STRUCTURAL ORGANISATION IN ANIMALS

ANIMAL TISSUES

Tissue : A group of cells in which cells are similar in structure, function and origin is called tissue. Group of similar cells along with intercellular substance perform a specific function such organisation is called tissue. But in a tissue, cells may be dissimilar in structure and function but they are always similar in origin.

Organ : Tissues are organised in specific proportion and pattern to form organ.

Organ system : When two or more organ perform common function by their physical &/or chemical interaction. they together form organ system.

Division of labour : Cell, tissue, organs and organ systems splits up the work in a way that they exhibit division of labour.

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

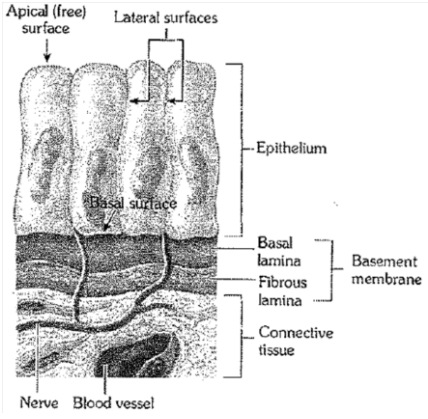
1. **Epithelium/Epithelial Tissue :** Covering & protective tissue.
2. **Connective Tissue :** To connect structures, provide support to the body and transport substances in the body.
3. **Muscular Tissue :** Helps in contraction & locomotion.
4. **Nervous tissue :** To generate and conduct nerve impulses in body.

HISTORICAL BACKGROUND

- Word Epithelium was given by - **Ruysch**
- 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**
- Detial study of tissue is called - **Microsopic anatomy**
- Founder of microscopic anatomy - **Marcello Malpighi**

EPITHELIUM TISSUE

1. During embryonic development epithelium orginates first.
2. Power of regeneration is present in this tissue while power of regeneration is absent or least power is found in nervous tissue.
3. This tissue faces either a body fluid or outside environment and thus provide a covering or a lining.
4. Word epithelium is composed of two words.
   Epi - Upon Thelia - growth
   A tissue which grows upon another tissue is called Epithelium.
5. It always rest upon underlaying connective tissue. Epithelium is the only tissue in which cells are always arranged in uniform layer. Epithelium cells are compactly packed with little intercellular matrix.



6. Due to absence 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 underlying connective tissue.
7. **Basement membrane :** Between epithelium and 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 and it is 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 mucopolysaccharide which is matrix of connective tissue. Mucopolysaccharide is present in the form of Hyaluronic acid.

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

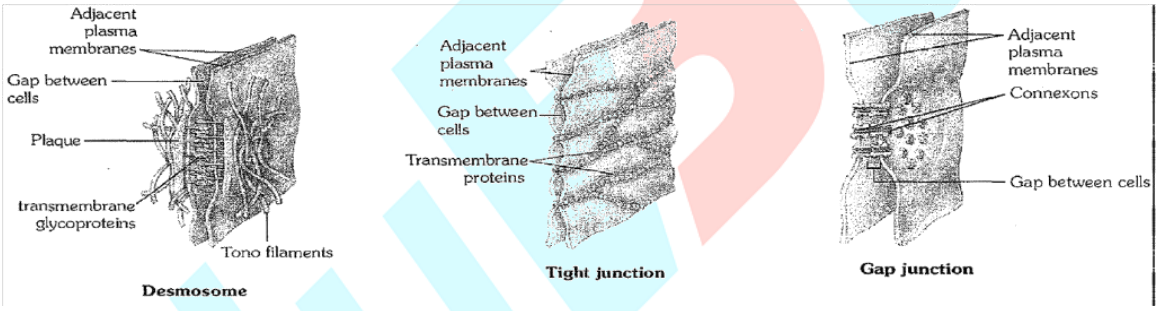
8. **Intercellular junction :** To provide both structural and functional link between its individual cell epithelial cells modify to form following structures (Intercellular Junctions) :

(i) Interdigitation - Finger like processes of plasma membrane which enter into cytoplasm of adjacent cell. These structures are mainly found in transitional epithelium.

(ii) Adhering / Desmosomes - This type of (Macula Adherens) Junction consists of disc - like protein plate with intermediate fibre known as tonofibrils composed of keratin like protein. These filaments are deeply situated in the cytoplasm of respective cell. These structures provide mechanical support to stratified epithelium or performing cementing to keep neighbouring cell together. e.g. Stratified epithelium

(iii) Tight Junction - At some places plasma membrane of adjacent cells become fused to form tight junction to stop substances from leaking across a tissue. These structures are mostly found in columnar epithelium.

(iv) Gap Junction - Facillate the cells to communicate with each other by connecting cytoplasm of adjoining cells for rapid transfer of ions. small molecules and sometimes big molecules.



9. Plasma membrane of free end modified in three of functional structure :-

	Microvilli	**Cilia/Kinocilia**	**Steriocilia**
1.	Minute process	Long cylindrical process (same diameter from base to apex)	Conical shape
2.	Non motile	Motile	Non Motile
3.	Non contractile	Contractil	Non contractile
4.	Function : Increase surface area for absorption and secretion	Function : Helps in movement and olomotion. It moves particles or mucus in specific direction over the epithelium. (Movement is in uniform direction)	Function : Increase surface area
	Eg : Wall of intestine gall bladder, PCT or Nephron	Eg : Inner surface of hollow organs like bronchioles and fallopian tube. Uterus, Trachea, Ependymal epithelium (Inner lining of brain cavitities (ventricle) and central canal of spinal cord) where it helps in cerebrospinal fluid conduction).	Eg : Epididymis and vas deferens

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- Inner living of gut (simple columnar Epithelium)

BEGINNER'S BOX-1

1. Epithelial tissue origined from :-
(1) Ectoderm (2) Endoderm (3) Mesoderm (4) All of these

2. Basement membrane is composed of :
(1) Hyaluronic Acid + glycoproteins (2) Only mucopolysacharides
(3) Endodermal cells (4) Epidermal cells

3. Stereocilia present in :-
(1) Epididymis (2) Seminal vesicle (3) Ureter (4) Kidney

4. Lining of brain ventricle & central canal of spinal cord is lined by :-
(1) Ependyma epithelium (2) Endothelium
(3) Mesothelium (4) Neurosensory

5. Desmosomes :-
(1) Connect the Epithelial cells (2) Are types of lysosomes
(3) Are granules of muscle fibres (4) Found in Bone

6. Ciliated Epithelium found in :-
(1) Oviduct (2) Trachea (3) Brain ventricles (4) All of these

7. Gap junctions :-
(1) help to stop substances from leaking across a tissue.
(2) perform cementing to keep neighbouring cells together
(3) provide stretchability to the epithelium
(4) facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells.

8. Condition necessary for the formation of organ system :
(1) presence of all four basic type of tissues
(2) Chemical interaction
(3) Physical interaction
(4) All of these

9. Tissue which provide support to the body is :
(1) Epithelial tissue (2) Connective tissue
(3) Muscular tissue (4) Nervous tissue

10. Intercellular junction which helps in exchange of substances is :
(1) Tight junction (2) Gap junction (3) Interdigitation (4) Desmosome

CLASSFICATION OF EPTHELIUM TISSUE

Types of Epithelium Tissue

On the basis of number of cell layers

Simple epithelium
- Composed of single layer of cells
- Functions as lining for body cavities, ducts and tubes

Compound epithelium
- Consists of 2 or more cell layers
- It has protective function as it does in our skin

On the bssis of shape / structural modifications of cells

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

SIMPLE EPITHELIUM TISSUE

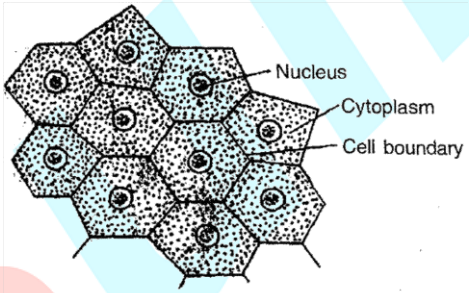
1. Simple Squamous epithelium

(i) Single layer of flat, scale like cells with irregular boundries.

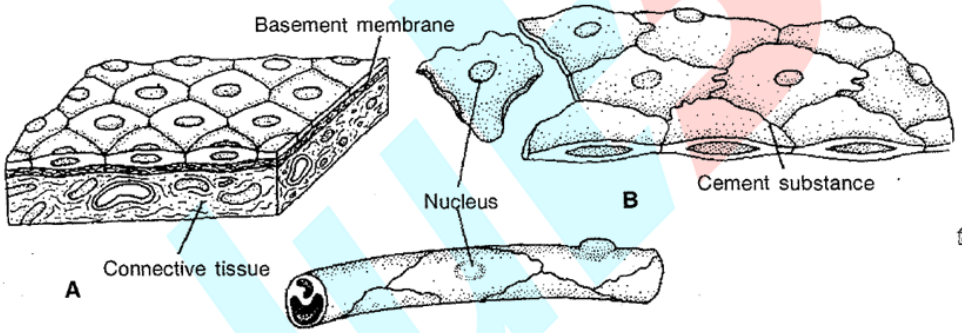
(ii) It is also called pavement epithelium due to its tile like appearance.

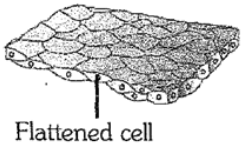
(iii) It is also called Tesselated epithelium due to its wavy appearance.

Functions : Forming a diffusion boundary.



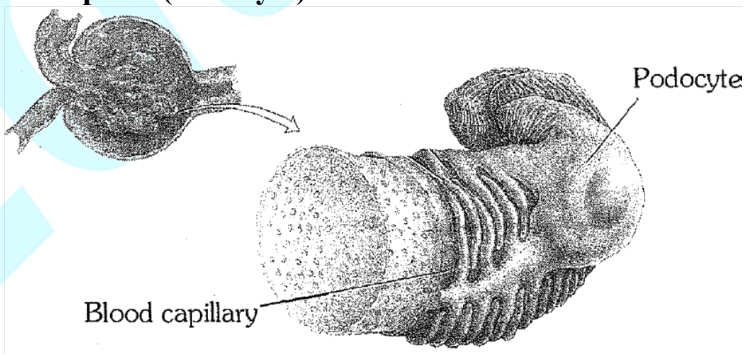
(Simple squamous epithelium)



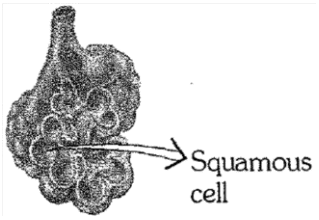


e.g. It is found in the lining of :

- **Bowman's capsule (Podocyte)**



- Alveoli of lungs (Penumocytes) (air sac)



- Mesothelium- Covering of coelom is called as mesothelium.(Tesselated). (Visceral & Parietal peritonium, Visceral and parietal pleura, and Parietal Visceral pericardium).
- Endothelium - Inner lining of blood vessels and lymph vessels. (Tesselated)
- Inner lining of heart wall (Tesselated).

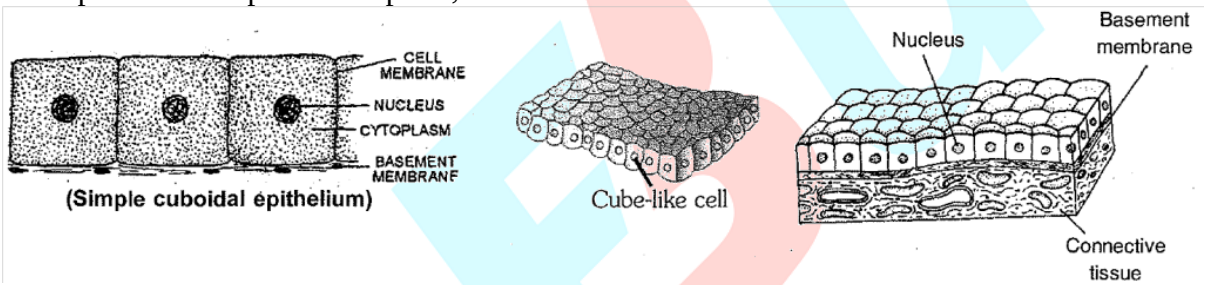
2. Simple Cuboidal Epithelium

(i) Cells are cube like in shape.

(ii) This epithelium is also called Germinal epthelium because in gonads (testis & ovaries) cubodial cells divide to form egg & sperm.

Functions:

This epithelium helps in absorption, secretion & excretion.



Eg.
- Vesicles of Thyroid gland
- Acini of Pancreas
- Sweat glands
- Iris, Choroid, Ciliary body of eye
- Tubular part of Nephrons

Modifications of simple cuboidal epithelium

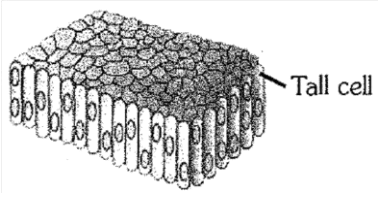
(i) Brush bordered cuboidal epithelium : When microvilli are present on free end of cuboidal cells then it is called as brush bordered cuboidal epithelium. It is found in PCT of nephron.

(ii) Ciliated cuboidal epithelium : When cilia present on free end of cuboidal cells then it is called as ciliated cuboidal epithelium. It is found in neck of the nephron and in collecting duct.

3. Simple columnar Epithelium

(i) Cells are pillar like in shape. (Tall and Slender)

(ii) Elongated nucleus is present at the base of cell.



Function : It helps in absorption and secretion.

eg. Bile Duct, Liver

Modifications of Simple Columnar epithelium

(a) Brush Bordered Columnar epithelium :

When microvilli are present on free end of columnar epithelium.

e.g. Gall bladder

(b) Glandular columnar epithelium :

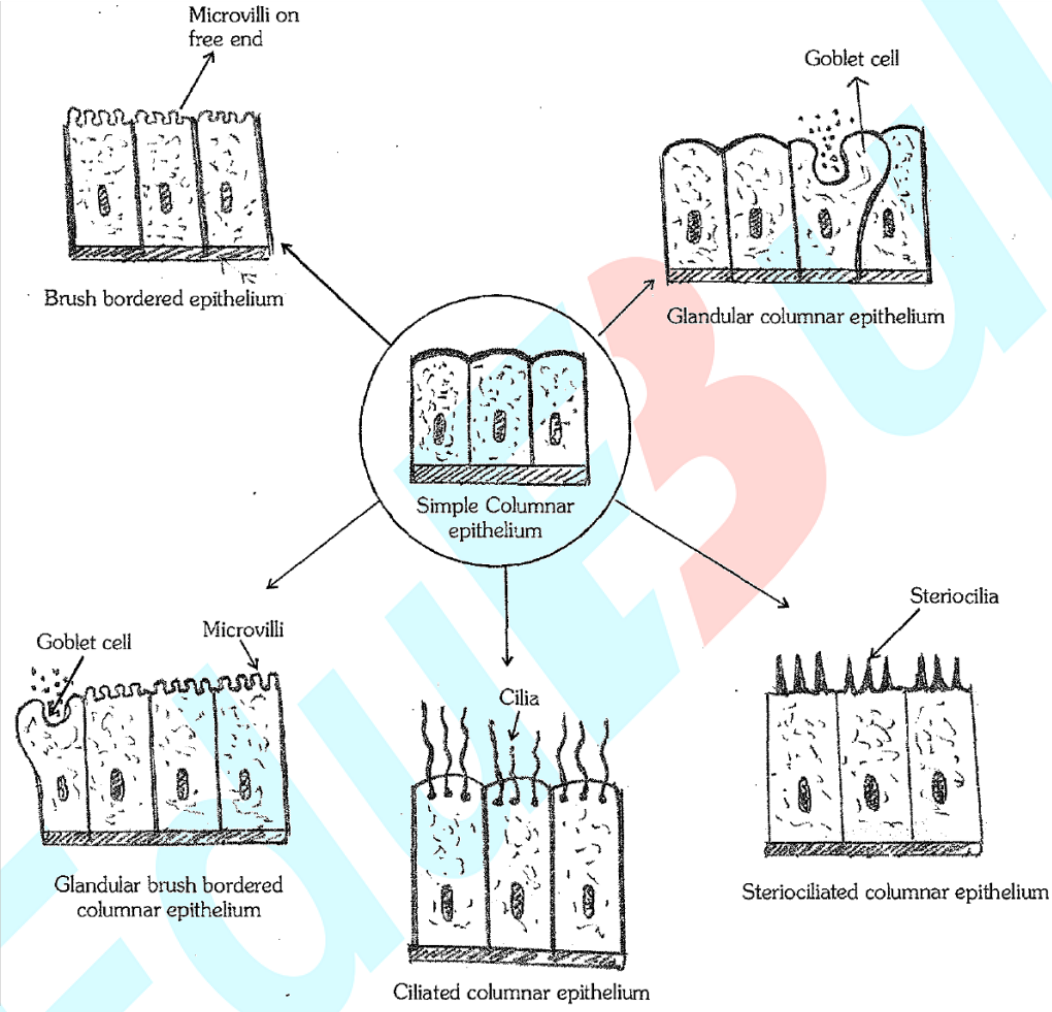
Unicellular mucous secreting goblet cells are also present in between columnar cells.

eg. Stomach, Colon, Rectum and Uterus

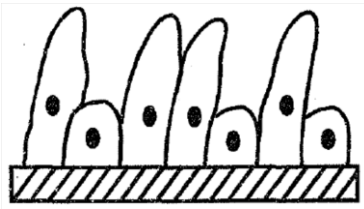
(c) Glandular Brushbordered columnar epithelium :
When microvilli present on free end of columnar cells and in between these cells goblet cells are also present.
eg. Duodenum and Deum

(d) Ciliated Columnar epithelium :
When cilia are present on free end of columnar cells.
Eg. Fallopian Tube and Ependymal epithelium of brain ventricles

(e) Sterio ciliated columnar epithelium : When steriocilia are present on free end of columnar cells.
Eg. Epididymis and Vasa deferens



PSEUDOSTRATIFIED EPITHELIUM



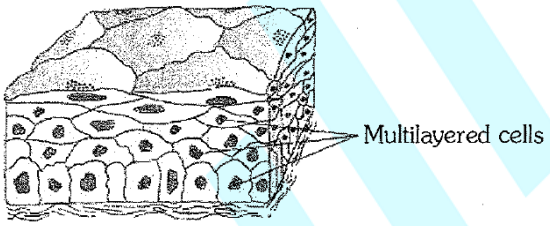
(i) These cells are pillar like in shape so it is also a modification of columnar epithelum.
(ii) In this epithelium two types of cells are present i.e. Long cells, Short cells.
(iii) Nucleus in both cells are present on different level so it appears bilayered because few cells are too short to reach the top surface.But all cells are present on single basement membrane so it is unilayered.

Pseudostratified ciliated columnar glandular epithelium [PSCCGE] :

In this epithelium cillia are present of free end of long cells and goblet cells are also present in this epithelium.
eg. Trachea
Bronchioles
Respiratory epithelium of nasal chambers.

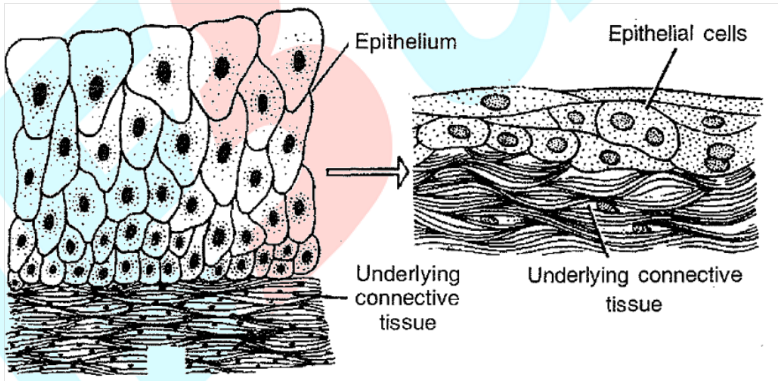
COMPOUND EPITHELIUM

It is multilayered and have limited role in secretion and absorption. It provide protection against chemical & mechanical stress.
On the basis of stretching ability it is of 2 types -
(1) Transitional epithelium :-Stretchable.
(2) Stratified epithelium :-Non-stretchable.



1. Transitional Epithelium (Urothelium)

(1) In resting conditions a thin basement membrane is present but on stretching basement membrane almost get disappeared.



(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 layers are composed of pear shaped or umbrella shaped cells/Polyheadral 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 line is present which makes this tissue water proof.
- Cells are interconnected by interdigitation.
Eg. Renal Pelvis, Ureter, Urinary Bladder, Proximal part of male urethra.

2. Stratified Epithelium

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

(A) STRATIFIED SQUAMOUS EPITHELIUM

(i) Innermost layer of cells are of cuboidal. These cells have high mitotic index. They get their nutrition from underlaying connective tissue. They divide to from layers of Stratified epithelium so this layer is called as Germinativum layer.
(ii) Middle layers are made up of polygonal cells. These cells are interconnected with Desmosomes which provide rigidity or mechanical support.
(iii) Cells of outermost layer are scale like flat cells .

On the basis of presence of keratin protein in the outer most cells this epitheluim is of two types .

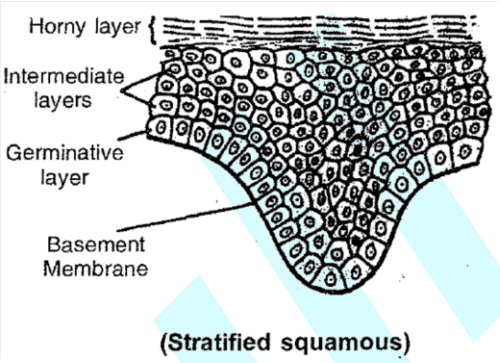
1. Keratinized Stratified squamous epithelium.

If keratin protein is present in scaly cells and cells become non nucleated dead cells.
eg. Epidermis of skin, Scale, Hom, Nails, Feathers etc.

2. Non Keratinized Stratified squamous epithelium :

If Keratin protein is absent. Cells are nucleated and Living.

Eg. - Buccal cavity or oral cavity of mammals
- Inner lining of cheeks, lips, hard palate, tonsils,
- Pharynx, Oesophagus, Anal canal,
- Lining of vagina
- Cornea of eye



(Stratified squamous)

STRATIFIED CUBOIDAL EPITHELIUM

1. Inner most layer is cuboidal.
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, pancreas, salivary glands.

STRATIFIED COLUMNAR EPITHELIUM

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

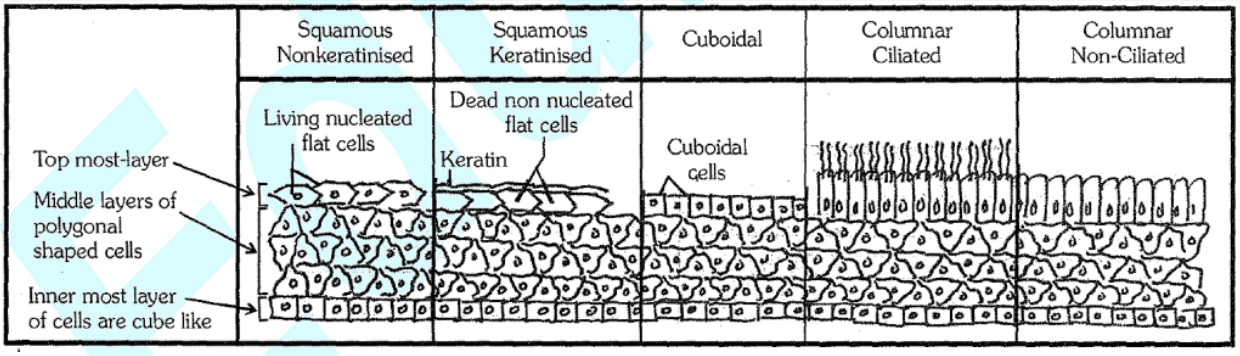
(1) Ciliated stratified columnar epithelium.

Eg. Buccopharyngeal cavity of Frog.
Larynx

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

Eg. Epiglottis.

STRATIFIED EPITHELIUM



GALANDS

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

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

Glands can be originate from all the three germinal layers.

CLASSIFICATION OF GLANDS

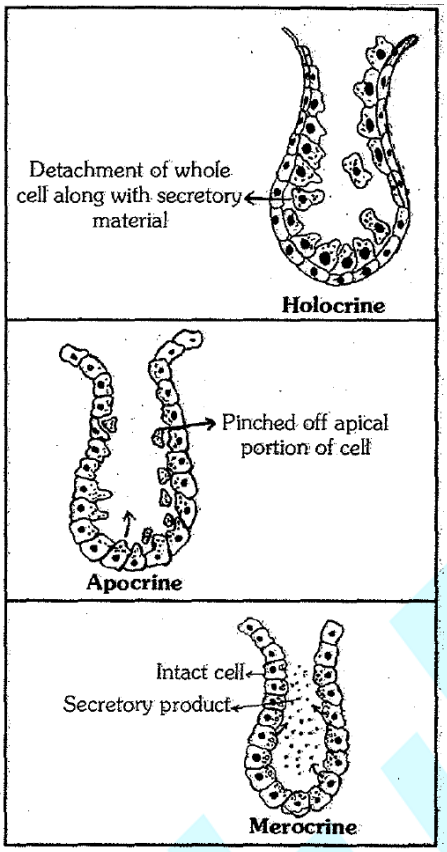
A. On the basis of method of the secretion.

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

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

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

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



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

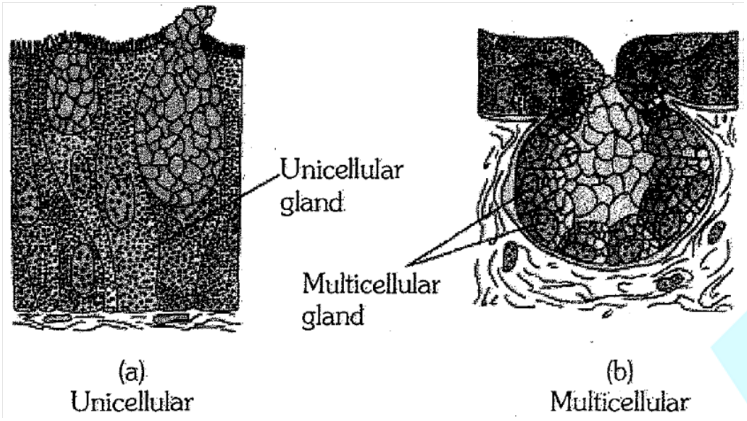
(2) Apocrine gland :- In this type of glands secretory products are collected in apical part of secretory cell and apical portion is also shed along with secretory matter. Secretory matter is comparitively concentrate.

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

On the basis of number of cells

(a) Unicellular glands (Isolated glandular cell)
Eg. Goblet cells, Paneth cells

(b) Multicellular glands
(Consisting of cluster of cell)



BEGINNER'S BOX-2

1. Pseudostratified epithelium is present in:
(1) Nephron & Neuron (2) Larynx & Pharynx
(3) Trachea & Bronchi (4) Urinary Bladder & Intestine

2. Transitional Epithelium is found in :-
(1) Renal pelvis & Ureter (2) Urinary bladder
(3) Upper part of male urethra (4) All of above

3. Columnar Epithelium with microvilli or Brush Border is present in :-
(1) Gall Bladder (2)Stomach
(3) Appendix (4) Pharynx

4. The internal lining of blood vessels is called as :-
(1) Mesothelium (2) Endothelium
(3) Pavement Epithelium (4) Stratified Epithelium

5. Which of the following tissue covers moist surface of buccal cavity and pharynx?
(1) Cuboidal epithelium (2) Columnar epithelium
(3) Transitional epithelium (4) Compound epithelium

6. Non keratin:ised stratified squamous epithelium is found in :-
(1) Skin (2) Stomach (3) Oesophagus (4) Intestine

7. Inner lining of gut, stomach & liver is made up of :-
(1) Simple squamous (2) Simple cuboidal
(3) Simple columnar (4) Pseudo stratified epithelium

8. Cells of Peritoneum comprise :-
(1) Ciliated Epithelium (2) Glandular Epthelium
(3) Columnar Epithelium (4) Squamous Epithelium

9. Stratified squamous Epithelium:-
(1) Outer most layer squamous & Inner most is cuboidal
(2) Outer most layer cuboidal & Inner most is squamous
(3) Outer most layer columnar & Inner most is cuboidal
(4) Outer most layer cuboidal & Inner most is columar

10. The correct statement with respect to epithelial tissue is:-

A - cells are compactly packed B - cells have no intercellular matrix

C - cells have little intercellular material D - it is single or multilayered

(1) A & D (2) B & C (3) A, C & D (4) All of these

CONNECTIVE TISSUE

(i) O. Hartwig called them Mesenchyme because they originated from embryonic mesoderm

(ii) It is most abundant and widely distributed for linking and supporting.

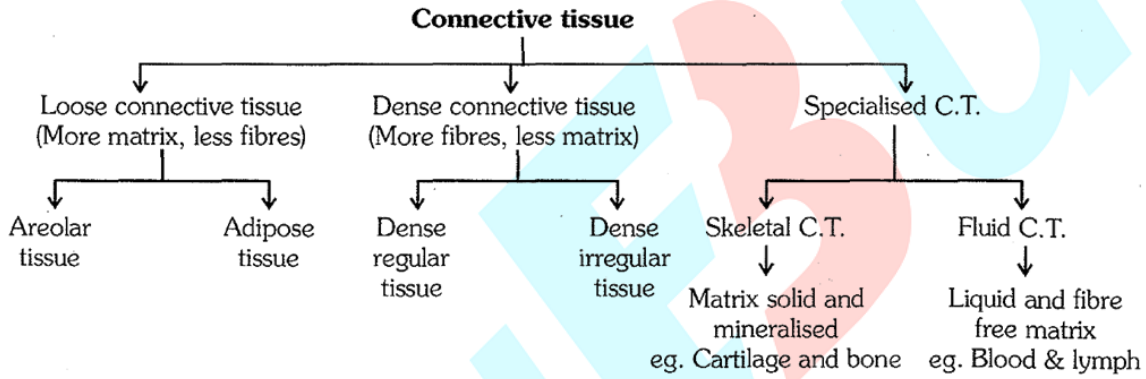
(iii) On the basis of matrix connective tissue is of 3 types.

1. **Connective Tissue Proper :-** Matrix soft and fibrous

2. **Connective Tissue Skeleton :-** Dense and mineralised matrix. Due to deposition of minerals it becomes hard.

3. **Connective tissue Vascular :-** Liquid and fibres free matrix.

In all connective tissue except blood. cells secretes fibres of structural protein (like collagen & elastin) and matrix.



CONNECTIVE TISSUE PROPER

Connective Tissue Proper is composed of three components

(A) Defferent types of cells.

(B) Fibres.

(C) Matrix.

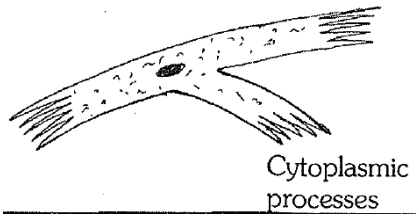
(A) CELLS OF CONNECTIVE TISSUE PROPER

1. FIBROBLAST CELLS

(i) Largest cell of connective tissue proper.

(ii) Maximum in number.

(iii) Branched cytoplasmic process arise from these cells so they appear irregular in shape.



(iv) Main function or primary function of these cells is to produces fibres. Fibres are composed of protein.

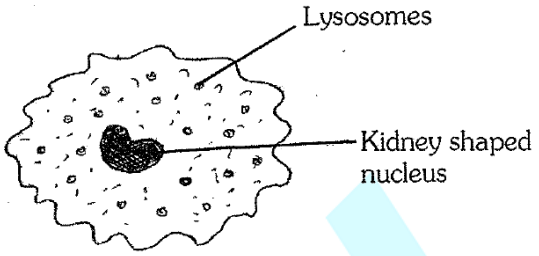
(v) They also synthesize most part of matrix of connective Tissue. (Chief matrix producing cell)

(vi) Old fibroblast cells (fibrocyte) are inactive cells and synthesize only little part of matrix.

(vii) Fibroblast cells are also considered as undifferentiated cells of connective tissue because they can be modified into Osteoblast & Chondrioblast cells to produce bone & cartilage.

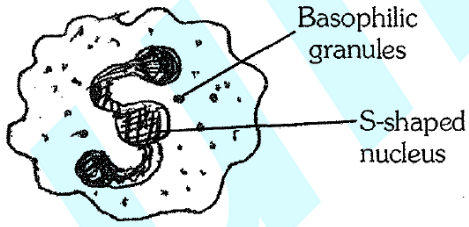
Function: (1) To produce fibres (2) To secrete matrix

2. MACROPHAGES (HISTEOCYTE)



(i) Amoeboid in shape with bean Reniform or kidney shaped nucleus.
(ii) Cytoplasm quantity is agranular but due to presence of more number of lysosome it appears granular.
(iii) They are phagocytic in nature. They destorybacteria & viruses by phagocytosis.
(iv) Also called as scavenger cells of connective tissue because they destroy dead or damged cells to clean connective tissue.

3. MAST CELLS (MASTOCYTES)



(i) Amoeboidal in shape.
(ii) These are like basophils of blood in structure and function.
(iii) In these cells 'S' shaped nucleus is present which is divided into 2 or 3 lobes.
(iv) In their cytoplasm basophilic granules are present which can be stained with basic dye Methylene Blue.
(v) It is important cell of connective tissue proper as they perform important functions.

(a) Histamine :- Histamine is a amino acid derivative. It is a vasodilator which dilate blood vessels and increases blood circulation in affected area.
(i) It also increase permeability of blood capillaries.
(ii) 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 exudates which causes swelling in affected area. This swelling is red, warm & painful. This type of swelling is called inflammation.

(b) Serotoinin :-
(i) It is also called as 5-hydroxy tryptamine.
(ii) It is a amino acid derivative. It is vasoconstrictor. It constricts vessels & blood circulation.
(iii) At the site of cut or injury mast cell secrate serotonin which decrease high blood loss.

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

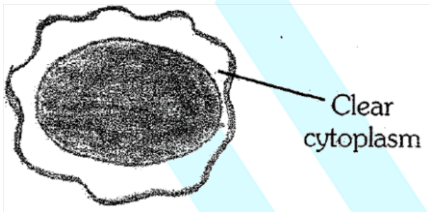
(d) Matrix is also synthesized by Mast cells.

4. ADIPOSE CELLS
(i) Oval shaped cells which stores fat.
(ii) Fat is collected in the form of fat globule is formed by the fusion of small oil droplets.
(iii) On the basis of number of fat globules adipocytes are of two types.

(a) Monolocular adipocytes :
(i) In these cells single large and central fat globule is present.
(ii) Nucleus and cytoplasm is peripheral and cytoplasm is less in amount.
(iii) Due to compression of fat globule, nucleus become flattened in shape. These adipocytes form white fat.

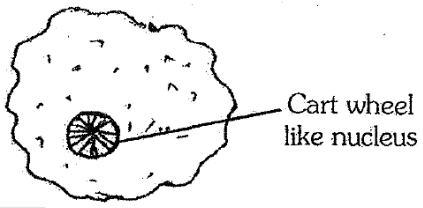
(b) **Multilocular adipocytes :-** In these cells many small fat globules are distributed in the cytoplasm around nucleus
(i) Cytoplasm is more in quantity.
(ii) Nucleus is rounded & found in the centre.
(iii) These adipocytes form brown fat. Brown co1our is due to the presence of Cytochrome pigment.

5. LYMPHOCYTES



(i) Amoeboidal in shape with a large nucleus and cytoplasm is present as peripheral layer. Cytoplasm quantity is less.
(ii) It's function is to produce, transport & secretes antibodies.
(iii) They divide to form plasma cells of connective tissue proper.

6. PLASMA CELL :- CART WHEEL CELL



(i) Amoeboidal in shape.
(ii) In these cells rounded nucleus is present in which chromatin material is arranged like spokes (radial rows) in a wheel so they are also called as Cart wheel cells.
(iii) According to scientists these cells are formed by the division of lymphocytes. So they are also called as clone of lymphocytes.
Function : To produce, Secrete & transport of antibody.

(B) FIBRES

I. Collagen fibres (White fibres)

1. They are bright & white fibres composed of collagen protein.
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. On boiling they convert into gelatin.

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.

III. Reticular Fibres :-

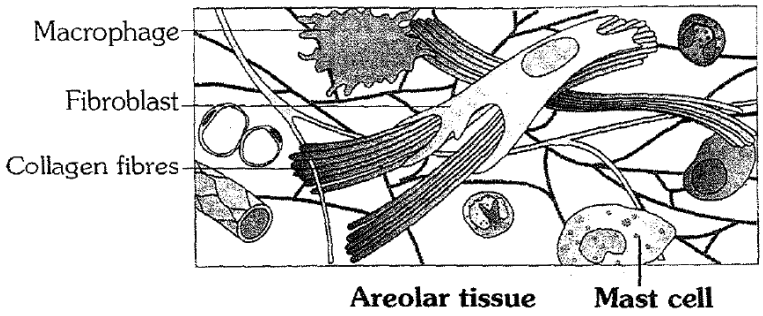
1. Also known as arzyrophil fibre since they can be stained with silver salts.
2. They are composed of reticulin protein.
3. They are highly branched fibres which always form dense network.
4. They are delicate fibres. Elesticity is completely absent.
5. These are mainly distributed in lymphoid organs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

(C) MATRIX (Ground substance)

Matrix is composed of mucopolysaccharide (modified polysaccharide) which is present in the form of hyaluronic acid.

TYPE OF CONNECTIVE TISSUE PROPER

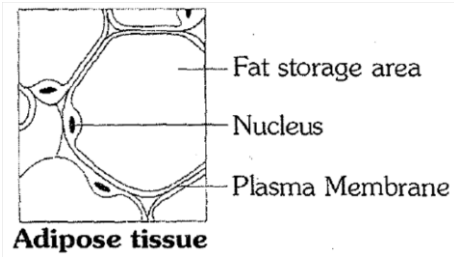
1. AREOLAR CONNECTIVE TISSUE



(i) Also known as loose connective tissue or spongy tissue.
(ii) It is most widely distributed tissue in the body.
(iii) In this tissue maximum intercellular space or substances/matrix is present.
(iv) Due to irregular arrangement of bundle of collagen fibres many gaps are present. These spaces are called Areolae.
(v) In areolae other components of connective tissue are distributed like fibres, cells & matrix.
(vi) Few elastic fibres are present but reticular fibres and reticular cells are completely absent.
(vii) In cells mast cells, macrophage & fibroblast are more in number.
(viii) In these areolae blood vessels & nerve fibres are also present.
(ix) It is also present below the skin.
Eg. Tela Subcutanea :- A thin continuous layer which connect skin with underlaying skelatal muscles (Panniculas carnosus) . In mammals skin is tightly attached with muscles.
Sub mucosa of Trachea, Bronchi, Intestine

2. ADIPOSE CONNECTIVE. TISSUE

(i) It is a modification of areolar connective tissue (Loose connective tissue). But in areolae major component is adipocytes· which store fats. Blood vascular system is also present in this tissue. It is also present beneath the skin.
(ii) If this tissue is treated with alcohol (organic solvent) Fat will be dissolved completely and adipocytes will become vacuolated.



(iii) On the basis of adipocytes 2 type of fats are found in animals.
(a) White fat (b) Brown fat

(a) White fat :- It is composed of monolocular adipocytes in which single large fat globule, peripheral cytoplasm and peripheral nucleus is present. Due to less amount of cytoplasm, Mitochondria are also less in number. So they produce less energy.
Eg. Panniculas adiposus :- A thin continuous. layer of white fat under the dermis of skin which is also called hypodermis of skin.
Yellow bone marow.
Blubber :- Thick layer of white fat found under dermis of skin. Found in whale, seal elephants. Hump of camel, Tail of marino sheep
(b) Brown fat :- It is composed of multilocular adipocytes in which many fat globules are present. Cytoplasm is more in amount. Due to more number of mitochondria it produces 20

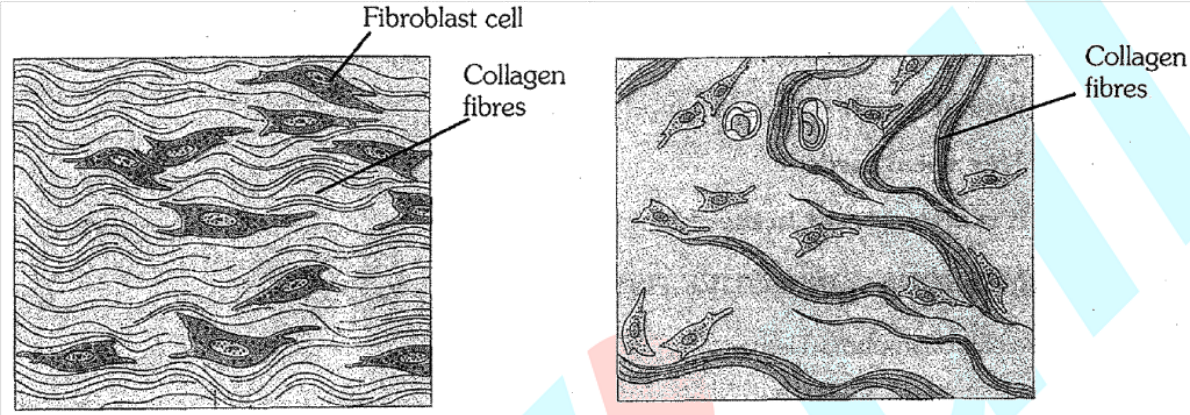
times more energy than white fat. Brown colour of fat is due to presence of cytochrome Pigment.

(i) Cold resistance device in new born baby is due to presence of brown fat.

(ii) Rodents like rat, shrew. They are hibernating animals & during hibernation they obtain energy from stored brown fat.

3. DENSE CONNETIVE TISSUE :

(i) Fibres and Fibroblast are compactly packed.



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

(A) WHITE FIBROUS CONNECTIVE TISSUE

(i) In this tissue bundle of collagen fibres are more in quantity & other components of connective tissue proper are less in quantity.

(ii) Yellow fibres & reticular fibres are completely absent.

(iii) In cells fibroblast and mast cells are more in number.

On the basis of arrangement of fibres & matrix this tissue occurs in two forms.

(a) Cord (Dense regular tissue) :-

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 Tendocalcaneal tendon. This tendon connects gastrocnemius muscle of shank with calcaneum bone of ankle.

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

eg.	Pericardium	-	Outer covering of heart.
	Periosteum	-	Outer covering of bone.
	Perichondruim	-	Outer covering of cartilage.
	Epimysium	-	Covering of muscle.
	Renal capsule	-	Around kidney.
	Glisson's capsule	-	Around hepatic lobule
	Duramater	-	Outermost covering of brain.
	Cornea of eye		

(B) YELLOW FIBROUS CONNECTIVE TISSUE

(i) In this tissue yellow fibres are more in quantity but collagen fibres are also present.

(ii) Reticular fibres are absent.

(iii) On the basis of distribution of fibres & matrix they are of two types.

(a) **Cord (Dense regular) :-**In this form bundle of collagen fibres & matrix distributed in a regular pattern & in matrix yellow fibres form network.
eg. Ugaments -A structure which connects bones.
(i) Strongest Ligament of body is Ilio femoral ligament.
(ii) This ligament connects Ilium bone of pelvic girdle with femur bone of hind limb.

(b) **Sheath (Dense irregular) :-** Irregular distribution of fibres and matrix with elastic fibre.
eg. Wall of lymph vessels & blood vessels
True vocal cords
It is also present in the skin

4. RETICULAR FIBROUS CONNECTIVE TISSUE
(i) It is also called lymphoid Tissue.
(ii) It is mostly found in lymphoid organs.
(iii) Provide support and strength and form the stroma (Frame work) of soft organs.
eg. Spleen
Lymph nodes (Tonsils, Payer's Patches).
Endosteum (covering of bone marrow cavity).

5. MUCOID CONNECTIVE TISSUE
Also called embryonic tissue because it is mainly found during embryonic life. Its matrix is composed of jelly like material called Wharton's Jelly.
eg. Umbilical cord (connect placenta with foetus)
Viterous humor- In viter.ous body of eye.
Comb of cock.

BEGINNER' BOX-3

1. Muscles are connected to Bone by means of :-
(1) Cartilage (2) Ligaments (3) Tendon (4) Adipose tissue

2. Brown adipose cells contain :
(1) Only one fat globule (2) More than one fat globules
(3) Without fat-globules (4) Peripheral nucleus

3. Histeocytes destroy bacteria by :
(1) Phagocytosis (2) Producing Antitoxins
(3) Producing antibodies (4) Producing antigen

4. Plasma cell :-
(1) Is modified B - lymphocytes of blood
(2) Produce antigen
(3) Produce Heparin, Histamine, Serotonin
(4) Produce matrix & Fibres

5. Yellow, White & Reticular fibres made up of protein
(1) Elastin , Reticulin, Collagen, respectively
(2) Reticulin , Elastin, Collagen , respectively
(3) Collagen , Elastin , Reticulin protein

(4) Elastin , Collagen, Reticulin protien

6. Which of the following is known as spongy connective tissue :-
(1) Dense fibrous connective tissue (2) Adipose connective tissue
(3) Areolar connective tissue (4) Reticular fibrous connective tissue

7. Which type of connective tissue used to form submucosa of intestine :-
(1) Dense fibrous C.T. (2) Adipose C.T.
(3) Reticular fibrous C.T. (4) Areolar C.T.

8. a. Monocular b. less mitochondria c. less energy
The above three statements are related to
(1) White fat – rat (2) White fat-new born baby
(3) Brown fat - camel hump (4) White fat- yellow bone marrow

9. Yellow fibrous connective tissue is found in:-
a. Renal capsule b. True vocal cords
c. Walls of blood vessels d. Epimysium
(1) a, b (2) b, c (3) c, d (4) a, b, c

10. Lymphocytes are more in:-
(1) White fibrous connective tissue (2) Reticular fibrous connective tissue
(3) Yellow fibrous connective tissue (4) Adipose connective tissue

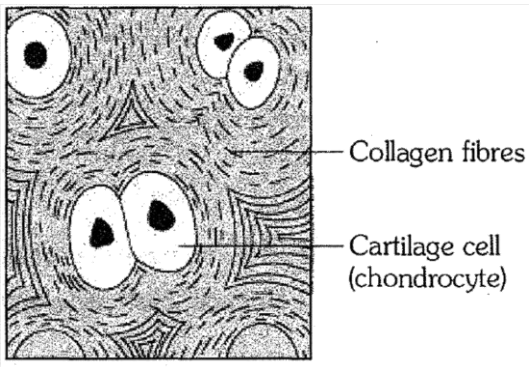
SPECIALISED CONNECTIVE TISSUE

SKELETON CONNECTIVE TISSUE

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

CARTILAGE

(i) Outermost covering of cartilage is called Perichondrium which is composed of white fibres connective tissue.
(ii) Cartilage producing cells are arranged on periphery of cartilage known as Chondroblast.
(iii) These are active cell & divide to form chondrocytes, and synthesize the matrix of cartilage.
(iv) Mature cells of cartilage is called Chondrocytes.
(v) They are found in vacuole like space in matrix called Lacuna, In which 1 - 4 Chontrocytes are present.
(vi) Chondroclast are cartilage destroying cells.
(vii) Matrix of cartilage is called chondrin composed



Cartilage

of chondromucoprotein having Chondrotin-6-sulphate and mucopolysacchride (Hyaluronic acid)

(viii) Matrix of cartilage provides rigidity & elasticity to cartilage (matrix solid. pliable and resists compression)

(ix) Blood circulation is absent in the matrix of cartilage but blood supply present in perichondrium.

Type of Cartilage -There are following types of cartilage

1. Hyaline cartilage

(i) It is maximum in human body.

(ii) Most of the part of embryonic skeleton is composed of this cartilage. So maximum bones of body are cartilagenous bones because they are developed from cartilage.

(iii) Outermost covering perichondirum is present.

(iv) Matrix of this cartilage is glass like clear or hyaline matrix because fibres are completely absent in the matrix of this cartilage.

(v) Colour of matrix is bluish & it is transluscent/glass like.

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
(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

(i) In the matrix of this cartilage yellow fibres form network so it is highly flexible cartilage of body.

(ii) Colour of matrix is pale yellow.

Eg. a. Tip of Nose b. Ear Pinna (Outer ear joint)
c. Epiglottis d. Wall of Eustachian tube

(B) White fibrous cartilage

(i) Perichondrium is absent because complete WFCT is converted into cartilage.

(ii) In matrix bundle of collagen fibres are more in quantity so it is strongest cartilage.

Eg. **(a) Pubic symphysis :** Pubis bone (Half part of pelvic girdle Os innominatum are interconnected by pubic symphysis.

(b) Intervertebral disc : A pad of cushion like structure which absorb mechanical shock & 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

(i) It is modified hyaline cartilage but due to deposition of calcium salts its matrix becomes hard like bones.

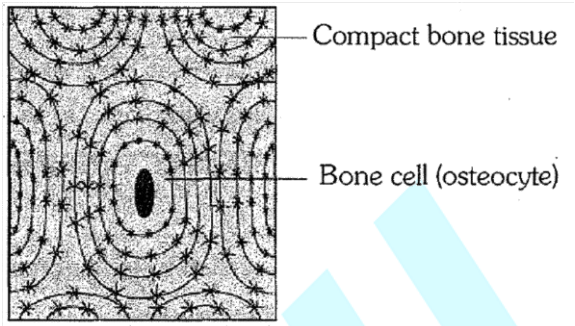
(ii) It is hardest cartilage of the body.

(iii) Ca salt deposits in the form of Hydroxy apatite.

Eg. Head of femur & humerus in man.

BONE

(i) Study of Bone - Osteology
(ii) Process of bone formation - Ossification
(iii) Hardest Tissue - Bones
(iv) 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.)
(v) Outermost covering of bone is Periosteum composed of white fibrous connective tissue.
(vi) Bone producing cell is called Osteoblast. They divide to form Osteocyte & synthesize organic part of matrix.



Bone

(vii) Mature cell of bone is called as Osteocyte which is found in lacuna. Only one osteocyte is found in one lacuna.
(viii) Bone destroying cells are Osteoclast cells.

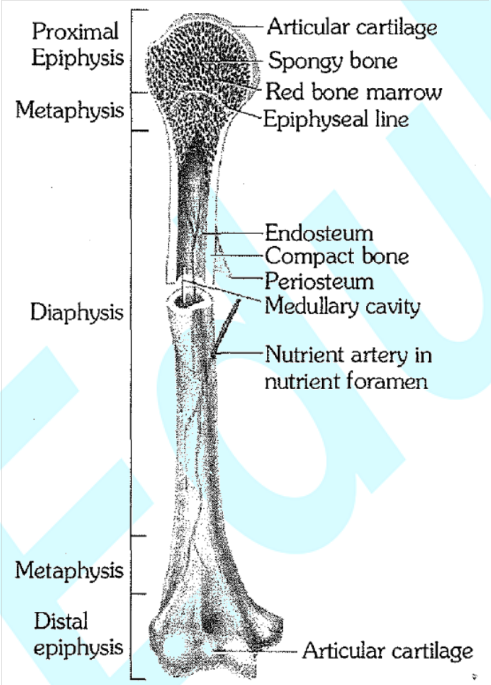
Matrix - Hard and Non-Pliable

It has two parts

Inorganic Part :- 65 - 68%

$Ca_3(Po_4)_2$ - 80% max. rest 20% $CaCO_3$ (10%), $Mg_3(PO_4)_2$ (10%), Flourides (very less).

Organic part :- 32 - 35% Ossein in which bundle of collagen fibres suspended in sulphated mucopolysaccharide.



(a) Partially sectioned humerus (arm bone)

Structure of long bone :

Long bone has three region

(1) Epiphysis (2) Diaphysis (3) Metaphysis

Epiphysis

(i) Ends of long bone is called Epiphysis. This part is composed of spongy tissue. If this part is present at the joint then on articular surface periosteum is absent & articular cartilage (Hyaline cartilage) is present.
(ii) It consist of lamellae that are arranged in an irregular pattern of thin columns called Trabeculae. Between the trabeculae are present spaces filled up with red bone marrow.
(iii) It is composed of myeloid tissue which produce blood corpuscles so epiphysis act as a haemopoietic organ.

Diaphysis

(i) Middle part or shaft of long bone is diaphysis which is composed of compact bone.
(ii) In this region hollow cavity is present called bone marrow cavity filled with yellow bone marrow. Function of YBM is storage of fat.

Metaphysis

(i) It formed little part between epiphysis & Diaphysis.
(ii) 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 epiphyseal plate is responsible for elongation of bone.
(iii) After complete development of long bone this plate is destroyed. So in completely developed bone only 2 regions are found while in a developing bone 3 regions are present.

Special points:

Spongy Bones

(i) Bones in which haversian canal systems are absent. In these bones marrow cavity is present in the form of trabeculae filled with RBM. So all spongy bones of body are haemopoietic.
Eg. Ribs, Pubis, Sternum, Vertebrae, Clavicle, End of long Bones, Scapula

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.

INTERNAL STRUCTURE OF MAMMALIAN BONE

It has following major structures.

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

1. Periosteum

(i) Outermost covering of bone is called Periosteum.
(ii) It consists of two layers.
(iii) Outer layer consist of WFCT in which blood circulation is present.
(iv) Inner layer- consists of single layer of osteoblast cells.
(v) They divide to form osteocyte and secrete layers of matrix.

2. Matrix

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

1. Haversian canal
2. Volkmann's canal

Haversian Canal

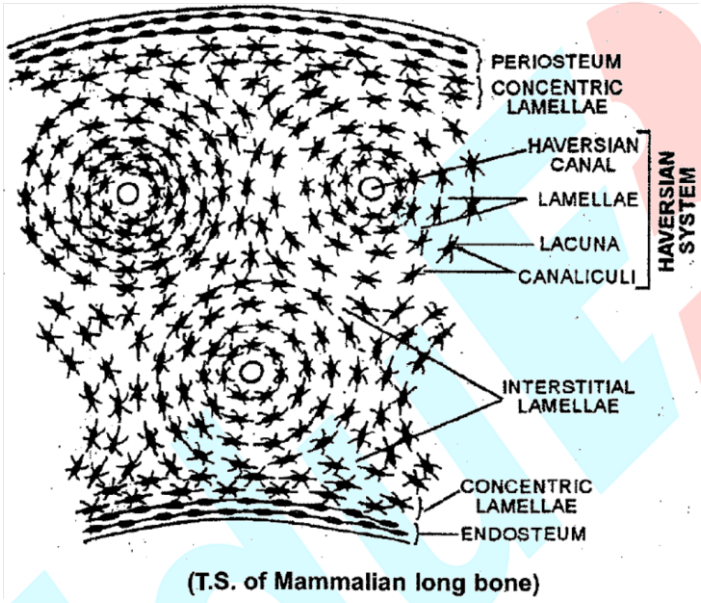
Longitudenal canals which are arranged parallel to long axis of bone. In these canals one or two blood capillaries and nerve fibres are present.

Volkamann's canal

(i) These are transverse/horizontal or oblique canals.
(ii) Haversian canals are interconnected by volkmannls canal.
(iii) Matrix of bone is synthesized in the form of layer. These layers of matrix are called **Lamellae.**

On the basis of arrangement three types of lamellae are present in the matrix.

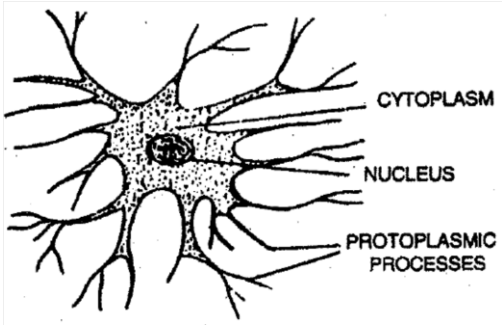
1. Haversian lamellae
2. Interstitial lamellae
3. Circumferential lamellae.



(T.S. of Mammalian long bone)

Haversian lamellae

(i) Concentric layers of matrix which are present around haversian Canal.
(ii) Between these lamellae layer of osteocyte cells are also present.
(iii) Haversian canal, Haversian lamellae & Osteocyte form Haversian system or Osteon.
(iv) Presence of haversian canal system is a typical feature of mammalian compact bones.
(v) Osteocyte are present in the lacuna. Each osteocyte is 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 two haversian systems.

Circumferential lamellae

Circumferential layer of matrix are of two types.

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

3. Endosteum

Endosteum consist of two layers.

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

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

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 four 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 two types of cells are required.
1. Chondroclast :- Which reabsorb cartilagenous 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 forelimb and hindlimb bones, Ribs.

2. Membranous bones/Dermal bones/Investing bones

These bones are developed from the connective tissue of dermis or formed by ossification in the connective tissue of dermis.
Eg. Pubis, Sternum, Clavicle, Scapula bone, Flat bones of skull

3. Sesamoid Bones

(i) These bones are developed by the ossification of tendons at the joints.
Eg. (a) Pisiform (wrist bone) of man.
(b) Patella (knee bone) Largest sesamoid bone.

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.

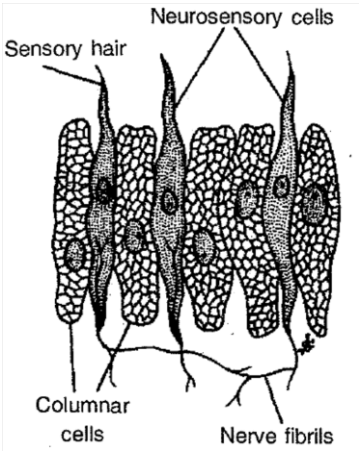
GOLDEN KEY POINTS

(i) Decalcified Bones :- If a bone is kept in dil HCl for 3 days then complete mineral part of the matrix get dissolved in acid & organic part remain in the bone so bone becomes soft & flexible.

(ii) **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 burn or kept into very high temp then complete organic part of bone is burn and mineral part of matrix remain as such in the form of ash called dried bone.

(iii) **Bright Bone :** 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

(iv) **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 end of sensory cell sensory hair is present by which they receive sensation. Base of these cells is attached with sensory nerve.



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

(b) Myoepithelium :- Around mammary and sweat gland (around secretary unit)
(c) Pigmented epithelium (Cuboidal) :- In Retina of eye.

(v) **Ilio-femoral ligament** - strongest ligament.
Another strongest ligament is ligamentum flava, present between two adjacent vertebrae.

(vi) In quardripeds like cow & buffalo strongest ligament is ligamentum nuchea present in the neck between two cervical vertebrae.

(vii) **Sharpey's fibres :-** extra bundle of collagen fibres which are present in the outermost layer of matrix called sharpey fibres. Which provide extra mechanical support to bone.

(viii) **Visceral Bones**
(a) 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 Cordis	:	Present in inter ventricular septum of deer's heart.
	Os Palbebrae	:	In the eyelid of crocodile.
	Os Penis (Baculum)	:	In the penis of rodents rat, shrew, bat, whale, tiger.
	Os rostralis	:	In the snout of pig.

BEGINNER'S BOX-4

1. Longitudinal channels of Bone called:
(1) Haversian canal (2) Volkmann's canals
(3) Narrow cavity (4) Lacunae

2. Glass like cartilage is:
(1) Hyaline cartilage (2) Fibro cartilage
(3) Calcified cartilage (4) Elastic cartilage

3. Formation of cartilagenous Bone involves :-
(1) Deposition of Bony matter by osteoblasts & Reabsorption by chondrioclasts
(2) Deposition of Bony matter by osteoblast only
(3) Deposition of Bony matter by osteoclasts & Reabsorption by chondrioblast
(4) None of above

4. Major Inorganic components of Bone :
(1) Calcium phosphate (2) Calcium carbonate
(3) Sodium hydroxide (4) Potassium hydroxide

5. Haversian system is feature of :
(1) Amphibian Bones (2) Reptiles Bone
(3) Pneumatic Bone (4) Mammalian Bone

6. Bone desolving cells :
(1) Osteoblast (2) Osteocyte (3) Osteoclast (4) Fibroblast

7. Eustachian tube is supported by :
(1) Elastic cartilage (2) White fibros cartilage
(3) Calcified cartilage (4) Hyaline cartilage

8. Perichondrium is:
(1) Adipose tissue (2) White fibrous connective tissue
(3) Yellow fibrous connective tissue (4) Areolar connective tissue

ANSWER KEY

BEGINNER'S BOX-1

1.	(4)	**2.**	(1)	**3.**	(1)	**4.**	(1)	**5.**	(1)	**6.**	(4)	**7.**	(4)
8.	(4)	**9.**	(2)	**10.**	(2)								

BEGINNER'S BOX-2

1.	(3)	**2.**	(4)	**3.**	(1)	**4.**	(2)	**5.**	(4)	**6.**	(3)	**7.**	(3)
8.	(4)	**9.**	(1)	**10.**	(3)								

BEGINNER'S BOX-3

1.	(3)	**2.**	(2)	**3.**	(1)	**4.**	(1)	**5.**	(4)	**6.**	(3)	**7.**	(4)
8.	(4)	**9.**	(2)	**10.**	(2)								

BEGINNER'S BOX-4

1. (1) **2.** (1) **3.** (1) **4.** (1) **5.** (4) **6.** (3) **7.** (1)
8. (2)