STRUCTURAL ORGANISATION IN ANIMALS

ORGAN AND ORGAN SYSTEM

ORGAN AND ORGAN SYSTEM CONNECTIVE TISSUE

- (i) 0. 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 mineralized 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 secrete fibres of structural protein (like collagen & elastin) and matrix.



CONNECTIVE TISSUE PROPER

Connective Tissue Proper is composed of three components

- (A) Different types of cells.
- (B) Fibres.
- (C) Matrix.



BIOLOGY



Fig. Representative cells and fibers present in connective tissues.

(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 & Chondroblast cells to produce bone & cartilage.
 Function: (1) To produce fibres, (2) To secrete matrix

2. Macrophages (Histocyte)

- (i) Amoeboid in shape with bean Reniform or kidney shaped nucleus.
- (ii) Cytoplasm quantity is agranular but due to presence of more number of lysosomes it appears granular.

BIOLOGY



- (iii) They are phagocytic in nature. They enterobacteria & viruses by phagocytosis.
- (iv) Also called as scavenger cells of connective tissue because they destroy dead or damaged cells to clean connective tissue.

3. Mast Cells (Mastocytes)

- (i) Amoebicidal 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 increases permeability of blood capillaries.
 - (ii) When allergic substance enters 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) Serotonin:

- (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 secrete 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 conversion 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 colour is due to the presence of Cytochrome pigment.

5. Lymphocytes

(i) Amoebicidal in shape with a large nucleus and cytoplasm is present as peripheral layer. Cytoplasm quantity is less.



(ii) Its function is to

produce, transport & secretes

antibodies.

(iii) They divide to form plasma cells of connective tissue proper.

BIOLOGY

6. Plasma Cell: Cart Wheel Cell



- (i) Amoebicidal 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 constitute 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 azurophil fiber 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. Elasticity 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.

Loose connective tissue.

Here cells and fibres are loosely arranged in semifluid ground substance. It is of two types:

(a) Areolar connective tissue -

- It is most widely distributed connective tissue in the body and contain maximum number of intercellular spaces and ground substance.
- It is present beneath epithelia of many visceral organs, skin and in wall of arteries and veins. It joins skin to muscles, fill space inside organs, form submucosa of tracts of body and found around muscles and nerves too.
- It helps in repair of tissue after injury.
- In the matrix which is made up of modified polysaccharides and glycoproteins, various types of cells and fibres are present
 - i. Fibroblast cells-

ii. Macrophages or Histiocytes

iii. Mast cell

iv. Plasma cell

- v. Adipocytes
- From the above mast cells, macrophage and fibroblast are more in number. These are also known as spongy tissues because three types of fibres viz. (collagen fiber, elastic fiber and reticular fibres) are present. In between cells and fibres, many air spaces are present which are called areole (provide sponginess) and so the name of tissue.
- This tissue is highly vascular as numerous blood capillaries and lymphatic capillaries are present.

Location

- i. Under skin as subcutaneous tissue.
- **ii.** In between muscle, nerves and blood vessels.
- iii. In sub-mucosa of alimentary canal and respiratory tract
- iv. In bone marrow.



Fig. Loose connective tissue: (a) Areolar tissue

(b) Adipose Tissue:

- It is a modification of areolar connective tissue where instead of fibroblast, adipocytes become major cells.
- It is highly vascular like as areolar tissue.
- It is fat storage connective tissue so if kept in organic solvent, cells become empty. Due to presence of fat, it can be stained with Sudan dye.

BIOLOGY

- Any excess of intake nutrient are converted to fat, which is stored here.
- Being fat reservoir, it can act as food reserve during prolonged fasting.
- Excessive accumulation of this tissue is called adiposis.
- It is also believed to secrete a hormone- leptin which regulate appetite and body weight. On the basis of adipocytes, 2 types 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 and peripheral nucleus is present.
- Due to less amount of cytoplasm, Mitochondria are also less in number. So, they produce less energy.
 - e.g. Blubber: Thick layer of white fat found under dermis of skin.
 - Found in whale, seal and elephants.
 - Hump of camel
 - Tail of Marino sheep
 - Yellow bone marrow

2. 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.
 - **e.g.**, Rodents like rat, shrew. They are hibernating animals & during hibernation they obtain energy from stored brown fat.

Location

In subcutaneous tissue, around heart, Kidney, eyeball.

Note: Brown fat is present new born babies of human. It can oxidize speedily liberating larger amount of heat so prevent shivering in new born. After some time of birth in human, brown fat is replaced by white fat.



Fig. Loose connective tissue: (b) Adipose

Loose connective tissue has two more types which are predominantly present in embryos. First is Mesenchyme (Coined by O. Hartwig) which consists of mesenchymal cells and reticular fibres. It is source of all connective tissues present in body. It is found in developing bones and below skin. Some mesenchymal cells are also present in adults around blood vessels. Other one is Mucoid Connective Tissue which is made up of fibroblasts present in a jelly like matrix containing fine collagen fibres. In embryo it is present in umbilical cord while in adults present in Vitreous humor of eye and also in cock's comb.

DENSE CONNETIVE TISSUE:

(i) Fibres and Fibroblast are compactly packed.

- It consists of fibres and fibroblast cells which are compactly packed in the ground substance. Orientation of fibres can be regular or irregular.
- It provides strong connections between different structures.
- On the basis of arrangement / Orientation of fibres can be it can be divided in to two types regular or irregular:



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

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

eg.

BIOLOGY

- (b) Sheath (Dense irregular): In this form there is no regular pattern of fibres & matrix. Cells and fibres are cress- crossed arranged.
 - Pericardium Outer covering of heart. Periosteum Outer covering of bone. -Perichondrium -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 Ilia 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 fiber.
 - eg. Wall of lymph vessels & blood vessels True vocal cords
 - It is also present in the skin

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).

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 fetus) Vitreous humor- In vitreous body of eye. Comb of cock.

Specialized Connective Tissue:

They are specialized for a particular function and in general structure bear remarkable differences from rest of the connective tissues in terms of structure and function.

Based on function, they are of following two types-

- (A) Skeletal Connective Tissue
- (B) Vascular Connective tissue

(A) Skeletal 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 two types: (a) Cartilage, (b) Bone

(a) Cartilage:

- Outer most covering of hyaline cartilage is called perichondrium which is composed of white fibres connective tissue.
- Cartilage producing cells are arranged on periphery of cartilage known as chondroblast. These are active cell & divide to form chondrocytes, and synthesize the matrix of cartilage. Mature cells of cartilage is called Chondrocytes. They are found in vacuole like space in matrix called Lacuna. In which 1 to 4 Chondrocytes are present.
- Matrix of cartilage is called chondrin composed of chondromucoprotein having Chondrotin-6-sulphate and mucopolysaccharide (Hyaluronic acid). Matrix of cartilage provides rigidity & elasticity to cartilage. (Matrix solid, Pliable and resists compression)
- 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.
- 2. Fibrous Cartilage:
 - (a) Elastic cartilage
 - (b) White fibrous cartilage
- 3. Calcified Cartilage.



Collagen fibres

Cartilage cell (chondrocyte)

Fig. Cartilage

(1) Hyaline Cartilage: Matrix is almost devoid of fibres and glass like but translucent.

It is most prevalent cartilage in our body. Most of embryonic endoskeleton is composed of this cartilage, so bones developed from it are called cartilaginous bones and they are most abundant in body.

e.g., Articular surfaces at joints of long bones, where it is called articular cartilage, Sterna parts of ribs where it is called costal cartilage. Trachea, bronchi, hyoid apparatus, nasal septum, parts of larynx (Thyroid, Cricoid and Arytenoid).

- (2) Fibrous Cartilage: it has well developed fibres in the matrix. Based on type of fiber present it can be of two types-
 - White Fibrocartilage which has abundant collagen fibres. It is strongest cartilage.
 - e.g., It occurs in intervertebral disc (central part- Nuclease pulposus) and at pubic symphysis.
 - Yellow Elastic Cartilage which has abundant elastic fibres due to which colour of cartilage becomes pale yellow.

e.g., It is present in external ear pinna and auditory canal of ear, eustachian tubes, tip of nose, epiglottis and cartilage of Santorini present in larynx.

- (3) Calcified Cartilage: initially it is hyaline cartilage but later on due to deposition of inorganic salts it becomes calcified and hence it is hard and inelastic.
 - e.g., It is present in suprascapular and pubis of Frog, and vertebrae of Shark.
 - (a) Bone:
 - Study of Bone Osteology
 - Process of bone formation Ossification
 - Hardest Tissue Bones
 - Softest Tissue Blood.
 - Hardest substance Enamel.
 - Outermost covering of bone is periosteum which is composed of white fibrous connective tissue.
 - Bone producing cell is called osteoblast. 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: Hard and Non-pliable It has two parts Inorganic Part: 65-68%

 $Ca_3(PO_4) - 80\%$ max. rest 20% $CaCO_3$ (10%), $Mg_3(PO_4)_2(10\%)$, Fluorides (very less). **Organic part**: 32 – 35% ossein protein in which bundle of collagen fibres suspended in sulphated mucopolysaccharide.

Sharpay's fiber: Bundles of collagen fibres are present in outermost layer of bone and called sharper's fibres. They provide extra mechanical strength to bone and teeth.

BIOLOGY



Internal Structure of Mammalian Bone

- It has following major structures
- 1. Periosteum
- 3. Endosteum

2. Matrix

4. Bone marrow cavity



(a) Partially sectioned humerus (arm bone)

(b) Longitudinally sectioned femur (thigh bone)

1. PERIOSTEUM

Outermost covering of bone is called Periosteum. It consists of two layers. Outer layer consist of white fibrous connective tissue in which blood circulation is present. Inner layer - consists of single layer of osteoblast cells. 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
- **1.** Haversian canal Longitudinal canals which are arranged parallel to long axis of bone. In these canals, one or two blood capillaries and nerve fibres are present.
- 2. 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 three types of lamellae are present in the matrix:

(I) 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 is interconnected with adjacent osteocyte by their cytoplasmic process. Cytoplasmic process of osteocyte are present in the canals of lacuna called as canaliculi.

(ii) Interstitial lamellae:

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

- (iii) Circumferential lamellae: Circumferential layer of matrix are of two types.
 - (a) Outer circumferential lamellae: These are present around all Haversian system. These are peripheral layers of matrix.
 - (b) Inner circumferential lamellae: Present around bone marrow cavity.

3. ENDOSTEUM - Endosteum consist of two layers:

- (a) Towards bone marrow cavity layer lined with reticular fibrous connective tissue.
- (b) Towards matrix of bone endosteum 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 (Periphery).

4. BONE MARROW CAVITY

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



Fig. Osteons (haversian system) in compact bone and trabeculae in spongy bone

Bone marrow- long bones such as humerus and femur contain a cavity inner to endosteum called bone marrow cavity. This cavity is filled with bone marrow which is actually myeloid tissue. Bone marrow is of two types-

- (a) Red Bone Marrow- its colour is red due to presence of abundant blood vessels. It is present in the spongy part of the bone. It produces RBC, WBC and blood platelets. During fetal life it is present in entire skeleton. In adults it is present in vertebrae, sternum, ribs, clavicle, scapula, cranial bones and proximal part of humerus and femur.
- (b) Yellow Bone Marrow- it is present in shaft of long bones. It is yellow in colour, has abundant adipose tissue, and deficient in blood supply. It produces blood corpuscles under emergency conditions i.e., changes into red bone marrow.