ANIMAL TISSUES

Tissue : A group of cells in which cells are sililar in structure, function and origin is called tissue.

Note : In a tissue cells may be dissimilar in structure and function but they are always similar in origin.

- ☞ Word animal tissue was coined by **–Bichat** (Plant tissue by - Grew)
- ☞ Study of tissue - **Histology**
- ☞ Histology word was given by - **Mayer**
- ☞ Father of Histology - **Bichat**
- ☞ Detail study of tissue is called **Microscopic anatomy.**
- ☞ Founder of microscopic anatomy -**Marcello Malpighi**

On the basis of functions & structure tissues are of four types :

1. **Epithelum Tissue :** Covering & tissues are of four types.
2. **Connective Tissue –**
   - * To connect structures
   - * To provide support to body.
   - * To transport substances in the body.
3. **Muscle Tissue –** Helps in contraction & locomotion.
4. **Nervous tissue –** To generate and conduct impulses in body.

EPITHELIUM TISSUE

- ☞ Word Epithelium was given by **- Ruysch**
- ☞ Epithielium is the only tissue in which cells are always arranged in uniform layer.
- ☞ During embryonic development epithelium orinates first.
- ☞ Power of regeneration is present in this tissue.
- ☞ Power of regeneration is absent or least power is found in nervous tissue.
- ☞ Word epithelium is composed of two words.

Epi – Upon

Thelio – grows

A tissue which grows upon another tissue is called Epithelium.

- ☞ It always rest upon underlaying connective tissue. Epithelium cells are closely packed with each other so ther is very little inter cellular space.
- ☞ Due to absence/less of intercellular spaces blood vessels, lymph vessels & capillaries are unable to pierce this tissue so blood circulation is absent in epithelium. Hence cells depend for their nutrients on underlaying connective tissue.
- ☞ Between epithelium & connective tissue, a thin non living acellular basement membrane is present which is highly permeable. Basement membrane consist of 2 layers.

(a) **Basal lamina :** Towards epithelium made up of glycoprotein, which is secreted by epithelium cells.

(b) **Fibrous lamina :** Towards connective tissue, in which collagen and reticular fibres are suspended in mucopoly saccharide which is matrix of connective tissue.

So basement membrane is secreted by both epithelium and connective tissue.

- Mucopolysaccharide is present in the form of Hyaluronic acid which is composed of 2 components – N actyl glucosamine & glucuronic acid. Bothe components are found in alternate form.
  -NAG-GA-NAG-
- To provide mechanical support for the tissue plasma membrane of adjacent epithelium cells modified to form following structures (intercellular Junctions) :
  (i) **Interdigitation –** Finger like processes of plasma membrane which enter into cytoplasm of adjacent cell. These structures are mainly found in **transitional** epithelium.
  (ii) **Desmosomes –** This type of (Macula Adherens) Junction of disc – like protein plate with intermediate fibre known as Tonofibrils composed of keratin like sclero protein. These filaments are deeply situated in the cytoplasm of respective cell. These structures provide mechanical support to **stratified epithelium.**
  (iii) **Tight Junction –** At some places Plasma membrane of adjacent cells become fused to from tight Junction. These structures are mostly found in **columnar epithelium.**

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

Microvilli

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

Cilia or Kinocilia

- Long cylindrical protoplasmic process.
- Motile & contractile
- Movement of ciliais in uniform direction.
- Originated from basal granule or kinetosome.
- Diameter of cilia is same from base to apex.
- in internal structure of cilia 9+2 arrangement of microtubules is present.
- They helps in conduction.
- These are found in

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

Steriocilia

(i) Long cytoplasmic process
(ii) Non motile non contractile
(iii) Basal granule is absent
Plasma membrane in thick & rigid.
(iv) Base of stereocilia is broad & apical part is narrow so they are conical in shape.
(v) They increase surface area & found in

e.g.
- Epididymis
- Vasadeferens

Origin of Epithelium Tissue

It is the only tissue which originated from all the three primordial germinal layers.

eg. (i) Ectodermal – Epidermis (stratified squamous Epithelium)
(ii) Mesodermal – Mesothelium (simple squamous Epithelium)
(iii) Endodermal – Endothelium (simple squamous Epithelium)

Types of Epithelium Tissue

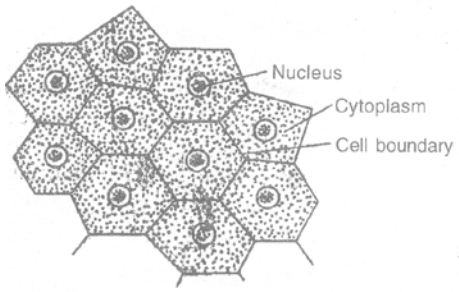
On the basis of number of layers of cell, epithelium is of two types –

(1) Simple Epithelium – Unilayered
(2) Compound Epithelium – Multilayered

SIMPLE EPITHELIUM TISSUE

On the basis of cell shape it is of following types –

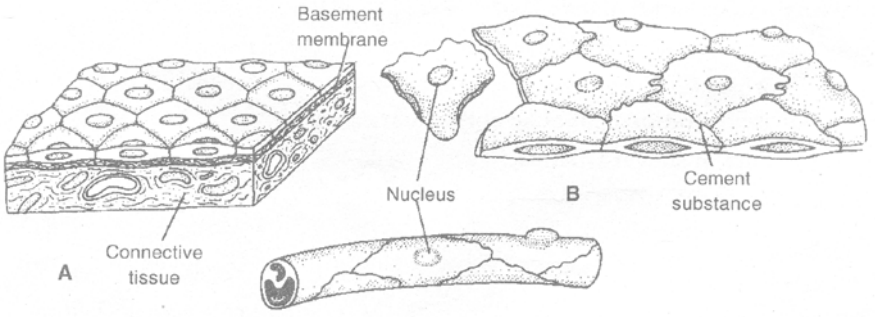
(i) Simple Squamous epithelium
(ii) Simple Cuboidal epithelium
(iii) Simple Columnar epithelium
(iv) Pseudostratified epithelium



(Simple squamous epithelium)

Simple Squamous epithelium

- Unilayered.
- Cells are flat or scale like in shape.
- A flattened / rounded nucleus present.
- Cells are more in which and less in length so in verticle section they appear rectangular in shape.
- It is also called **pavement epithelium** due to its tile like appearance.
- Also called **Tesselated epithelium** due to its wavy appearance.
- This epithelium is associated with **filtration & diffusion**

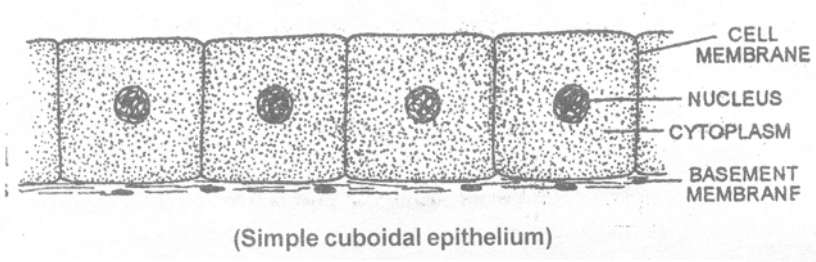


eg. It is found the lining of :

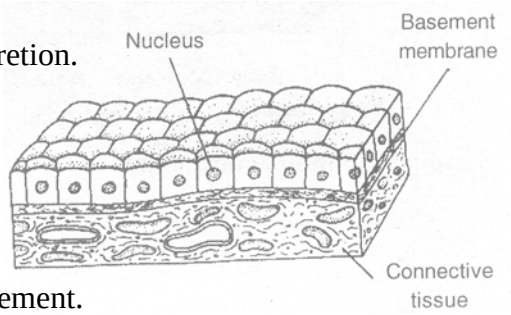
- Bowman's capsule (Podocyte)
- Descending limb & thin part of ascending limb of loop of Henle.
- Rete Testis
- Alveoli of lungs (Pnemocytes)
- Small bronchioles
- Mesothelium – Covering of coelom is called as mesothelium. (Tesselated)
- Visceral & Parietal peritoneum, Visceral and parietal pleura, Visceral and Parietal pericardium.
- Endothelium – Inner lining of blood vessels and lymph vessels. (Tesselated)
- Inner lining of heart wall (Tesselated).

Simple Cuboidal Epithelium

- ☞ Basement membrane is present.
- ☞ Cells are cube like in shape
- ☞ A rounded nucleus is present in the centre of cell
- ☞ Cells are same in length & width so they appear square shaped in vertical section.



(Simple cuboidal epithelium)



- ☞ This epithelium helps in absorption, secretion & excretion.
  It also form gametes in gonads.
  Mostly cuboidal cells are found in glands.
  Vesicles of Thyroid gland
- ☞ Thyrold is the largest endocrine gland of body.
- ☞ It is the only a gland which stores its hormones in its cavity & release into the blood as per body requirement.
- - **Acini of Pancreas**
- ☞ Pancreas is heterocrine or mixed gland – Exocirne part of this gland is composed of acini & cuboidal cells of acini produce pancreatic juice.
- ☞ While endocrine part of this gland is composed of islets of Langerhans.
- - **Pancreatic duct**
- - **Secretory unit of sweat glands**
  Sweat glands are coileld tubular glands in structure.
  Coiled part of this gland is secretory unit in which simple cuboidal epithelium is present while in secretory duct of this gland **stratified cuboidal epithelium** is present.
- - **Secretory duct of salivary glands**
  Submandibular – Whartson's duct
  Parotid – Stenson's duct
  Sublingual – Bartholin duct or duct of Rivinus
  While secretory unit of salivary glands is composed of **stratified cuboidal epithelium.**
- - **Iris**
- - **Choroid**
- - **Ciliary body of eye**
- - **Thick part of ascending limb of loop of henle**
- - **DCT of nephron**
- ☞ This epithelium is also called **<u>Germinal epithelium</u>** because in gonads (testis & ovaries) cubodial cells divide to form egg & sperm.
  It is found in peripheral region of ovary & lining of seminiferous tubules in Testis.

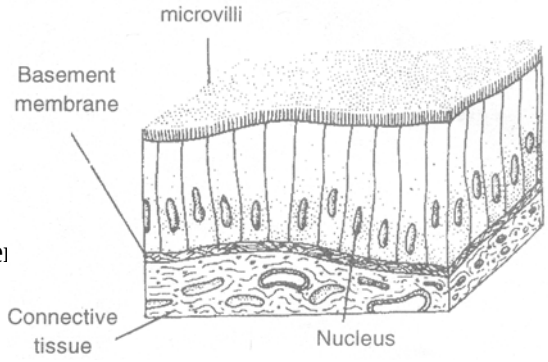
Modifications of simple cuboidal epithelium

- (i) When microvilli are present on free end of cuboidal cells then if is called as **Brush bordered cubioiddalepithelium .**
- Found in PCT of nephron.
- (ii) When cilia present on free end of cuboidal cells then it is called as **ciliated cuboidal epithelium .**
- Found in certain part of nephron and in collectiong duct.

SIMPLE COLUMNAR EPITHELIUM

- Basement membrane is present .
- Cells are pillar like in shape
- Elongated nucleus is present in the bas of cell.
- Cells are more in length & less in width so they appear pillar shaped in vertical section.
- It helps in absorption and secretion.

eg. **Bile Duct**
Liver



Modifications of Simple Columnar epithelium

(1) Brush Bordered Columnar epithelium:
When microvilli are present on free end of columnar epithelium.
eg. Gall bladder

(2) Glandular columnar epithelium:
Unicellular mucous secreting **goblet cells** are also prese in between columnar cells.
eg. Stomach
Colon
Rectum

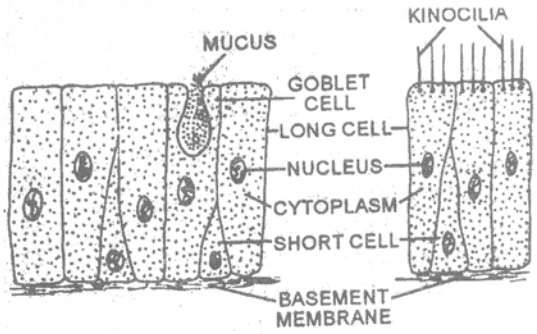
(3) Glandular Brushbordered columnar epithelium :
When microvilli present on free end of columnar cells & in between these cells goblet cells are also present .
eg. Duodenum
Ileum
Caecum .

(4) Ciliated Columnar epithelium :
When cilia are present on free end of columnar cells.
eg. Fallopian Tube
Ependymal epithelium

(5) Sterio ciliated columnar epithelium : When steriocilia are present on free end of columnar cells.
eg. Epididymis
Vasa Deferens

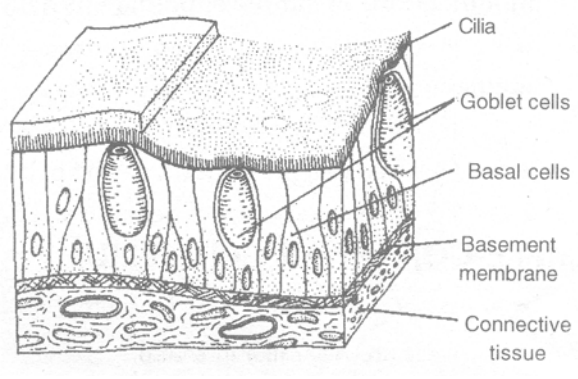
PSEUDOSTRATIFIED EPITHELIUM

- In this epithelium two types of cells are present
  i.e. Long cells
  Short cells.
- All these cells are pillar like in shape so it is also a mokification of columnar epithelium .



(Pseudostratified columnar & ciliated columnar)

- In long cells. Elongated nucleus is present at the base of cells & in short rounded nucleus is present in the centre of cell.
  eg. Middle part of male Urethra
- Nucleus in both cells are present on different level so it appears bilayered because few cells are too short to reach the top surface. But all cells are present on single basement memrane so it is unilayered.



Modification :

Pseudostratified ciliated glandular epithelium :

In this epithelium cillia are present of free end of long cells and goblet cells are also present in this epithelium.

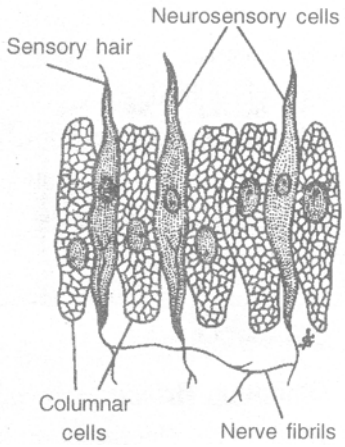
eg. Trachea
Bronchi
Respiratory epithelium of nasal chambers.

Special Types of Epithelium

(a) Neuro sensory epithelium :

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

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



(b) Myoepithelium :- Around mammary and sweat gland

(c) Pigmented epithelium (Cuboidal) :- In retina of eye

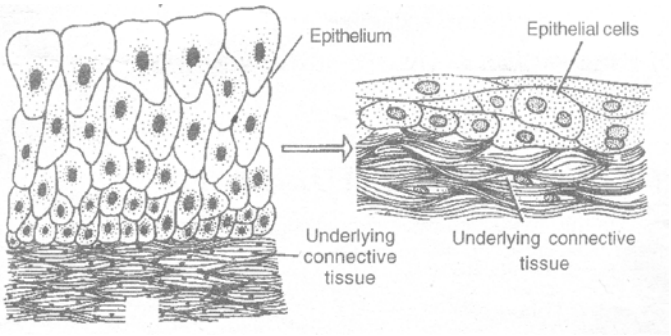
COMPOUND EPITHELIUM

On the basis of stretching ability it is of 2 types –

(1) **Transitional epithelium :-** Stretchable .

(2) **Pigmented epithelium (Cuboidal) :-** In Retina of eye

TRANSITIONAL EPITHELIUM (UROTHELIUM)



(1) It is only tissue in which basement membrane is absent. So innermost layer directly rest upon underlaying connective tissue.

(2) In this epithelium 4-6 layers of cells are persent.
- Inner most layer of cell is composed of **cube like cells.**
- Middle 2-4 layars are composd of pear shaped or umbrella shaped cells.
- Outermost 1 or 2 layers are of oval shaped cells.

- These different shape of cells appears only in resting stage. When this tissue is stretched, all the cells become flattened.
- At outermost layer a thin cuticle is present which makes this water proof.
- Cells are interconnected by interdigitation

Eg.
- Renal Pelvis
- Ureter
- Urinary Bladder
- Proximal part of male urethra.

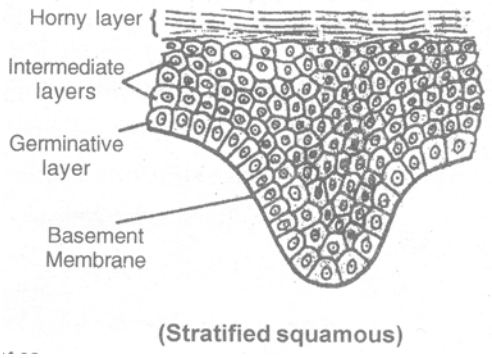
STRATIFIED EPITHELIUM

- On the basis of shape of the cells of outermost layer it is of three types.
  (1) **Stratified squamous epithelium**
  (2) **Stratified cuboida epithelium**
  (3) **Stratified columnar epithelium**

STRATIFIED SQUAMOUS EPITHELIUM

- Innermost layer of cells are of cuboidal or columnar shaped.
- They get their nutrition from underlaying connective tissue.
- They divide to from layers of Stratified epithelium so this layer is called as **Germinativum** layer. Middle layer are made up of polygonal cells.
- Cells of outermost layer are scale like flat cells.
- On the basis of presence of Keratin protein in the outer most cells this epithelium is of two types.

1. **Keratinized Stratified squamous epithelium.**
   If keratin protain is present in scaly cells and cells become non nucleated dead cells.
   eg.
   - Epidermis of skin
   - Scale
   - Horn
   - Nails
   - Feathers etc.



(Stratified squamous)

2. **Non Keratinized Stratified squamous epithelium .** If Keratin protein is absent . Cells are nucleated & Living .
   eg.
   - **Buccal cavity or oral cavity of mammals**
     Inner lining of cheeks
     Inner lining of lips
     Lining of hard palate.
     Lining of Tonsils.
     Lower part of soft palate
     Pharynx
     Oesophagus
     Anal canal
     Lining of vagina
     Cornea of eye

SRTATIFIED CUBOIDAL EPITHELIUM

1. Inner most layer cuboidal/Columnar
2. Middle layer – polygonal shaped cells.
3. Outermost layer of cells are cube like & cells are nucleated & living .

Eg.
- Secretory duct of sweat glands, mammary glands and sebaceous gland.
- Secretory unit of salivary glands, sebaceous gland .
- Female Urethra.
- Conjunctiva of eye.

STRATIFIED COLUMNAR EPITHERLIUM

Outermost layer is composed of pillar shaped cells, cells are nucleated. On the basis of presence of cilia this epithelium is 2 types

(1) Ciliated stratified columnar epithelium .

Eg. Buccopharynageal cavity of Frog.
Upper part of soft palate towards nasoharynx
Larynx
Uterus

(2) Non ciliated St. columnar epithelium. Cilia absent on free end.

Eg. Distal part of male urethra
- Epiglottis

GLANDS

A cell or a group of cells which secretes chemical substances are called glands.
All glands are composed of Epithelium tissue.
Glands can be originate from all the three germinal layers.

CLASSIFICARTION OF GLANDS

On the basis of presence of secretory duct glands are of 3 types

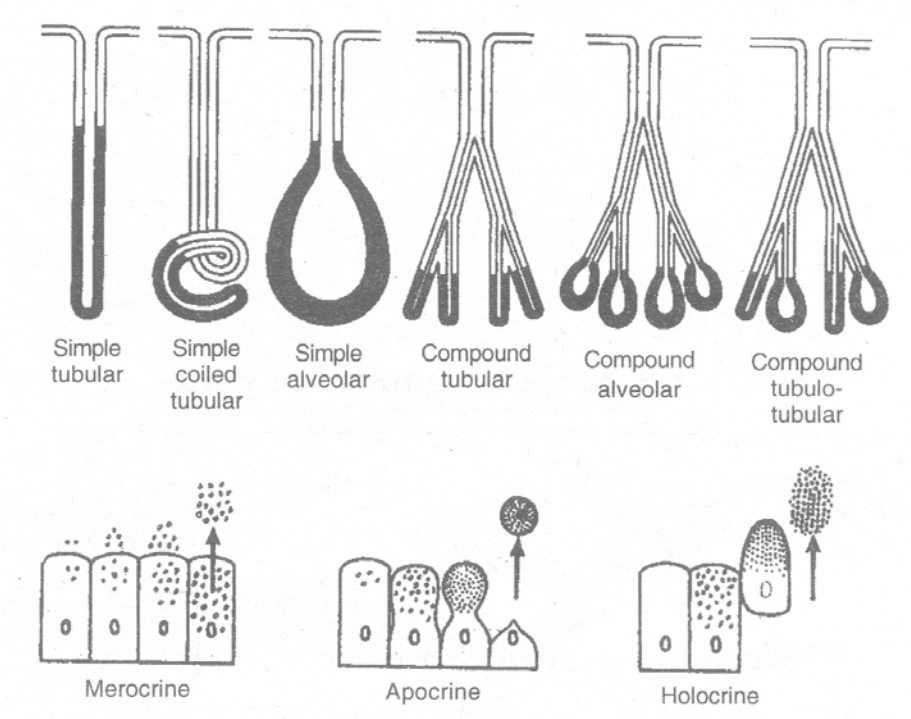
(a) **Endocrine glands :-** Secretory duct absent
(b) **Exocrine gland :-** Secrertory duct present .
(c) **Heterocrine/mixed gland :-** Both endocrine & exocrine parts are present .
eg. Pancreas, Gonads etc.

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

(1) **Eccrine/Acrine/ Merocrine gland :-** In these glands secretory cells secrete substances by simples diffusion (Exocytosis). No part of cytoplasm is destroyed in secretion. Secretory matter like water.
Eg. Maximum sweat glands of humans, Paws of rabbit, Goblet cells, Salivary gland .
Tear gland, Intestinal glands, Mucous gland.

(2) **Apocrine gland :-** In this type of glands secretory products are collected in apical part of secretory cell and apical portion is also shed alongwith secretory matter.
Secretory cells gain their lost part of cyloplsm by process of regeneration. Secretory matter is comparatively concentrate.
- Mammary glands.

Eg. Sweat gland of Arm pit, pubic region, skin around anus , lips nipples etc.
Largest sweat gland of body are found around nipples – Areola mamme.



In Rabbit sweat glands of this type are found on lips & Skin around lips .

(3) **Holocrine glands :-** The production or secretion is shed with whole cell leading to its destruction . i.e. Whole cell is shed as secretion (Secretory matter concentrate)

Example : Sebaceous, meibomian & Zeis gland .

On the basis of secretory matter

(i) Serous glands
Secretion – Watery fluid
Eg. Sweat glands

(ii) Mucous glands
Secretion : Mucous/glatinous
Eg. Goblet cell

(iii) Mixed glands
Secretion : Watery + Mucous
Eg. Pancreas, gastric glands

On the basis of number of cells

- (a) Unicellular glands
  Eg. Goblet cells, Paneth cells
- (b) Multicellular glands
  Eg. Rest glands

On the basis of Shape of secretory unit

- (1) Tubular glands
  - (A) Simple glands
    - (i) S. Tubular glands
      eg. Intestinal glands
      (Crypts of leiberkuhn)
    - (ii) S. coiled tubular
      – Sweat glands
    - (iii) S. branched tubular
      – Sweat glands of armpit
      – Gastric glands
  - (B) Compound tubular glands
    eg. - Brunner's gland
    - Mammary glands of Prototheria.
    - Inactive mammary glands of eutheria
- (2) Saccular/Alveolar glands
  - (A) Simple Glands
    - (i) Simple Alveolar
      eg. Cutaneous glands of frog
      - Poison glands
      - Mucous glands
    - (ii) Simple branched alveolar
      eg. Most sebaceous glands
  - (B) Compound alveolar glands
    eg. - Sublingual gland
    - Submandibular gland
    - Few sebaceous glands
- (3) Compound tubulo saccular
  - Active mammary glands
  - Parotid gland
  - Cowper's gland
  - Pancreas

CONNECTIVE TISSUE

- O. Hartwig called them **Mesenchyme** because they originated from embryonic mesoderm
- Only connective Tissue constitutes 30% of total body weight .
  (Muscle – 50%, Epithelium – 10%, Nervous – 10%)
- On the basis of **matrix** connective tissue is of 3 types
  1. **Connective Tissue Proper :-** Martix soft and fibrous
  2. **Connective Tissue Skeletone :-** Dense and mineralised matrix . Due to deposition of minerals it becomes hard.
  3. **Connective tissue Vascular :-** Liquid and fibres free matrix

CONNECTIVE TISSUE PROPER

Connective Tissue proper is composed of three components
(A) Defferent types of cells.
(B) Fibres .
(C) Matrix .

(A) CELLS OF CONNECTIVE TISSUE PROPER

1. FIBROBLAST CELLS

- Largest cells of connective tissue proper .
- Maximum in number.
- Cell body is oval shaped .
- Branched cytoplasmic process arise from these cells so they appear irregular in shape.
- Oval shaped nucleus.
- Cytoplasm of fibroblast is rich in rough ER because main function or primary function of these cells is to produces fibres. Fibres are composd of protein and site of protein synthesis in cell is ribosome which are found on the surface of fough ER .
- They also synthesize most part of Martix of connective Tissue. (Chief matrix producing cell)
- Old fibroblast cells (fibrocyte) are inactive cells and synthesize only little part of matrix .
- Fibroblast cells are also considered as undifferentiated cells of conn. tissue because they can be modified into **Osteoblast & Chondrioblast** cells to produce bone & cartilage.

Function : (1) To produce fibres (2) To secrete matrix

2. PLASMA CELL :- CART WHEEL CELL

- Less in number.
- Small in size
- Amoeboidal in shape
- In these cells rounded nucleus is present in which chromatin material is arranged like spokes in wheel so they are also called as **Cat wheel cells.**
- According to scientists these cells are formed by the division of lymphocytes. So they are also called as **clone of lymphocyes.**

  Function :- To produce, secrete & transport antibody

3. MAST CELLS (MASTOCYTES)

- More in number.
- Smaller in size.
- Amoeboid in shape.
- These are like basophils of blood in structure and function .
- In these cells 's' shaped nucleus is present which is divided into 2 or 3 lobes and lobes are interconnected by protoplasmic strands.
- In their cytoplasm basophilic granules are present which can be stained with basic dye methylene Blue.
- It is important cell of connective tissue proper as they perform important functions.

(a) Histamine :- Histamine is a protein. It is a vasodilator which dilate blood vessels and increase blood circulation in affected area.

- It also increase permeability of blood capillaries
- When allergic substance enter into body mast cell stimulate and secrete histamine so a part of blood comes out from blood capillaries with WBC and accumulate in intercellular spaces. This part of blood is called as **exudate** which causes swelling in affected area. The swelling is red, warm & painful. This type of swelling is called **inflammation .**

(b) Serotonin :-

- It is also called as 5-Hydroxy tryptamine
- It is a protein. It is a vasoconstrictor. It constricts vessels & decrease blood circulation .
- At the site of cut or injury mast cell secrate serotonin which decrease high blood loss.

(c) Heparin :- Heparin is a mucopolysaccharide. It is a natural anti coagulant. It prevents clotting of blood in uninjured blood vessels. (Prevent the conversion of prothrombin into thrombin.)

- Other natural anticoagulants are

Hirudin	-	found in leech.
Anophelin	-	found in female Anophelese.
Lampredin	-	found in Peteromyzon
Cumerin	-	Obtain from plants
Warfarin	-	obtain from plants

- To collect blood in bottle in bank artificial anticoagulants are used like
  - Soduim citrate
  - Sodium oxalate
  - EDTA (Ethylene diamine tetra acetic acid)

  These chemicals act as Calcium binding units and remove Ca^{+2} ionw from blood .

(d) **Matrix** is also synthesized by Mast cells.

4. ADIPOSE CELLS

- Oval shaped cells which stores fat.
- Fat is collected in form of fat globule . Fat globule is formed by the fusion of small oil droplets .
- On the basis of number of fat globules adipocytes are of two types .

MONOLOCULAR ADIPOCYTES

- In these cells single large and central fat globule is present .
- Nucleus & cytoplasm is peripheral and Cytoplasm is less amount .
- Due to compression of globule, nucleus flattened in shape. These adipocytes form **White Fat.**

Multilocular adipocytes :- In these cells many small fat globules are distributed in the cytoplasm around nucleus

- Cytoplasm is more is quantity .
- Nucleus is rounded & found in the centre.
- These adipocytes form **Brown Fat.**

5. MESENCHYMAL CELLS

- Less in numbers. Small sized with cytoplasmic process having irregular shape.
- Oval shaped nucleus is present in these cells.
- These are undifferentiated cells of connective tissue because they can transform into any cell of connective Tissue proper.
  (Like interstitial cells Hydra (totipotent in nature)

Function : To form other cells of connective tissue.

6. MACROPHAGES (HISTEOCYTE)

- It is 2^{nd} largest in size & 2^{nd} maximum in number.
- Amoeboid in shape with bean or kidney shaped nucleus.
- Cytoplasm quantity is more.
- Cytoplasm is agranular but due to presence of more number of lysosome it appears granular.
- They are phagocytic in nature They destroy bacteria & viruses by phagocytosis. They arises by the fusion of monocytes
- Also called as **scavenger cells** of connective tissue because they destroy dead or damaged cells to clean connective tissue.

** Macrophages of

Lung	-	Dust cells
Liver	-	Kupffer cells
Blood	-	Monocytes
Brain	-	Microgleal cells
Thymus gland	-	Hessels granules
Spleen	-	Reeticular cells

7. LYPHOCYTES

- Less n number and small in size having amoeboid shape.
- A large nucleus is present & cytoplasm is present as peripheral layer. Cytoplasm quantity is less.
- Its function is to produce, transport & secretes antibodies.
- They divide to form plasma cells of connective tissue proper.

(B) FIBRES

1. Collagen fibres (White fibres)

1. They are bright & white fibres composed of collagen protein (Tropocollagen).
2. It is present in maximum quantity in vertebrates and only collagen fibres constitutes one third part of connective Tissue fibres.
3. They are wavy & tough fibres always arranged in bundle . Bundle is called fascia.
4. In fascia elasticity is absent but in single collage fibre very less elasticity is present.
5. On boiling they convert into gelatin .
6. They are digestible by Pepsin enzyme.

II. Elastic fibres – (Yellow fibres)

1. They are yellow in colour and composed of elastin protein .
2. They are branched fibres but always arranged singly. Branches of these fibres form network
3. In these fibres maximum elasticity is present .
4. They are highly resistant to chemicals.
5. When boiled they do not dissolve.
6. They are digestible by **trypsin** enzyme.

III. Reticular Fibres :-

1. Also known as Arzyrophil fibre since they can be stained with silver salts.
2. They are composed of reticulin protein.
3. They are highly branched fibres which always from dense network.
4. They are delicate fibres. Elesticity is completely absent .
5. These are mainly distributed in lymphoid organs like spleen or lymph nodes

(C) MATRIX

- Matrix is compsed of Mucopolysaccharide which is present in the form of Hyaluronic acid.

TYPE OF CONNECTIVE TISSUE PROPER

1. AREOLAR CONNECTIVE TISSUE

- Also known as **loose** connective tissue or **spongy** tissue.
- It is most widely distributed tissue in the body.
- In this tissue maximum intercellular space or substances/matrix is present .
- Due to irregular arrangement of bundle of collage fibres many gaps are present . These spaces are called **Areolae.**
- In areolae other components of connective tissue are distributed like fibres, cell & matrix.
- Few elastic fibres are present but reticular fibres are completely absent.
- In cells mast, Macrophage & Figroglast are more in number.
- In these areolae Blood vessels & nerve fibres are also present .

Eg. **Tela Subcutanea:-** A thin continuous layer which connect skin with underlaying skeletal muscles (Panniculas carnosus). In mammals skin is tightly attached with muscles.
While in frog it is present in the form of septum so skin is loosely attached with muscles

Endomysium – Around single muscles fibre .
Periysium –Around bundle of muscle fibres.
Endoneurium – Afound single nerve fibre.
Outside of somniferous Tubules.
Medulla of ovary
Sub mucosa of
Trachea
Brounchi
Intestine

2. ADIPOSE CONNECTIVE. TISSUE

- It is a modification of Areolar connective tissue. But in areolae major component is adipocytes which store fats. Blood vascular system is also present in this tissue.
- If this tissue is treated with alcohol (organic solvent) Fat will be dissolved completely and adipocytes will become vacuolated.
- This tissue can be stained with sudan solution.
- On the baisis of adipocytes 2 type of fats are found in animals.
  1. White fat 2. Brown fat

1. **White fat :-** It is composed of monolocular adipocytes in which single large fat globule & peripheral cytoplasm is present. Due to less amount of cytoplasm , Mitochondria are also less in number. So they produce less energy .

Eg. **Panniculas adiposus :-** A thin continuous layer of white fat under the dermis of skin which of also called **hypodemis** of skin.
Panniculas adiposus is absent in rabbit. Fat is collected in form of adipose connective tissue as a discontinuous layer.
Blubber :- Thick layer of white fat found under dermis of skin. Found in whale, seal elephants. Maximum thicknss of this layer is found in Blue whale (80 cm.)
Hump of camel
Tail of marino sheep
Yellow Bone marow.

2. **Brown fat :-** It is composed of multilocular adiocytes in which many fat globules are present. Cytoplasm is more in amount . Due to more number of mintchondria. It produces 20 times more energy than white fat. Brown colour of fat is due to Cytochroe Pigment

- Cold resistance device in new born baby is due to presence of brown fat.
- Rodents like rat, shrew.
- They are hibernating animals & during hibernation they obtain energy form stored brown fat.
- When fat is oxidised it produce water & energy .

3. WHITE FIBROUS CONNECTIVE TISSUE

In this tissue bundle of collagen fibres are more in quantity & other components of connective tissue proper are less in quantity
Yellow fibres & reticular fibres are completely absent.
In cells fibroblast and mast cells are more in number.
On the basis of arrangement of fibres & matrix this tissue accure in two forms.

(A) Cord :-

1. Bundle of collagen fibres & matrix are distributed in regular pattern (alternate pattern).
2. Fibroblast cells are arranged in a series. Mast cells are scattered in matrix.

eg. Tendon :- A structure which connects muscles & bones.

Strongest tendon of the body is **Tendocalcaneus Tendon.** This tendon connects Gestrocnemius muscle of shank with calcaneum bone of ankle.

(B) Sheath :- In this form there is no regular pattern of fibres & matrix . Cells and fibres are criss-crossed arranged.

eg.

- **Pericardium**
- **Periosteum** - Outer covering of bone.
- **Perichondruim** - Outer covering of cartilage.
- **Epimysium** - Covering muscle.
- **Renel capsule** - Around Kidney.
- **Tunica Albugenia** - Covering of Testis.
- **Spleinc capsule** - Covering of spleen.
- **Duramater** - Outermost covering of brain .
- **Cornea of eye**
- **Tunica adventia of**
  - **Trachea**
  - **Bronchi**
  - **Oesophagus.**
- **Gison's capsule –** Around lobe of liver.

4. YELLOW FIBROUS CONNECTIVE TISSUE

- In this tissue yellow fibres are more in quantity but collagen fibres are also present.
- Reticular fibres are absent.
- On the basis of distribution of fibres & matrix they are of two types.

(A) Cord :- In this form bundle of collagen fibres & matrix distributed in a regular pattern & in matrix yellow fibres form network .

eg. Ligaments – A structure which connects Bones.

- Strongest Ligament of body is **Ilio femoral ligament .**
- This ligament connects Ilium bone of pelvic girdle with femut bone of Hind limb.
- Another strongest ligament **Ligamentum flava,** Present between two adjacent vertebrae.
- In quardrupeds like cow & buffaloo strongest ligament is **ligamentum nuchea** present in the neck between two cervical vertebrae.

(B) Sheathe – irregular distribution of fibres and matrix with Elastic fibre.

eg.

- **Wall of Alveoli of lungs**
- **Wall of small bronchioles**
- **Wall of lymph vessels & Blood vessels**
- **True vocal cords**

5. RETICULAR FIBROUS CONNECTIVE TISSUE

- It is also called Lymphoid Tissue.
- It is mostly found in lymphoid organs.
- Matrix of this tissue is like lymph.
- Reticular fibres are more in amount & form dense network around reticular cells.
- Lumphocyte cells arealso more in number.
- **Provide support and strength and form the stroma (Frame work) of soft organs.**

eg.
- **Spleen**
- **Lymph nodes (Tonsil, Payer's Patches).**
- **Cortex of ovary.**
- **Endosteum (covering of bone marrow cavity).**
- **Lamina Propia**

  Trachea

  Bronchi

  Intestine

6. MUCOID CONNECTIVE TISSUE

Also called **Embryonic** Tissue because it is mainly found during embryonic life.

- Matrix is in abundance.
- Few collagen fibres & fibroblast cell may be present.
- Matrix is composed of jelly like material called **Wharton's Jelly.**

eg.
- **Umbilical cord (connect Placenta with foetus)**
- **Viterous humor — In vitreous body of eye.**
- **Comb of cock.**

7. PIGMENTED CONNECTIVE TISSUE

It is a modification of areolar connective tissue but in areolae pigmented cells are more in number known as **Chromatophores** which provide colouration.

Melanophore – Melanin – Black

Guanophore – Guanine – White

Xanthophore – Xanthophil – Yellow

eg.
- **Dermis of frog skin**
- **Iris & choroids of eye.**

SKETETON CONNECTIVE TISSUE

- Matrix is dense & mineralized. Due to deposition of minerals it becomes hard.
- Also known as **Supporting Tissue** i.e. Provide support to body.
- It is of 2 types
  1. Cartilage
  2. Bone

CARTILAGE

- Other most covering of cartilage is called **Perichondrium** which is composed of white fibres connective tissue
- Cartilage producing cells are arranged on periphery of cartilage known as Chondrioblast.
- These are active cell & divide to form chondriocytes, and synthesize the matrix of cartilage.
- Mature cells of cartilage is called Chondriocytes.
- They are found in vacuole like space in matrix called Lacuna. In which 1 – 4 Chontrocytes are present.
- Chondrioclast are cartilage destroying cells.
- Matrix of cartilage is called Chondrin composed of Chondromucoprotein having Chondrotin-6 sulphate and Mucopolysacchride (Hyluronic acid)
- Matrix of cartilage provides rigidity & elasticity to cartilage.
- Blood circulation is absent in the matrix of cartilage.

Type of Cartilage — There are following types of cartilage

1. Hyaline Cartilage
2. Fibrous Cartilage - (a) Elastic cartilage (b) White fibrous cartilage
3. Calcified Cartilage

1. Hyaline cartilage

- It is maximum in Human body.
- Most of the part of embryonic skeleton is composed of this cartilage . So maximum bones of body are cartilaginous bones because they are developed from cartilage.
- Outermost covering **Perichondirum** is present.
- Matrix of this cartilage is **glass like** clear or hyaline matrix because fibres are completely absent in the matrix of this cartilage. Only few collagen fibres may be present.
- Colour of matrix is **bluish** & it is translucent.

eg. (a) **Nasal septum.**
(b) **'C' shaped rings of Trachea and Bronchi.** (Incomplete in dorsal surface)
(c) **Sternal part of ribs.** (Coastal cartilage)
(d) **Larynx : Thyroid, Cricoid, Arytenoid.** Maximum part of Larynx is composed of hyaline cartilage.
(e) **Articular cartilage :-** At the junction of two long bones on articular surface. At the end of long bone periosteum is absent and Hyaline cartilage is present known as Articular cartilage.

2. Fibrous cartilage

(A) Elastic cartilage

- Perichondrium is present.
- In the matrix of this cartilage yellow fibres form network so it is highly flexible cartilage of body
- Colour of matrix is pale yellow.

Eg. **a. Tip of Nose**
b. Ear Pinna
c. Epiglottis
d. Larynx — Cartilage of santorini of larynx
e. Wall of Eustachian tube

(B) White fibrous cartilage

- Perichondrium is absent because complete WFCT is converted into cartilage.
- In matrix bundle of collagen fibres are more in quantity so it is **strongest cartilage.**

Eg. **Pubic symphysis**
Pubis bone (Half part of pelvic girdle osinnomineta) are interconnected by pubic symphysis.
Intervertebral disc
A pad of cushion like structure which absorb mechanical shok & jerks and protect vertebral column. Central part of this disc is soft called as Nucleus pulposus.
Slight elongation of body after death or in sleeping posture is due to relaxation of this disc.

3. Calcified cartilage

- It is modified hyaline cartilage but to deposition of calcium salts its matrix becomes hard like bones.
- It is **hardest cartilage** of the body
- Ca salt deposits in the form of Hydroxy apatite $Ca_{10}(PO_4)_6(OH)_2$

Eg.
- Pubis of frog's pelvic girdle.
- Supra scapula of pectoral girdle
- Head of Femur & Humerus

BONE

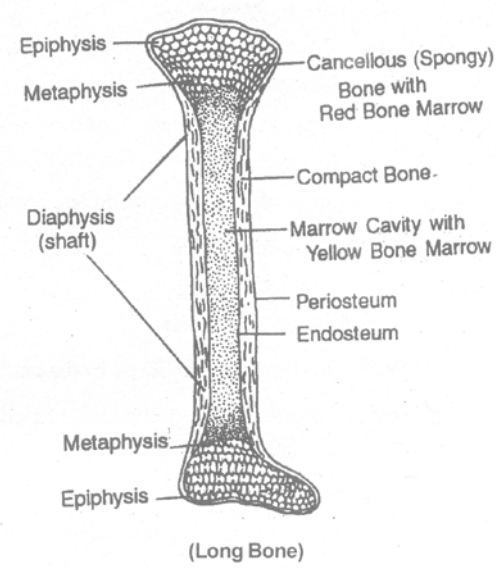
- Study of Bone – **Osteology**
- Process of bone formation – **Ossification**
- Hardest Tissue – Bones
- Softest Tissue – Blood.
  Hardest substance – Enamel. (It is not a group of cell but it is formed by the secretion of ameloblast cells of teeth.)
- Outermost covering of bone is **Periosteum** composed of white fibrous connective tissue.
- Bone producing cells is called **Osteolast.** They divide to form **Osteocyte** & synthesize organic part of matrix.
- Mature cell of bone is called as **Osteocyte** which is found in Lacuna. Only one osteocyte is found in lacuna.
- Bone destroying cells are **Osteoclast** cells.

Matrix

It has two parts
Inorganic Part :- 65 – 68%
$Ca_3(PO_4)_2$ – 80% max. rest 20% $CaCO_3$, $Mg_3(PO4)_2$, Flourides.
Organic part :- 32 – 35% Ossein in which bundle of collagen fibres suspended in sulphated mucopolysaccharide.
Sharpay's fibre :- extra bundle of collagen fibres which are present in the outermost layer of matrix called sharpay fibres. They are also found in the cement of teeth which provide extra mechanical support to bone & teeth.

Structure of long bone :

Long bone has three region
- Epiphysis
- Diaphysis
- Metaphysis



(Long Bone)

Epiphysis

- Ends of long bones is called **Epiphysis.** This part is composed of spongy bone. If this part is present at the joint then on articular surface **Periosteum** is absent & Articular cartilage (Hyaline cartilage) is present.
- Cavity is present in the form of **Trabeculae** filled with red bone marrow.
- It is composed of myeloid Tissue which produce blood corpuscles so epiphysis act as a Haemopoietic organ.

Diaphysis

- Middle part or shaft of long bone is diaphysis which is composed of **compact bone.**
- In this region hollow cavity is present called bone marrow cavity filled with yellow bone marrow composed of white fat. Function of YBM is storage of fat.
- If required or essential in anaemic condition YMB is replaced by RBM.
- At the time of birth RBM is 70 ml. while in adult it is about 4 litre.

Metaphysis

- It formed little part between epiphysis & Diaphysis.
- In this region **epiphyseal plate** is present which is made up of osteoblast cells. They divide to form osteocyte and also synthesize matrix of bone, so epiphysial plate is responsible for elongation of bone.
- After complete development of long bone this plate is destroyed. So in complete developed bone only regions are found while in a developing bone 3 regions are present.

Special points :

Spongy Bones

- Bones in which haversian system are absent. In these bones marrow cavity is present in the form of Trabeculae filled with RBM. So all spongy bones of body are haeopoietic

Eg. Ribs, Pubis, Sternum, Vertebrae, Clavicle, End of long Bones, Scapula

Compact Bone

In this bone Haversian system is present.

Eg. Diaphysis of long bone.

Diploic / Heterotypic

- In these bones middle part of bone is composed of spongy bone, in which Trabeculae is filled with RBM. While this bone is covered by compact bone on upper & lower surface.

Eg. All flat bones of skull.

Pneumatic Bone

- In the matrix of these bones air filled spaces are present so bone become light in weight.

Eg. Bones of birds.

INTERNAL STRUCTURE OF MAMMALIAN BONE

It has following major structures.

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

1. PERIOSTEUM

- Outermost covering of bone is called **Periosteum.**
- It consists of two layers.
- Outer layer consist of WFCT in which blood circulation is present.
- Inner layer – consists of single layer of osteoblast cells. These cells are cube like in shape in which oval shaped nucleus & basophilic granules are present in cytoplasm.
- They divide to form osteocyte and secrete layers of matrix.

2. MATRIX

It is composed of inorganic & organic compounds.

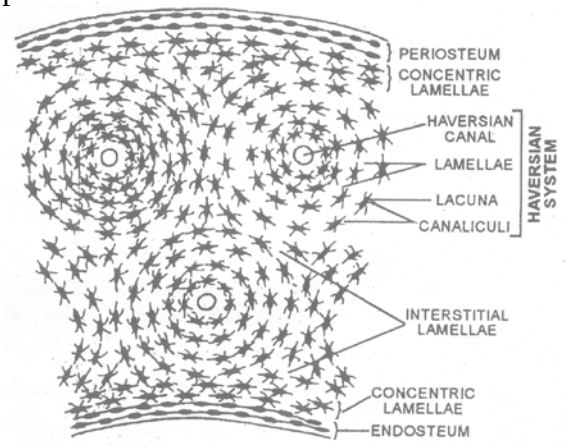
- In the matrix of bone 2 types of canals are present.
  1. Haversian canal 2. Volkmann's canal

HAVERSIAN CANAL

Longitudenal canals which are arranged parallel to long axis of bone. In this canals 1 or2 blood capillaries and nerve fibres are present.

VOLKMANN'S CANAL

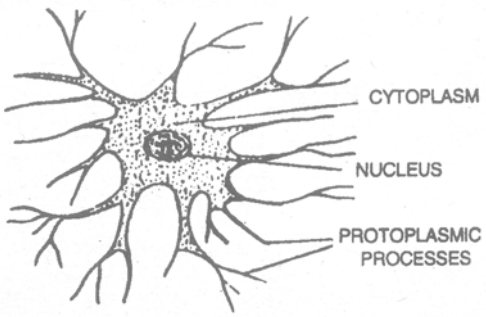
- These are transverse/ horizontal or oblique canals.
- Haversian canals are interconnected by volkmann's canal.
- Matrix of bone is synthesized in the form of layer. These layers of matrix are called **Lamellae.** On the basis of arrangement 3 types of lamellae are present in the matrix.
  1. Haversian lamellae
  2. Interstitial lamellae
  3. Circumferential lamellae.



(T.S. of Mammalian long bone)

HAVERSIAN LAMELLAE

- Concentric layers of matrix which are present around Haversian Canal.
- Between these lamellae layer of Osteocyte cells are also present.
- Haversian canal, Haversian lamellae & Osteocyte form **Haversian** system or **Osteon.**
- Presence of Haversian system is a typical feature of **mammalian** compact bones.
- Osteocyte are present in the lacuna. Each Osteocyte in inter connected with adjacent Osteocyete by their cytoplasmic process.
  Cytoplasmic process of Osteocyte are present in the canals of lacuna called as **canaliculi.**



Bone Cell

INTERSTITIAL LAMELLAE

☛ These layers of matrix are present in the space between 2 haversian systems.

CIRCUMFERENTIAL LAMELLAE

Circumferential layer of matrix are of 2 types.

1. Outer circumferential lamellae :
   - These are present around all haversian system.
   - These areperipheral layers of matrix.
2. Inner circumferential lamellae :
   - Present around bone marrow cavity.

3. ENDOSTEUM

Endosteum consist of 2 layers.

1. Towards bone marrow cavity layer lined with reticular fibrous connective tissue.
2. Towards matrix of bone line with layer of Osteoblast cell. They divide to form osteocyte & synthesize matrix. So growth of bone is bidirectional (Periphery & central region). While Growth of cartilage is unidirectional

4. BONE MARROW CAVITY

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

TYPES OF BONES

On the basis of development or location of ossification bones are of your types.

1. Cartilagenous bones/ Replacing / Endochondral bone

- These bones are developed from cartilage or they are formed by the ossification of cartilage.
- In the formation of these bones 2 types of cells are required.

1. Chondrioclast :- Which reabsorb cartilaginous matter.

2. Osteoblast :- Which deposit bony matter into cartilage so cartilage is replaced by bone. Hence these bones are also called as replacing bones.

Eg. Maximum bones of our body like limb bones (Fore & Hind), Ribs

2. Membranous bones / Dermal bones / Investing bones

☛ These bones are developed from the connective tissue of formed by ossification in the connective tissue of dermis.

Eg. Pubis, Sternum, Nasal Bone, Clavicle, Vomer Bone (Present in the posterior part of Nasal chamber) Scapula.

Flatbones of skull – Parietal Bone, Frontal, Lachrymal, Temporal

Bones of upper Jaw – Maxilla, Palatine

Bones of lower Jaw – Mandible (Human)/ Dentary (other mammals)

3. Sesamoid Bones

☛ These bones are developed by the ossification of tendons at the joints.

Eg. ☛ Pisciform (wrist bone) of man and rabbit. (One out of 8 carpals in manand 1 out of 9 carpals in Rabbit).

☛ Patella (knee bone) Largest sesamoid bone. (Patella and two fabillae in rabbit)

4. Visceral Bones

- If ossification takes place in the visceral organs then visceral bones are formed. These are rare bones, found in few animals. In rabbit & man these bones are absent.

Eg. **Os Cardis** : Present in inter ventricular septum of Deer's heart

Os Palpebrae : In the eyelid of crocodile

Os Penis (Baculum) : In the Penis of rodents rat, shrew, Bat, Whalle, Tiger.

Os rastralis : In the snout of pig.

Special Points

- **Decalicified Bones :-** If a bone is kept indil HCI for 3 days then complete mineral part of the matrix get dissolved in acid & organic part remain in the bone becomes soft & flexible.
- **Black Bone :-** If a bone is dipped into conc. acid then outer surface of the bone get burnt & it appears black in colour called black bone.
- **Dried Bone :-** If a bone is kept in sunlight for long time then complete aqueous part of the bone disappear. In these bones empty lacuna & empty bone marrow cavity is present. Shape of bone remain unchanged.

  If a bone is burnt of kept into very high temp then complete organic part of bone is brunt and mineral part of matrix remain as such in the form of ash called dried bone.
- **Bright Bones :-** If a bone is kept into KOH then complete attached muscle fibres are dissolve in KOH & bone becomes clear & bright called bright bone. Bone will remain unchanged.

  Eg. Bones of laboratory

VASCULAR CONNECTIVE TISSUE

There are two types of vascular connective tissue :

- (1) Blood (2) Lymph

  Matrix is liquid & fibre free

BLOOD

Study of Blood – **Haematology**

Process of blood formation **Haemopoiesis.**

- Colour — Red
- PH — 7.4 (Slightly alkaline)
- By weight — 7 to 8% of body weight
- By volume — 5-6 litres in male and 4-5 litres in female.

a. Cells of blood have no power of division.

b. Fibres are completely absent in blood.

c. Matrix of blood is produced & sybthesized by liver and lymphoid organs.

Composition of Blood

1. Liquid Part — Matrix — Plasma 55%

   Solid Part — Blood corpuscles — 45% (RBC, WBC & Platelets)

Packed cell volume :- (PCV) % volume or Total number of blood corpuscles in blood.

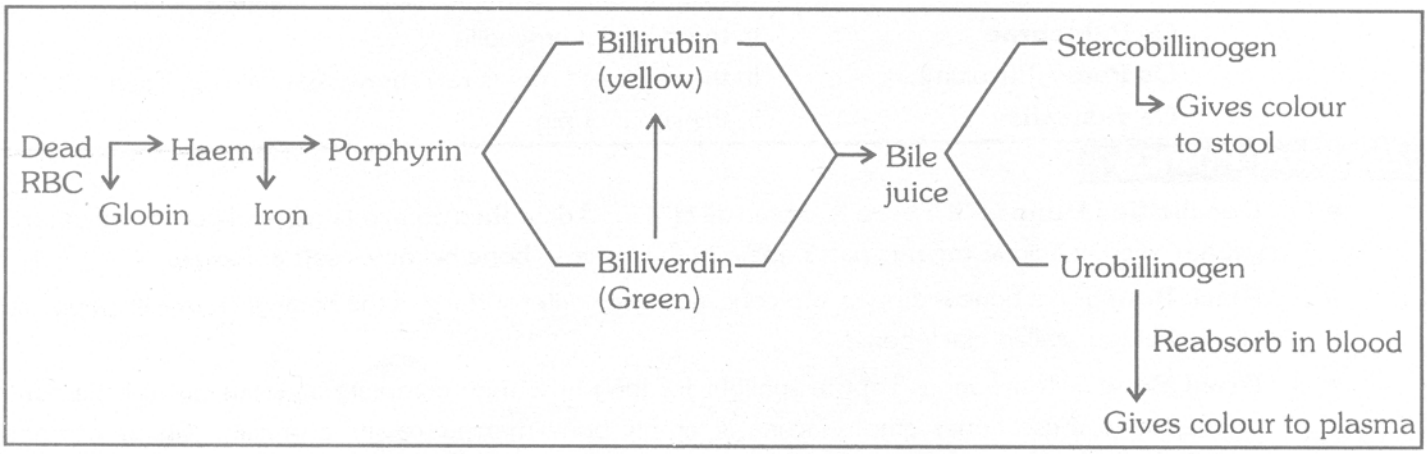
Haematocrit Volume :- % volume or only number of RBC in blood.

PCV ≈ HV

because 99% of Packed cell volume is completed by RBC & in rest 1 % WBC & Plaletets are present.

PLASMA

1. matrix of blood is called Plasma.
2. It is pale yellow in colour due to Urobillinogen. (Billirubin)



Composition of plasma

Water : 90% - 92%
Solid part : 8 -10%
In which inorganic and organic compounds are present
Inorganic part of plasma – 0.9% in which –

1. Ions — Na^+, K^+, Ca^{++}
Cl^-, HCO_3^-, $SO4^{--}$, $PO4^{---}$
Cl^-, > Na^+

2. Salts — $NaCl$, KCl, $NaHCO_3$, $KHCO_3$
Maximum : NaCl also called as common salt.

3. Gases — O_2 , CO_2 , N_2
Each 100 ml of plasma contains 0.29% O_2 , 0.5% N_2 , 5% CO_2
Present in dissolved form

Organic Part of Plasma — 7 – 9%

1. Proteins

- 6 -7% Maximum

(A) Albumin → 4% (Max.)

- Produced & synthesized by liver
- Smallest Plasma Protein
- Responsible to maintain BCOP (28 – 32 mm Hg.)

(B) Globulin :- 2 – 2.5%

- Ratio of Albumin & Globulin is 2 :1.
- Produce and secreted by liver and Lymphoid organs..
- Transport of carry substance in body.
- Destory bacteria virus & toxic substances.
- In blood 3 type of Globulins are present.

[i] **α - Globulin** – Produced by liver.
Eg. Ceruloplasmin – Cu carrying protein.

[ii] **β - Globulin –** Produced by liver

Eg. Transferin – Fe carrying protein.

[iii] **γ-Globulin –** Produced by Lymphoid organs

- Present in the form of antibodies which destroy Bacteria, Virus & Toxic substance. Also called **Immunoglobulins.** These are of 5 types.

[A] lg G (γ Immuno) — 75%

- Max. in quantity and smallest in size.
- Molecular wt. 1,46,000
- Single antibody to cross placents which mother gives to child during embryonic life.

[B] lg A (α Immunoglobin) –10 – 15%

- Molecular wt. 1,70,000
- Secertory antibody because it is present in glandular secretions like milk or intestinal secretions. After birth mother gives to child Immunoglobulin. A

  Colostrum – 1st milk after parturition in which more lg A is present.

[C] lg M (μ Immuno) 5 10%

- Molecular wt. 9,60,000
- Produced & sybthesized at the time of recent infection of Bactria & Viruses.
- Largest & haviest
- Oldest antibody.

[D] lg D (δ Immuno) 1 - 3%

- Molecular wt. 1,84,000
- Surface antibody. Present on the surface of B iymphocyte

[E] lg E (ε Immuno) 0.005%

- Molecular wt. 1,88,000.
- Produced at time of severe allergy.

(C) **Prothrombin** - 0.3% Produced by liver

(D) **Fibrinogen** - 0.3% Produced by liver

- Largest plasma protein.
- Help in blood clotting

2. Digested Nutrients

Amino acid
Glucose (Blood Glucose level - 80 – 100 mg %)
Fatty acid
Glycerole
Cholesterole (Blood Cholesterol level – 150 – 260 mg %)
Vitamins

3. Waste Products

Urea
Uric acid
Creatine
Creatinine

Normal blood urea level – 17 – 30 mg%

If blood urea becomes more then 40 mg this condition is called **Uremia** in which R.B.C. become irregular in shape called burr cell which are destroyed in spleen so uremia is a type of anaemia.

4. Anticoagulant

- Heparin – A Mucopolysacchride which prevent clotting of blood in blood vessels.

5. Defence compounds

1. **Lysozyme :** A protein which act as an enzyme which dissolve cell wall of the Bacteria & destroy them.
2. Properdin : Large protein molecules which destroy toxins synthesize by Bacteria or Viruses so act as anti-toxin

6. Hormones

- Secreted by endocrine glands which are transported by blood plasma.

BLOOD CORPUSCLES

RBC

Erythrocytes (Red blood Corpuscles)

- Mammalian RBC's are Biconcave, circular & non nucleated.
- At the time of origin nucleus is present in the RBC but it degenerates during maturation process.
- Biconcave shape of RBC increases surface area.
- Due to absence of nucleus & presence of biconcave shape more Haemoglobin can be filled in RBC.

  Exception :- Camel & Lame are mammals with biconvex, oval shaped & nucleated RBC.
- In RBC Endoplasmic Reticulum is absent so endoskeleton is composed of structural protein, fats and Cholesterol present in the form of network called **stromatin** which is a spongy cytoskeleton.
- Plasma Membrane of RBC is called **Donnan's membrane.** It is highly permeable to some ions like Cl^- & HCO_3^- ions and impermeable to Na^+ & K^+ ions. It is called Donnan's phenomenon.
- Due to presence of stromatin spongy cytoskeleton & flexible Plasma Membrane RBC (7.5μ) can pass through less diameter blood capillaries (5μ).
- In RBC higher cell orhanelles like Mitochondria & Golgi complex is absent.
- Due to higher cell organelles like Mitrochondria & Golgi complex is absent.
- In RBC enzyme of glycolysis process are present, while enzyme of Krebs cycle are absent.
- In RBC carbonic anhydrase enzyme is present which increases rate of formation & dissociations of carbonic acid by 5000 times. (Fastest cateyst (with zinc))
- Antigen of blood group is present on the surface of RBC.
- If Rh Antigen is present then it is also found on the surface of RBC.
- Single RBC is pale yellow in colour while group of RBC appear red in colour.
- In RBC red coloured respiratory pigment **Haemolobin** is present.
- In each RBC 26.5 crores molecules of Hb are present.
- Molecular weight of each molecule of haemoglobin - 67,200
- In composition of RBC 60% H_2O & 40% soild part is present. Only Hb. Constitutes 36% of total weight of RBC and 90% on dry weight.

Haemoglobin

It is composed of two components

1. Haem - 5% Lipid part
2. Globin - 95% Protein part

Haem (Iron and Porphyrin)

Iron Present in the form of Fe^{+2}

While in muscles myoglobin is present in which iron is present in the form of Fe^{+3}

- Prophyrin is composed of Acetic acid & Glycene amino acid
- Each molecule of Hb carries 4 molecules of O_2
- 1 gm Hb carries 1.34 mL O_2
- 100 ml blood contain 15 gm Hb
- 100 ml blood transport 20 mL O_2

Globin : Each molecule of globin protein is composed of 4 polypeptide chains. Polypeptide chains of 4 types.

1. α polypeptide chain having 141 Amino Acids
2. β polypeptide chain having 146 Amino Acids
3. γ polypeptide chain having 146 Amino Acids
4. δ polypeptide chain having 146 Amino Acids

On the basis of these polypeptide chains 3 type of Hb are formed in Human –

- Hb A (Adult Hb) – $2\alpha + 2\beta$
- Hb A 2 (Adult – 2) – $2\alpha + 2\delta$
- Hb F (Foetal Hb) – $2\alpha + 2\gamma$

(Oxygen binding capacity of foetal Hb is more than adult Hb.)

Size of RBC

Human	-	7.5 μ
Rabbit	-	6.9 μ
Frog	-	35 μ

Largest RBC – Amphiuma 75 – 80 μ (Class : Amphibia)

Smallest RBC – Musk Deer 2.5 μ . (Class : Mammalia)

- Largest RBC among all mammals in Elephant 9 -11 μ.
- Change in the size of RBC is called as **Anisocytosis.**
  1. Due to Vit B12 deficiency RBC become largest in size called as **Macrocytes.** These are immature RBC which are destroyed in spleen. In these RBCs amount of haemoglobin is normal.
  2. Due eto Fe deficiency RBC become smaller in size called as **Microcytes.** They are also destroyed in spleen. In these RBCs amount of haemoglobin is less.

Shape of RBC –

- Biconcave
- Change in the shape of RBC is called as **Poikilocytosis.**

- Uremia – RBC become irregular in shape.
- Sickle cell anaemia – RBC become sickle shaped.
- If RBC is kept in Hypertonic solution it will shrink (crenation).
- In Hypotonic solution it will brust.
- 0.8 - 1% Na Cl solution is isotonic for RBC. (0.9% of Na Cl)
- 80 – 100 mg% of glucose is also isotonic.

Life span of RBC

Human	–	120 days
New Born Baby	–	100 days
Rabbit	–	80 days
Frog	–	100 days

Avg. life span of RBC in all mammals 120 – 127 days.

RBC count

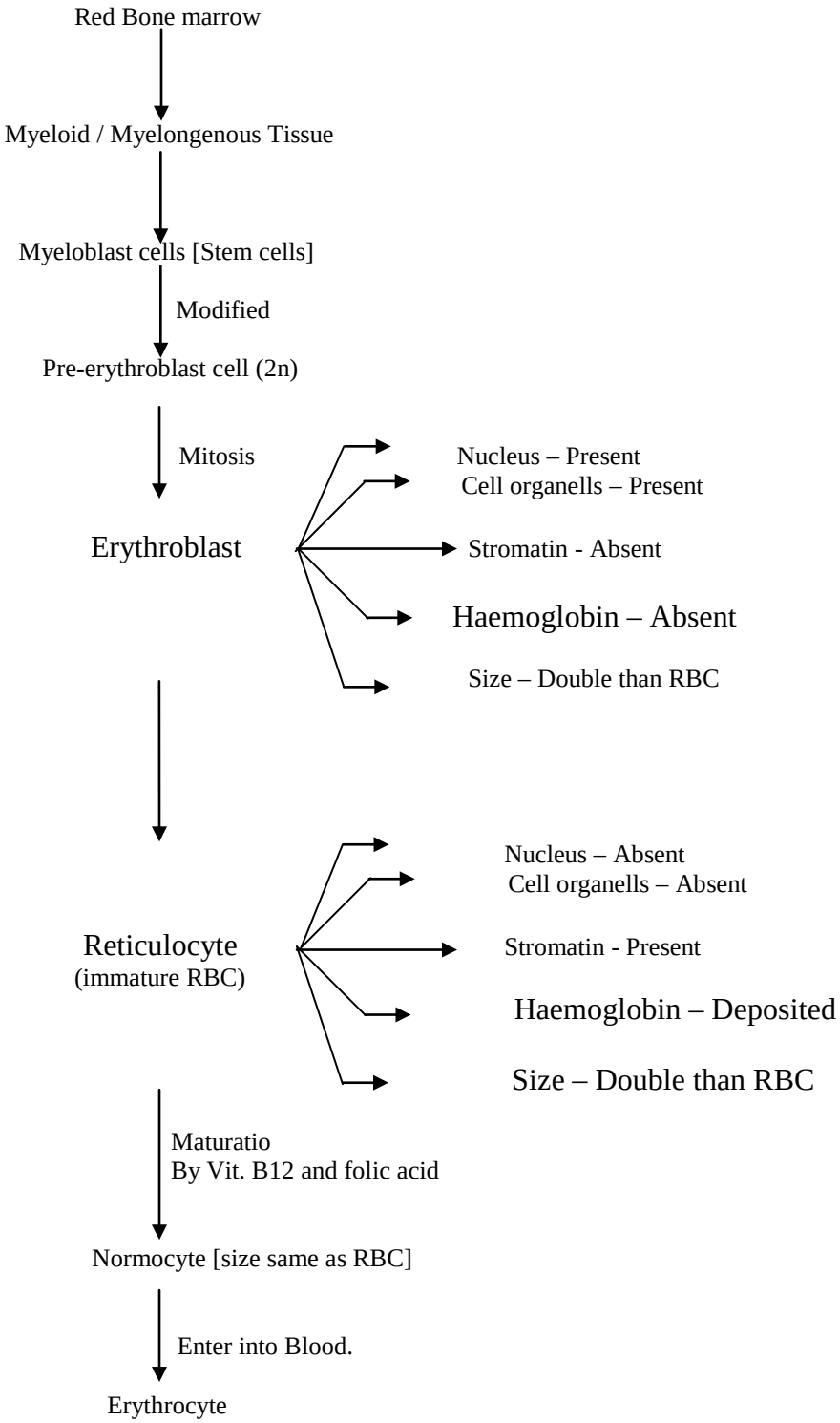
Number of RBC in per cubic mm of blood is called RBC count.

Human (Male)	5.5 million	± 1 Million
Human (Female)	4.5 million	
Newly born baby	6.8 million	
Rabbit	7 million	
Frog	0.4 million	

- Increase in the RBC count condition id called **polycythemia.** This condition occurs at hill station.
- Decrease in RBC count condition is called **Anaemia.**
  1. **Macrocytic Normochromic anaemia** – Due to Vit. B 12 defiency macroytes are formed which are destroyed in spleen. In Macrocytes % of Hb is normal.
  2. **Microcytic Hypochromic anaemia** – Due to Fe deficiency microcytes are formed.
  3. **Normocytic, Normochromic Anaemia** – Excess blood loss.

Formation of RBC

- Process of formation of RBC is called **Erythropoiesis.**
- Organs which produce RBC's called **Erythropoietic organs.**
- Hormone which stimulate Erthyropoiesis is called **Erythropoetin** synthesize by kidney.
- 1st RBC produced by yolk sac.
- During embryonic life RBC are produced by Liver, Spleen, Placenta, Thymus gland.
- In adult stage RBC is produced by RBM which filled in Trabeculae of spongy bones.
- Kidney is an erthyropoetic organ in frog.



- 1% RBC are destroy daily but in same number new RBC are entered in the blood.
- Destruction of RBC occur in spleen. So spleen is called **Grave yard** of RBC.
- Spleen stores excess blood corpuscles so it is called **Blood Bank of body.**
- In resting and slow flowinggg blood, the RBC form piles called **Roulaux** by adhering together due to surface tension.
- Minute bits of disintegrated red blood corpuscles in known as **Haemoconia**
- Ghost of RBC is made up of its plasma membrane.

WBC

- WBC (White Blood Corpuscles) are also called as **leucocytes** because they are colourless. **TLC –** Total leucocyte count. Number of WBC / $mm^3 \rightarrow 8000 – 11000/ mm^3$

DLC :- Differential leucocyte count: number / (%) of different type of leucocyte in per cubic mm. of blood

Acidophils	—	4% of TLC
Basophils	—	0.5% -1 % TLC
Neutrophils	—	65 – 70% TLC
Monocytes	—	4 – 8% TLC
Lymphocytes	—	25 – 30% TLC

Leucocytosis :- Increase in TLC. This condition occur in Bacterial & Viral infection.

Leucocytopenia :- Decrease in TLC. Normally TLC increases in Bacterial & Viral infection but in tyhoid & AIDS, TLC decrease

Leukemia :- Abnormal increase in TLC (more then 1 Lakh) it is called as blood cancer.

- **On the basis of nucleus & nature of cytoplasm, Leucocyte are of 2 types.**

1. <u>Granulocytes</u>

- In their cytoplasm granules are present which can be stained by specific dye.
- Nucleus is multilobed and lobes are interconnected by protoplasmic strand.
- Due to presence of lobed nucleus they are called as polymorphonuclear WBC.
- Produced in Bone marrow

They are (i) Acidophils, (ii) Basophils & (iii) Neutrophils

(2) <u>Agranulocytes</u>

- Cytoplasm in clear & granular
- Nucleus do not divide in lobes so called as Mononuclear WBC.
- Produced in bone marrow.

They are of 2 types (i) Monocytes (ii) Lymphocytes

<u>ACIDOPHILS / EOSINOPHILS</u>

- 4% OF tlc.
- Amoeboid in shape.
- Size 10 14 μ
- Life span – 14 Hours
- In their cytoplasm acidophilic granules are present which can be stain by acidic dye Eosin.
- Nucleus is bilobed.
- They protect body against allergy & parasitic infection.
- In allergy they synthesize **histamine.**
- In parasitic infection they act as lysosome. They attach with the surface or body wall of parasite and synthesize enzymes which dissolve body wall of parasite & destroy them.
- Increase in number of acidophils condition is eosinophilia which occurs in Taeniasis, Ascariasis, Hay fever (Parasitic infection)

BASOPHILS

- 0.5 — 1% of TLC
- Minimum in number
- Amoeboidal in shape
- Size 8 – 10 μ
- Smallest granulocytes
- Life span – 10 Hours
- In their cytoplasm basophilic granules are present which can be stain with basic dye methylene blue.
- Nuclues is divided in 2 or 3 lobes. 'S' shaped.
- Their main function is to secrete & transport Heparin, Histamine & Serotonin. Which are produced in liver.

NEUTROPHILS / HETEROPHILS

- 65- 70% OF tlc
- Maximum in number
- Amoeboidal in shape
- Size 10 – 12 μ
- Life span – 12Hours
- In their cytoplasm granules can be stain by dye (acidic, neutral, basic).
- Nuclues is divided in 3 – 5 or more lobes. So maximum lobed nucleus is present in Neutrophils.
- Counting of lobes of Neutrophils is called **Arneth count.**
- They are active, motile WBC
- They can squeeze & comes out from the wall of blood capillaries in Tissue. This phenomenon is called **Diapedesis.**
- Phagocytic in nature
- Destroy Bacteria & Viruses by phagocytosis.
- Due to their smaller size & Phagocytic nature they are called **Micropolice man.**
- Help in sex detection. In female neutrophils barr body is attached with lobe nucleus which is formed by the modification of x chromosomes.
- Barr body is absent in male.

MONOCYTES

- 4 – 8% of TLC
- Size 12 - 20 μ
- Largest Blood Corpuscles.
- Life span – In blood less then 24 hrs but in connective tissue it may be week / month.
- Nucleus kidney shaped / bean shaped.
- Power of Diapedesis is present.
- Active motile WBC.
- Phagocytic nature.
- Destroy Bacteria & Viruses by phagocytosis so called **Macropoliceman.**
- Also called **scavenger** of blood because they engulf damaged or dead & minute bits of blood corpuscles.

LYMPHOCYTES

- 25 – 30% of TLC
- Amoeboidal shape.
- Size 6 – 16 μ (smallest WBC)
- Life span in blood – 5 – 7 days or less then 10 days but in connective tissue it may be month / year / whole life
- Large nucleus is present. Cytoplasm as peripheral layer.
  Lymphocytes are of 2 types.

T – LYMPHOCYTES

- Produced in bone marrow but mature in thymus gland. On the basis of function T – Lymphocytes are of 3 types
  1. T – Killer / Cytotoxic :- Direct kill Bacteria of Viruses
  2. T – Helper :- Stimulate B – lymphocytes to produce antibody
  3. T – Suppressor :- Suppress T killer & protect immune system.

B – LYMPHOCYTES

- Produced in bone marrow and mature in bone marrow. Its function is to produce, synthesize & transport antibodies

PLATELETS

- Also known as Thrombocytes
- Found only in mammals while in other vertebrates, Spindle corpuscles are present which perform same function.
- They are non nucleated and derived from **Magakaryocyte** cells of bone marrow.
- In shape platelets are disc like, oval shaped or biconvex.
- While spindle corpuscles are spindle in shape & rounded nucleus is present in the centre.
- In their cytoplasm basophilic granules are present which can be stained by methlene blue.
- Maximum part of cytoplasm is composed of contractile protein **Thrombosthenin.**
- Size 2 – 3 μ
- Life span – 2 – 4 /5 days
- Count – 1.5 – 4.5 lakh / mm^3
- Decrease in number of Blood Platelets is called **Thrombocytopenia.**
- Critical count to Thromocytes is 40,000/ mm^3. If number is less then critical count then red spot or rashes appears on the skin called **Purpura disease.**

Function

1. Repair endothelium of blood vascular system by the formation of platelet plug because they have tendency to attach on gelatinous or mucilaginous surface.
2. Synthesize Thromboplastin which in blood clotting.
3. Synthesize serotonin.

BLOOD CLOTTING

- Blood flows from cut wound but after some times it stops automatically, it is called clotting of blood.
- Bleeding time 1 – 3 min.
  Clotting time 2 – 8 min.
  Some times clots are also formed in intact blood vessels which are of 2 types.

Thrombus Clot

- Static clots which grow bigger & bigger & ultimately block the blood vessels.
- If this clot is formed in the coronary vessels then as Coronary Thrombosis which can cause Heart attack.
- If found in brain, then called as Cephalic Thrombus causes paralysis.

Ambolus clot

- Moving clots which flow with blood & ultimately dissolve in blood.
- More harmful due to their moving nature.

Mechanism of blood clotting (Enzyme Cascade theory)

- Proposed by **Macfarlane & Co – workers .**
- According to this theory there are 3 steps in blood clotting.

1. Releasing of Thromboplastin :-

- Injured tissue synthesize exothromboplastin and platelets synthesize endothromoplastin.
- Both these thromboplastin react with plasma proteins in the presence of Ca^{++} ions to form **Prothrombinase enzymes.** (Thrombokinase)
- This enzyme inactivate Heparin. (Antiheparin)

2. Conversion of Prothrombin into Thrombin

- Prothrombinase enzyme convert inactive prothrombin into active Thrombin in the presence of Ca^{++} ion.

3. Conversion of fibrinogen into fibrin

- Fibrinogen is soluble protein of plasma. Thrombin protein polymerise monomers of fibrinogen to form insoluble fibrous protein fibrin.
- Fibrin fibres form network on cut or wound in which blood corpuscles got trapped. This form clotting of blood.
- After clotting a pale yellow liquid oozes from clot called Serum. In which antibodies are found .

Blood	-	Corpuscles	= Plasma
Plasma	-	fibrinogen and large proteins	= Serum

Clotting Factors :-

- 13 factors help in blood clotting.
- These factors are mainly produced in liver.
- Vitamin K is required in the synthesis of these clotting factors.
- These factors are represented in Roman number.

- I — Fir=brinogen
- II — Prothrombin
- III — Thromboplastin
- IV — Ca^{+2} (cofactor in each step of blood clotting)
- V — Proaccelerin
- VI — Accelerin (Rejected)
- VII — Proconvertein
- VIII — AHG Anti Haeomophelic Globin
  (Absent in Haemophilia - A)
- IX — Christmas factor
- X — Stuart factor
- XI — PTA (Plasma Thromboplastin Anticedent)
- XII — Hangman factor (become active by friction)
- XIII — FSF factor (Fibrin stabilizing factor) (Laki Lowand factor).

Blood Groups

- Antigen of blood groups is present on the surface of RBC also called as **aglutinogen.**
- Antibody for blood group antigen is present in serum (plasma) called **agglutinin.**
- Antigen & Antibody are special type of **glycoproteins.**
- Blood groups are of 4 type A , B, AB, O
- A , B, O discovered by **Landsteiner.**
- AB discovered by Decastello & Sturli

Blood groups	**Antigen**	**Antibody**	**Receive**	**Donate**
A	A	b	A, O	A , AB
B	B	a	B ,O	B, AB
AB	A , B	-	A , B , AB , O	AB
O	-	Ab	O	A , B , AB, O

- Blood group O is universal donar & Blood group is AB is universal acceptor.
- Blood groups are example of **multiple alleles.**
- For gene of blood group 3 alternatives are present.
- Gene A & B are dominant gene. They can give their expression in homozygous and heterozygous condition so blood groups A & B are due to dominant gene A & B
- $I^A I^O$
- $I^A I^A$ — A
- $I^B I^O$
- $I^B I^B$ — B

- Gene O is a recessive gene which gives its expression in homozygous condition. Blood Group O is due to recessive gene.
- $I^O I^O$ O
- Blood group AB is an example of codominence in which both dominant gene A & B are present.
- $I^A I^B$ AB

RH FACTOR

- Discoverd by **Landsteiner** & **weiner** in Rhesus monkey.
- Rh antigen is due to dominant gene. So if one of the gamete possess gene of Rh factor, its off Spring will be always Rh +Ve
- If antigen is present then Rh^+
- If antigen is absent then Rh^-

In India % ratio of Rh is

Rh^+ — 80%

Rh^- — 3%

In World

- Rh^+ — 80%
- Rh^- — 20%
- In Rh^+ antibody is absent for this antigen
- Rh antibody is also absent in Rh^- blood

But

1. If Rh^+ blood is transfused to Rh^- then 1^{st} blood transfusion is complete successfully but during I^{st} blood transfusion Rh antibodies are formed in receiver's blood so in next blood transfusion, agglutination of blood takes place.
2. If mother is Rh^- & father is Rh^+ then offspring is also Rh^+ In this case 1^{st} delivery Rh antibody is formed in mother's blood due to damaged blood vessel so in next pregnancy death of foetus will occur in the earlier stage due to agglutination of blood called **erythroblastosis foetalies.**

- To destroy Rh antibody medicines are used like **Rhogam, Rholin, Anti D.**