called **cerebral hemispheres**; cerebral hemispheres are connected with each other by a nerve band called **corpus callosum**; outer surface of cerebral cortex is greyish in appearance due to accumulation of cell bodies of neuron (**grey matter**); cerebral cortex has special neural areas called motor area, sensory area and association areas. **Association areas** are concerned with functions like intersensory associations, memory and communication. Inner part of cerebral hemisphere is whitish in appearance due to presence of myelinated nerve fibers (**white matter**).

Thalamus – major coordinating center for sensory and motor signaling

Hypothalamus –control body temperature, hunger, thirst etc. possess neuro secretory cells secreting hormones like oxytocin and vasopressin.

Limbic system –include two special areas called amygdala and hippocampus; it is concerned with regulation of sexual behavior and expression of emotions like pleasure, anger, excitement and motivation.

Midbrain

Midbrain is located between thalamus/ hypothalamus of forebrain and pons of hindbrain; midbrain consists of four swellings called **corpora quadrigemina**; a canal called **cerebral aqueduct** passes through midbrain;

Midbrain and hind brain together forms **brain stem**.

Hind brain

Pons – tract of nerve fibers which connect forebrain, midbrain and hindbrain

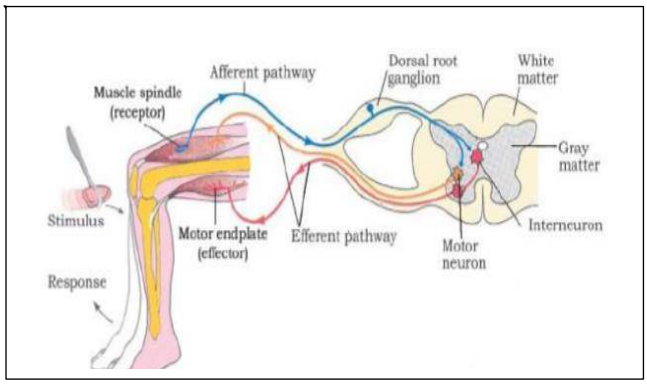
Cerebellum – second largest part; outer part is highly folded; control voluntary movements.

Medulla oblongata – connect brain to spinal cord; control respiration, cardiovascular reflexes and gastric secretions.

Reflex action and reflex arc

Reflex action is sudden involuntary response to a stimulus, without conscious effort but involves a part of nervous system.

Pathway of information in a reflex action is called **reflex arc**.

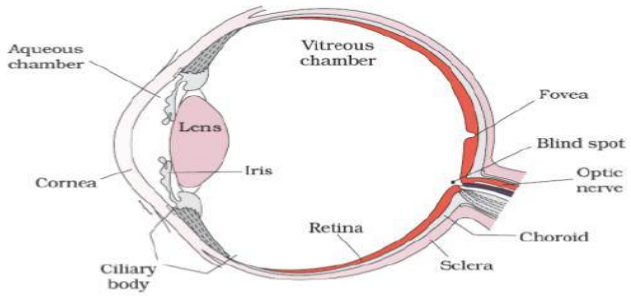


Reflex arc

Stimulus → Receptor → Afferent pathway → Dorsal root ganglion → Spinal cord → Inter neuron → Efferent pathway (motor neuron) → Effector (muscle /gland)

Sensory Reception and Processing

Eye



Sclera – outer layer formed of dense connective tissue;

Cornea – anterior transparent portion of sclera;

Choroid – middle layer with blood vessels and pigments.

Ciliary body – thickened anterior portion of choroid;

Iris – visible colored portion of eye, pigmented opaque structure in front of lens;

Lens – transparent, crystalline, held in place by ligaments from ciliary body;
Pupil –Regulates the amount of light entering the eye

Retina – innermost layer; photosensitive layer; retina has 3 layers; they are ganglion cells bipolar cells (middle) and photoreceptor cells (outer).

Photoreceptor cells are **rods and cones**. They contain photopigments. **Cone** cells are concerned with day light vision (Photopic **vision**) and **color vision**.. **Rod** cells contain a red pigment called **rhodopsin** (visual purple) which is a derivative of **vitamin A**. Rod cells are concerned with dim light vision **(scotopic vision**).

Blind spot – region of retina at the posterior pole of eyeball; photoreceptors are absent here; **optic nerve** emerges from here; no vision at blind spot

Yellow spot/ Macula lutea – region of retina where only cone cells are densely packed; located lateral to blind spot; it has a central pit called **fovea** where **maximum vision** is available.

Aqueous chamber – present between lens and cornea; contain a watery fluid called aqueous humor.

Vitreous chamber - present between lens and retina; contain a transparent gel called aqueous humor.

Mechanism of vision

Light rays fall on retina ⟶ Opsin – retinal complex dissociate
Structural change in opsin ⟶ Action potential generated in ganglion cells ⟶ Action potential transmitted to brain through optic nerve ⟶ Image formed on retina

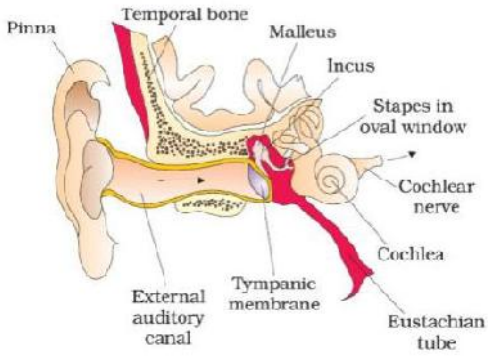
The Ear

Ear performs two sensory functions, hearing and bala Ear has 3 major divisions

Outer ear – pinnae, external auditory canal

Middle ear – tympanic membrane/ ear drum, ear ossicles, eustachian tube

Inner ear/ labyrinth – cochlea, vestibular apparatus



Pinnae – collect sound waves;

External auditory canal- transfer sound waves to eardrum; wax secreting glands and hair present on the sides of this canal;

Eardrum/ tympanum – vibrate according to sound waves; formed of connective tissue with skin outside and mucous membrane inside

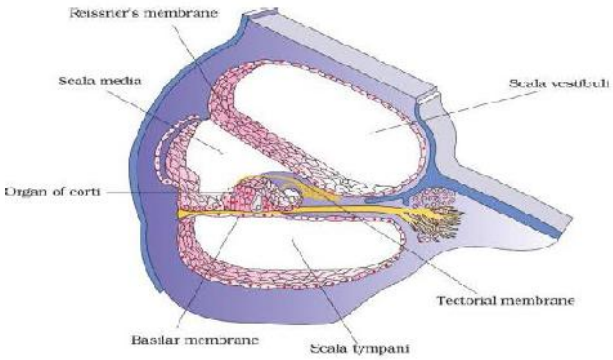
Ear ossicles – **malleus , incus and ;** Ear ossicles amplify the sound waves

Eustachian tube – connect middle ear cavity with pharynx; equalizes pressure on either side of tympanum.

Inner ear / labyrinth – has an outer series of channels called **bony labyrinth** filled with perilymph and inner tubular **membranous labyrinth** filled with endolymph.

Cochlea – coiled part of membranous labyrinth; possess sensory hair cells called **Organ of Corti** for hearing.

Structure of cochlea



Scala vestibuli- upper chamber

Scala Media- middle chamber

Scala vestibuli- lower chamber

Scala Tympani and Scala Media are separated by **Basilar membrane** which possess sensory hair cells called **Organ of Corti** for hearing.

Organ of Corti – sensory hair cells connected to afferent fibers present on Basilar membrane

Vestibular apparatus- concerned with balancing

Vestibular apparatus consists of three **semicircular canals** and **otolith organ**. Otolith organ has a **utriculus** and **sacculus**; **Cristae and macula** are the sensory cells present in vestibular apparatus for **balancing and posture**

Mechanism of hearing

Sound waves → Pinna → External auditory canal → Tympanum → Ear ossicles → Oval Window → Vibration of perilymph in Scala vestibuli and Scala tympani → Vibration of endolymph in Scala media → Rippling movement in Basilar membrane → Organ of Corti cells touch tectorial membrane → Nerve impulse generated → Impulse carried by auditory nerve to auditory area of brain → Sound heard

Chemical control and Coordination

Endocrine glands and hormones

Endocrine glands are ductless glands secreting chemical messengers called **hormones**;

Human Endocrine system

Hypothalamus

Releasing hormones — Eg. GnRH

Inhibiting hormone — Eg. Somatostatin

Oxytocin & ADH

Pituitary gland - located inside brain protected by a bony cavity called sella tursica

Pituitary gland

Anterior pituitary- Adenohypophysis

- Growth hormone (GH); Prolactin (PRL) TSH (Thyroid stimulating Hormone)
- ACTH (Adreno Cortico Trophic Hormone)
- Luteinizing Hormone (LH)
- Follicle stimulating Hormone (FSH)

Posterior pituitary – Neurohypophysis

Store and release **oxytocin** and **vasopressin**

GH (Growth Hormone) – regulate overall growth; abnormal secretion can

affect growth; Gigantism- due to hyper secretion; Dwarfism – due to under secretion

Prolactin (PRL) – growth and development of mammary gland and formation of milk

Thyroid Stimulating hormone (TSH) – stimulate synthesis and secretion of hormone from thyroid gland.

Adrenocorticotrophic Hormone (ACTH) - stimulate synthesis and secretion of hormone from adrenal cortex.

Gonadotrophins- Eg. **Follicle stimulating Hormone (FSH) and LH Luteinizing Hormone** stimulate growth and development of testis and ovary and formation of gametes

Oxytocin – stimulate contraction of smooth muscles; in females it induces contraction of smooth muscles and help child birth; milk ejection after child birth is also induced by oxytocin;

Vasopressin / ADH- stimulate kidney tubules (DCT) to reabsorb water and electrolytes and hence reduce water loss through urine.

Pineal Gland

Secrete melatonin; **Melatonin** – regulate 24 hour rhythm of body (sleep wake cycle, body temperature),

Thyroid gland

T3 and T4 (Thyroxin)

Maintain basal metabolic rate

Metabolism of carbohydrate and protein

RBC formation

TCT (Thyrocalcitonin)

Decreases blood calcium

Deficiency of Iodine in food causes **hypothyroidism / Goiter**

Deficiency of thyroxine during pregnancy can lead to **cretinism**; this is characterized by stunted growth and mental retardation

Hyper thyroidism / exophthalmic goiter/ Grave's disease due to cancer or nodule formation in thyroid gland

Parathyroid gland

Parathyroid Hormone (PTH)- increases blood calcium level

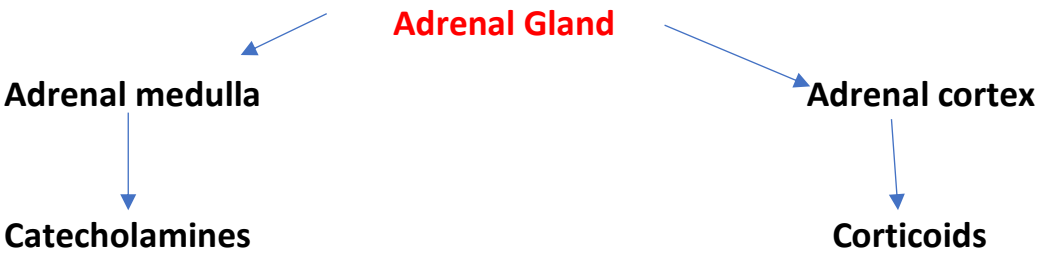
TCT is a **hypocalcemic** hormone; PTH is a **hypercalcemic** hormone

Blood calcium level is balanced by these two hormones

Thymus gland

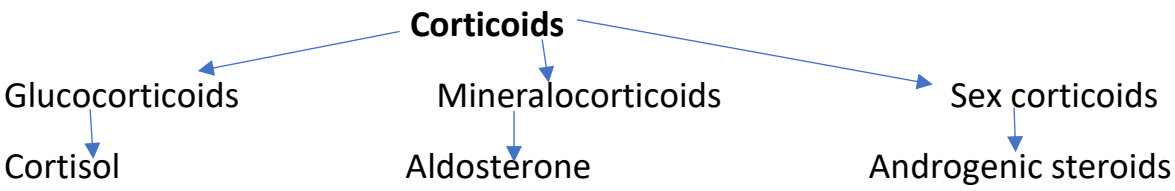
Thymosin- immunity , differentiation of **T lymphocytes** which provide **Cell Mediated Immunity**

Thymus gland gradually degenerate in old age; so older people have weak immune system.



Hormones of flight or fight or emergency hormones

Eg. Adrenalin (epinephrine)and noradrenalin (nor epinephrine)



Hormones of flight or fight or emergency hormones- they are secreted in response to stress or any emergency situations like fear; increase alertness, sweating, raise heart beat and rate of respiration,

Aldosterone - stimulate reabsorption of Na^+ and elimination of K^+ and phosphate ions

Addison's disease – due to deficiency of corticoids

Pancreas

Endocrine part is called **Islets of Langerhans**.

αcells	**βcells**.
Glucagon	**Insulin**
Hyperglycemic hormone.	Hypoglycemic hormone
increase blood glucose level	decreases blood glucose level

Glucose → Glycogen (Insulin)

Glycogen → Glucose (Glycogen

Diabetes mellitus- deficiency disease of insulin; disease can be treated by insulin therapy

Testis – Androgens; **Eg. Testosterone -** development, maturation and functioning of male reproductive system and accessory glands, development of male sex characters and behavior, spermatogenesis

Ovary

Estrogen

Growth and development of female sex organs, accessory parts, mammary glands, female sex characters and behavior.

Progesterone

Secreted by ovarian follicles after ovulation; progesterone supports pregnancy; stimulate formation of mammary alveoli and milk secretion.

Hormones of Heart, Kidney and Gastro Intestinal Tract

Heart –**Atrial Natriuretic Factor (ANF)** which decrease blood pressure; reduce GFR.

Kidney – Juxta glomerular cells of kidney secrete **erythropoietin** which stimulate erythropoiesis (RBC formation

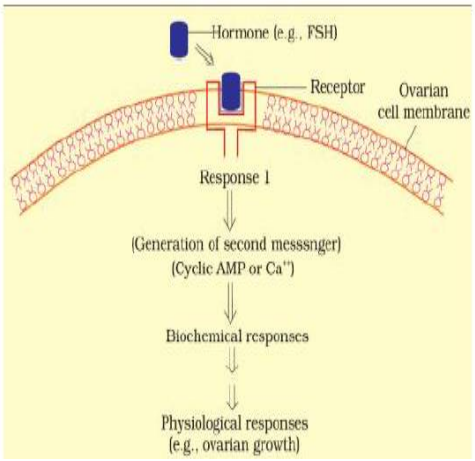
Gastrointestinal tract hormones	Target organ	Function
Gastrin	Gastric gland	Secretion of HCl and pepsinogen
Secretin	Exocrine pancreas	Secretion of pancreatic juice (water & bicarbonates)
Cholecystokinin (CCK)	Pancreas and gall bladder	Secretion of pancreatic juice and bile
Gastric Inhibitory Peptide (GIP)	Gastric gland	Inhibition of gastric glands and gastric motility

Classification of hormones

Chemical Nature of Hormone	Examples
Peptide, polypeptide, protein	Insulin, glucagon, pituitary and hypothalamic hormone
Steroids	Cortisol, estrogen, progesterone, testosterone
Iodothyronines	Thyroid hormones
Amino acid derivatives	Epinephrine / Adrenalin

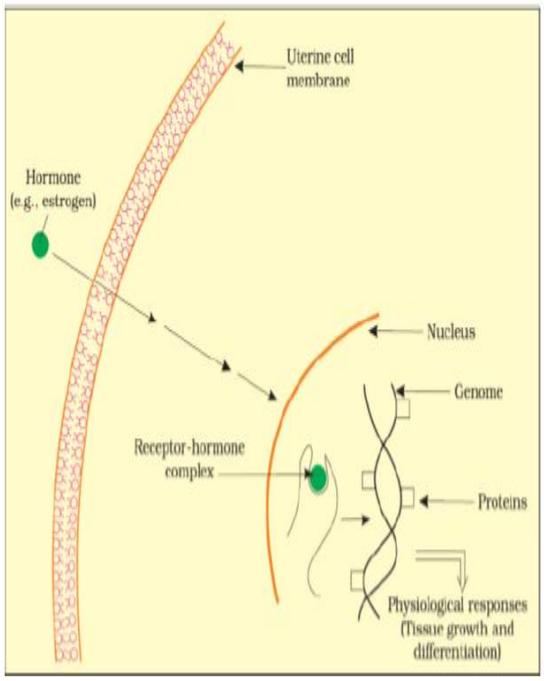
Mechanism of Hormone Action

Action of Protein hormones



Hormone + Receptor on cell membrane → Hormone receptor complex → Response1 → Generation of second messengers like cAMP or Ca++ → Biochemical response → Physiological response

Action of Steroid hormones



Hormone directly enter cell → Bind with receptor present inside nucleus → Regulate gene expression → Biochemical change → Physiological change