

MICROSCOPIC STUDY OF EPITHELIAL TISSUE AND CONNECTIVE TISSUE

Background ^[1]

A tissue is a group of one or more types of cells and their intercellular substance that perform a particular function. The word “tissue” was given by a French anatomist and physiologist Bichat. Bichat.

Study of tissues is called “histology”. Histology is also called microscopic anatomy. The term “histology” was given by a German histologist Mayer. An Italian scientist Marcello Malpighi is known as “founder of histology”. Bichat is considered “Father of Animal Histology”.

Based on the location and function, the animal tissues are classified into four types:

TYPE	ORIGIN	FUNCTION
1. Epithelial Tissue	Ectoderm, endoderm, mesoderm	Protection, secretion, absorption, excretion, reproduction
2. Connective Tissue	Mesoderm	Attachment, support, storage, protection, transport.
3. Muscular Tissue	Mesoderm	Movement of body parts and locomotion
4. Nervous Tissue	Ectoderm	Control and coordination by nerve impulse.

The aim of the experiment is to study the microscopic structure of epithelial and connective tissue.

PART I EPITHELIAL TISSUE

Requirements

A compound microscope and permanent tissue slides

Theory

Epithelial tissues (Epithelia): An epithelium is a tissue composed of one or more layer of cells covering the external and internal surfaces of various body parts. The word ‘epithelium’ was introduced by Dutch anatomist Ruysch. It was applied originally to thin skin covering the nipple (epi=upon, thele=nipples). They are located on the outer surfaces of organs, including the skin. They form the linings of tracts, cavities, and vessels. The epithelial tissues arise from all the three primary germ layers: ectoderm, mesoderm and endoderm. Epithelial tissues consist of variously shaped cells closely held together by intercellular junction like desmosomes, tight junctions, interdigitations etc. The cells of lowermost layers always rest

on a non living basement membrane or basal lamina. Basement membrane is made up of no cell product of epithelial tissue. It is formed of mucopolysaccharides, glycoprotein and collagen or reticular fibres. Blood vessels are absent in the epithelial tissues. However, nerve endings may penetrate the epithelium. The free surface of cells may be smooth or may have fine hair like cilia, stereocilia, and microvilli. Epithelium is subjected to continuous wear and tear and injury.

Classification of epithelial tissue ^[1,2,3]

It is mainly based on the location and functions of tissue.

A. Simple Epithelia

The cells are arranged in a single layer, forming one cell thick epithelium. Simple epithelia are further divisible as follows:

1. Simple Squamous Epithelium

Structure: It consists of only one layer of flat, scale like cells, usually polygonal cells which are closely fitted together like the tiles on a floor. It is also known as **pavement epithelium**. There is a round flattened nucleus in the centre of the cell that produce bulging of the cell surface. In surface view the cells have polygonal outlines that interlock with those of adjoining cells.

Location: This epithelium is present in the wall of the Bowman's capsule and descending loop of Henle of the nephrons of kidneys, terminal bronchioles and alveoli of the lungs, membranous labyrinth (internal ear), blood vessels, lymph vessels .

Function: Protection, excretion, gas exchange and secretion

2. Simple Cuboidal Epithelium

Structure: The simple cuboidal epithelium is composed of one layer of cuboidal or squarish shaped cells resting on a basement membrane. The nuclei are rounded and situated centrally. The cells of cuboidal epithelium often form microvilli on their free surface border called **brush bordered cuboidal epithelium**.

Location: This epithelium is present in the proximal and distal convoluted tubules of the nephrons of kidneys, ovaries, seminiferous tubules of testes, small salivary and pancreatic ducts and ciliary bodies, choroid and iris of eyes.

Function: Protection, secretion, absorption, excretion, gamete formation

3. Simple Columnar Epithelium

Structure: It consists of a single layer of elongated cells placed side by side, many of which have modified structure. Three common modifications are **goblet, cilia and microvilli**. In the intestine plasma membranes of many columnar cells extend out in hundreds and hundreds of microscopic finger like microvilli, to increase the absorptive surface area and is called **brush bordered columnar epithelium**. Certain cells of this epithelium contain mucus or goblet cells along with underlying supporting connective tissue is called mucous membrane.

Location: This epithelium lines the stomach, intestine, gall bladder and bile duct. It also forms the gastric glands, intestinal glands.

Function: Protection, secretion, and absorption.

4. *Simple Ciliated Epithelium*

Structure: It bears numerous delicate hair like outgrowths called **cilia** arising from basal granules which help to create a current to transport the materials. Mucus secreting goblet cells also occur in the ciliated epithelium.

The ciliated epithelium is of two types:

- i. Ciliated columnar epithelium: It lines respiratory tract, fallopian tubes, ventricles of brain, central canal of spinal cord, tympanic cavity and auditory tube.
- ii. Ciliated cuboidal epithelium: It occurs in certain parts of nephrons of the kidneys.

Function: The main function of ciliary epithelium is to maintain flow of mucus or liquid or suspended particles or bodies constantly in one direction. In the respiratory tract the cilia helps to push mucus towards the throat. In the oviducts the cilia help to move the an egg towards the uterus. In nephrons of kidney, cilia keeps the urine moving..

5. *Pseudo-stratified Epithelium*

Structure: The cells present in this epithelium are columnar shaped but unequal in size. The **long cells** extend upto the free surface whereas the **short cells** do not reach the outer surface. The long cells have oval nuclei and the short cells have

rounded nuclei. Mucus secreting goblet cells are also present. It is called **pseudo-stratified** because the epithelium appears to be multi-layered although it is one cell thick.

The pseudo-stratified epithelium is of two types:

- i. Pseudostratified columnar epithelium: It consists of columnar cells and occurs in the parotid salivary glands and urethra of the human male.
- ii. Pseudostratified columnar ciliated epithelium: It consists of columnar cells in which the long cells bear cilia at their free surface. It occurs in trachea and large bronchi.

Function: Protection, secretion, movement of secretions.

B. Compound Epithelia

It is complex in structure and basically made up of two or more than two layers of cells. The compound epithelia may be stratified and transitional.

1. Stratified Epithelium

Structure: This epithelia comprises of many layers of cells in which the deepest layer is made up of columnar cell or cuboidal cells. This epithelia is further classified into following types on the basis of the shape of the cells present in the superficial layers:

- i. Stratified keratinized squamous epithelium: The cells in the deepest layer are columnar or cuboidal with oval nuclei called the **germinative layer**. The middle layer, called the **intermediate layer** consists of polyhedral cells with rounded nuclei. The superficial layer called the **squamous layer** consists of flat cells with transversely elongated nuclei. In the outer few layers, the cells replace their cytoplasm with a hard water proof protein called **keratin**. These dead cell layers are called horny layer or stratum corneum.

Location: Epidermis of the skin of land vertebrates

- ii.* Stratified squamous non keratinized epithelium: its free surface is moist, and the outer epithelial cells, unlike those found in the skin, do not contain keratin. This type of epithelium serves as a protective function.

Location: It is found lining the oral cavity, pharynx, oesophagus, anal canal, lower part of urethra, vocal cords, vagina, cervix and conjunctiva of eyes.

- iii.* Stratified cuboidal epithelium: It consists of two or more rows of low cuboidal shaped cells which are arranged randomly over a basement membrane.

Location: It is found in the sweat gland ducts, larger salivary and pancreatic ducts.

- iv.* Stratified columnar epithelium: It is protective epithelium and has multiple layers of columnar cells. Only the most superficial cells are truly columnar in appearance. Epithelium of this type is rare.

Location: It is found in male urethra and in the mucous layer near the anus. It also lines mammary gland ducts and epiglottis.

2. Transitional Epithelium

This is a multi-layered epithelium and is 4-6 cells thick. It differs from stratified squamous epithelium in that the cells at the surface are not squamous. The deepest cells are columnar or cuboidal. The middle layers are made up of polyhedral or pear-shaped cells. The cells of the surface layers are large and often shaped like an umbrella. Because of its distribution in the urinary system, it is also called **urothelium**. When stretched this epithelium appears to be thinner and the cells become flattened or rounded.

Location: This epithelium is found in the renal pelvis and calyces, the ureter, the urinary bladder and part of the urethra.

Types of Epithelium

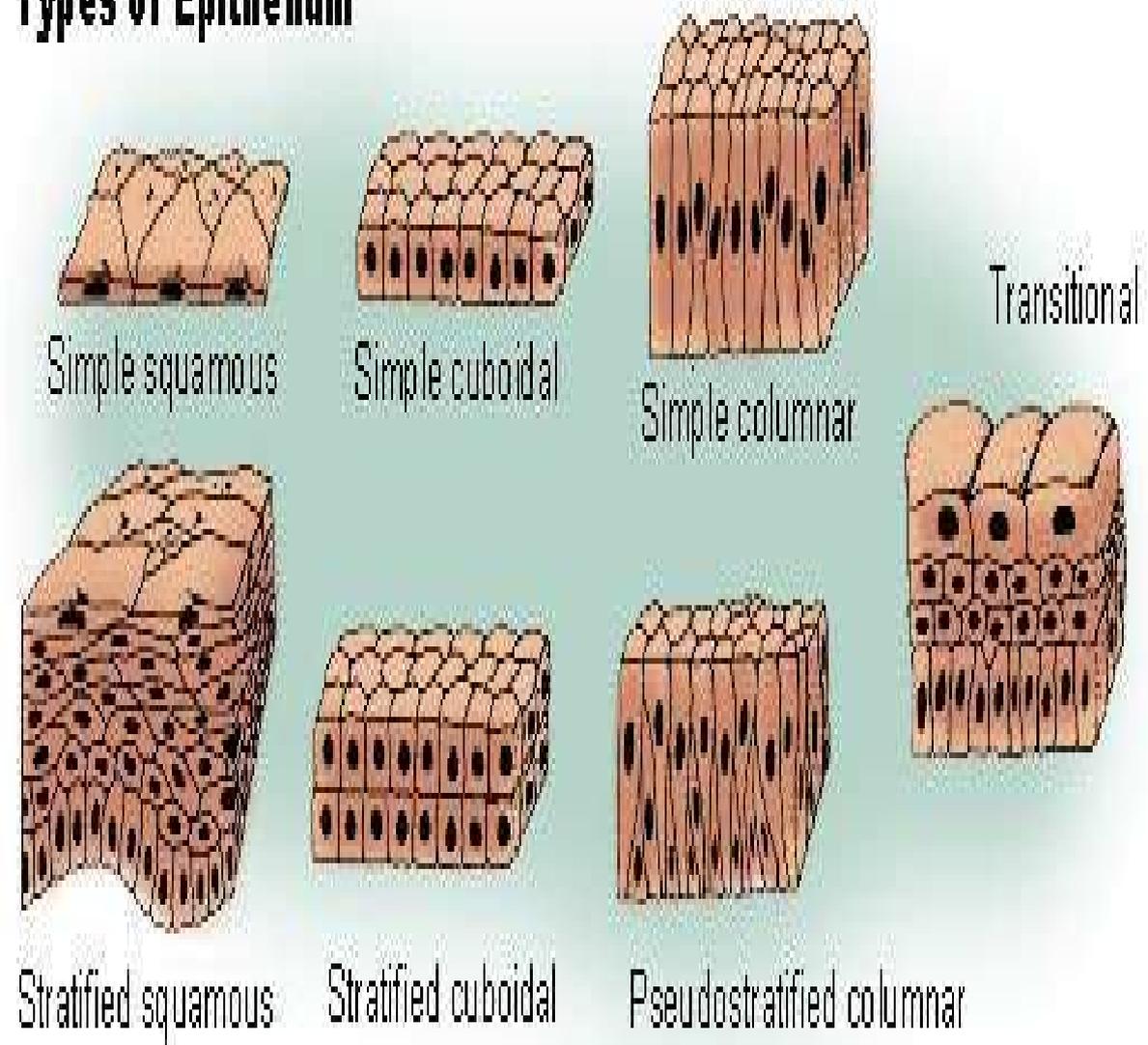


FIGURE: Showing Different Types Of Epithelial Tissue

PART II CONNECTIVE TISSUE [1,3]

Requirements

A compound microscope and permanent tissue slides

Theory

This is the most widespread and abundant type of tissue in the human body. Its function is primarily to **support**, **anchor** and **connect** various parts of the body. Connective tissues are formed by the mesoderm of the embryo. Although connective tissue exists in a number of forms, all types have three basic structural elements -- cells, fibres and intercellular substance (ground substance).

Ground Substance (Matrix): It is mainly a mixture of carbohydrates and proteins. These have been identified as various forms of mucopolysaccharides. The most common mucopolysaccharide ground substance is hyaluronic acid.

Connective Tissue Cells: The most common cell types are **fibroblasts**, which produce fibres and other intercellular materials. **Adipose cells** store fat. **Plasma cells** synthesize antibodies. **Mast cells** produce heparin (anticoagulant), histamine (autocoid, dilates blood vessels in allergic reactions) and serotonin (vasoconstrictor). **Macrophages** ingest cell debris, bacteria and foreign matter.

Connective Tissue Fibres: The most common types of fibres are: collagen fibres (white fibres), elastic fibres (yellow fibres) and reticular fibres. **Collagen fibres** are for strength and made up of **collagen protein**. While the elastic fibres are for elasticity of the tissue and made up of **elastin protein**. **Reticular fibres** are inelastic and made up of **reticulin protein**. They always form network.

Both the cells and the fibres are embedded in the intercellular substance. The consistency of this substance is highly variable from gelatin-like to a much more rigid material. The proportions of the cells, fibres, and intercellular substance vary, depending on a particular nature and function of the connective tissue. For example, a strong connective tissue needs a greater proportion of the collagen fibres and fewer cells. An example would be a dense regular connective tissue, which is found in tendons and ligaments. On the other hand, a connective tissue composed of mostly cells would not be very strong. An example would be an adipose (fat) connective tissue.

Classification of Connective Tissue

- I. Connective Tissue Proper** -- encompasses all organs and body cavities connecting one part with another and, equally important, separating one group of cells from another. This is a very large and diverse group of tissues and includes adipose tissue (fat), areolar (loose) tissue, and dense regular tissue.
- II. Specialized Connective Tissues** -- this group includes cartilage, bone, and blood. Cartilage and bone form the skeletal framework of the body while blood is the vascular (transport) tissue of animals.

I. Connective tissue proper

a) Areolar (Loose) Connective Tissue

Areolar connective tissue is the most widespread connective tissue of the body.

Structure: The fibres of areolar connective tissue are arranged in no particular pattern but run in all directions and form a loose network in the intercellular material. Collagen (collagenous) fibres are predominant. They usually appear as broad pink bands. Some elastic fibres, which appear as thin, dark fibres are also present. The cellular elements, such as fibroblasts, are difficult to distinguish in the areolar connective tissue. But, one type of cells - the mast cells are usually visible. They have coarse, dark-staining granules in their cytoplasm. Since the cell membrane is very delicate it frequently ruptures in slide preparation, resulting in a number of granules free in the tissue surrounding the mast cells. The nucleus in these cells is small, oval and light-staining, and may be obscured by the dark granules.

Location : It is present under the skin as subcutaneous tissue in between and around muscles, nerve and blood vessels, in submucosa of gastro-intestinal tract and respiratory tract, in the bone marrow etc.

Function: It is used to attach the skin to the underlying tissue. It also fills the spaces between various organs and thus holds them in place as well as cushions and protects them. It also surrounds and supports the blood vessels.

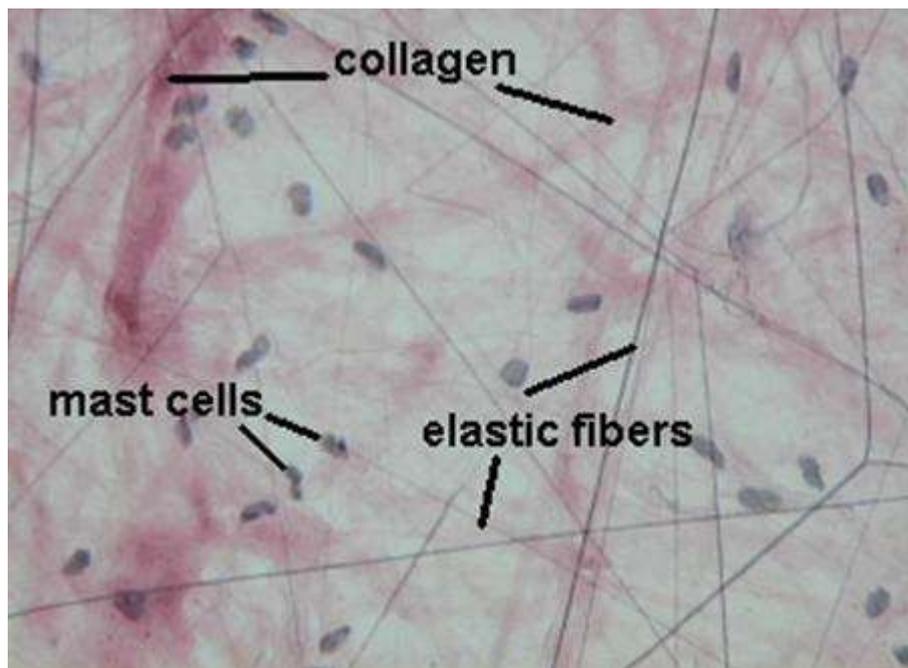
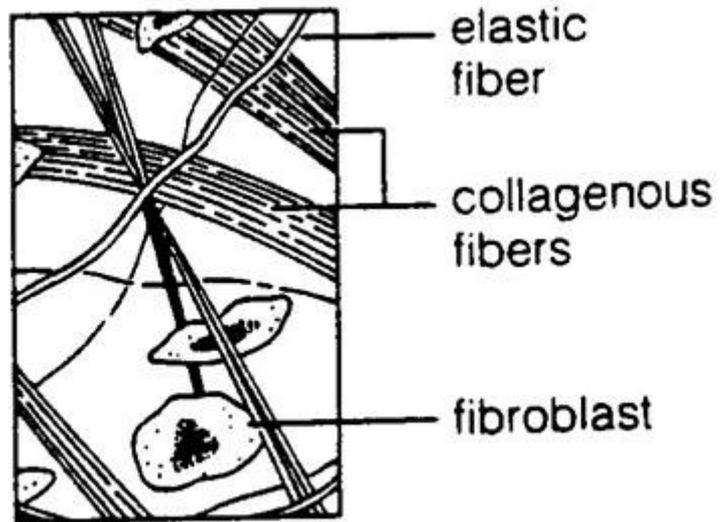


FIGURE: Showing microscopic view of areolar connective tissue.

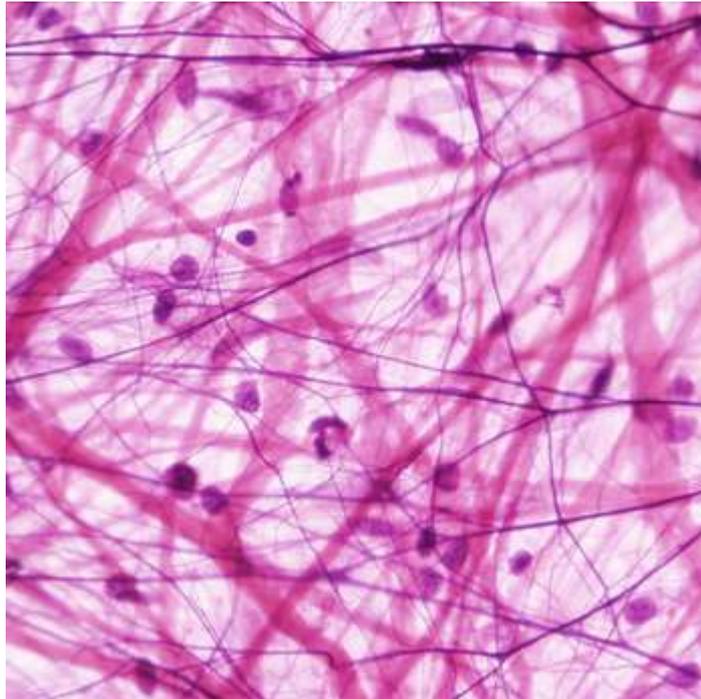


FIGURE: Microscopic view of Loose or areolar connective tissue. Thick pink bands are the protein collagen, while the thin dark threads are the protein elastin.

b) Adipose Connective Tissue

It is fat storing connective tissue.

Structure: The cells of adipose (fat) tissue called adipocytes or fat cells are characterized by a large internal fat droplet, which distends the cell so that the cytoplasm is reduced to a thin layer and the nucleus is displaced to the edge of the cell. These cells are often called signet ring cells as they resemble a signet ring when seen in cross section. These cells may appear singly but are more often present in groups. When they accumulate in large numbers, they become the predominant cell type and form adipose (fat) tissue.

Location: These tissues are found in the subcutaneous tissue, around the heart, kidney, eyeballs, mesenteries and omenta where fat is stored.

Functions: Adipose tissue is chiefly a food reserve. Adipose tissue, also forms shock absorbing cushion around and protects certain organs (eye balls & kidney) and regions

of the body. As well, it forms an insulating layer under the skin which helps regulate body temperature.

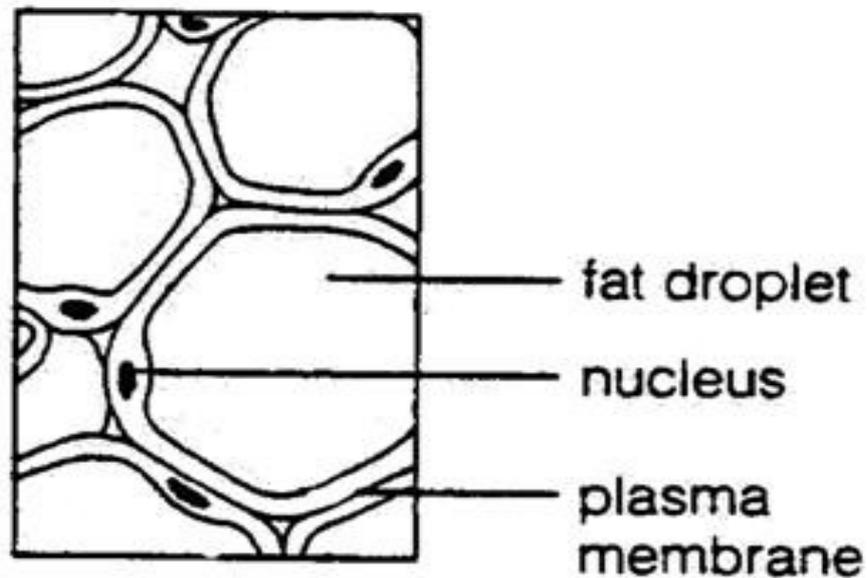


FIGURE: Showing the adipose connective tissue.

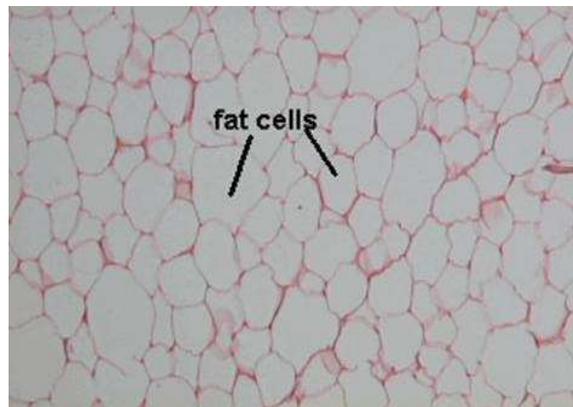


FIGURE: Showing microscopic view of adipose connective tissue.

C) Dense (Fibrous) Regular Connective Tissue

Dense connective tissue is characterized by an **abundance of parallel bundles of fibres** with **fewer cells**, as compared to the loose connective tissue. It is divided into two types: White fibrous connective tissue and yellow elastic connective tissue.

- **White Fibrous Connective Tissue:** It comprises of white collagen fibres which are arranged in bundles. The fibroblast are present in rows between the bundles. The fibrous connective tissue forms cords called tendons which connect skeletal muscle with bones. Whit fibrous connective tissue also forms flat plates oe sheets.

Location: It occurs in the dermis of skin, outer coat of large blood vessels, periosteum of bone, pericardium of cartilage, duramatar of brain and spinal cord, sclera and cornea of the eye, fibrous capsule of penis and testes.

Function: It provides great strength but flexibility is limited.

- **Yellow Elastic Connective Tissue:** It is mainly made up of thick branched loose network of yellow fibres. the fibroblasts are irregularly scattered. The cords formed by yellow elastic connective tissue are called ligaments which joins bone to bone. It also forms yellow fibrous sheets.

Location: It occurs in the walls of blood vessels, lungs, bronchioles, true vocal cords, cartilage of larynx, trachea, capsule of spleen.

Functions: This tissue provides considerable strength and remarkable elasticity and also allows stretching of various organs.

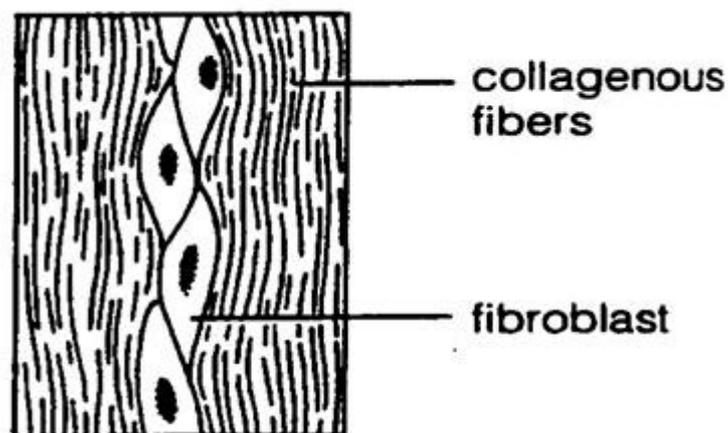
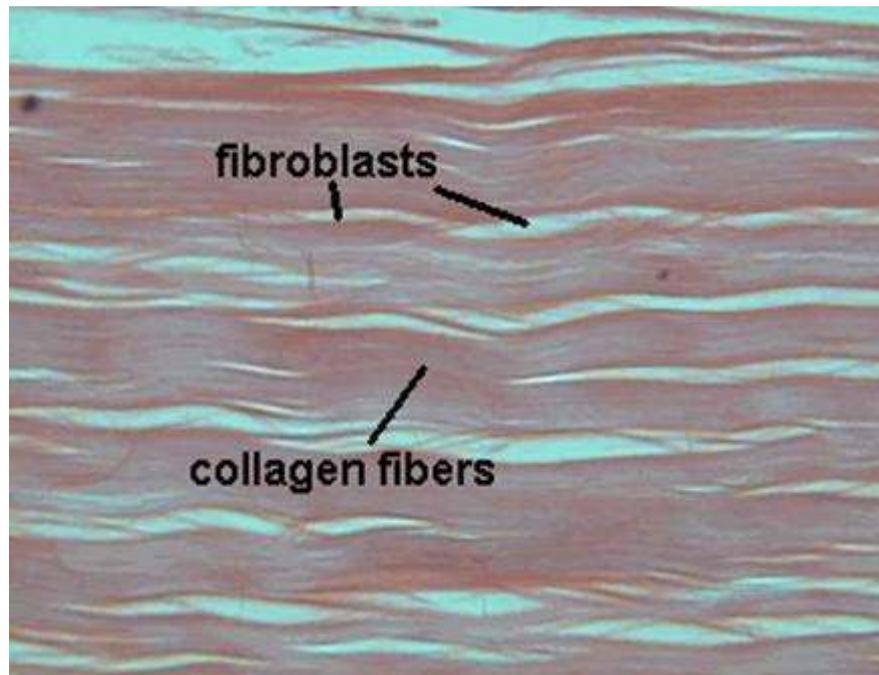


FIGURE: Showing dense regular connective tissue.



II. Specialized Connective Tissues

a) Cartilage (Gristle) ^[1,2]

Cartilage is a somewhat elastic, pliable, compact type of connective tissue. It is a soft skeletal tissue. Cartilage is a non-vascular tissue. As such, the cartilage cells or chondrocytes rely on blood vessels in the tissue surrounding the cartilage for nutrient supply and waste removal.

Structure: It is characterized by three traits: **lacunae**, **chondrocytes**, and a **rigid matrix**. Cartilage cells or chondrocytes are present in a fluid-filled space called the cartilage lacuna. The matrix or ground substance is a firm gel material that contains fibres and other substances. It consists essentially of water, proteoglycans, some lipid, collagen. The core protein is aggrecan. The carbohydrates are chemically glycosaminoglycans (GAG). The cartilages are of three types: Hyaline, Fibrous and Calcified cartilage.

Hyaline Cartilage: It contains a clear, large amount of translucent, slightly elastic matrix with less fibres. It is bluish white in colour and shiny in appearance. It is flexible.

Location Of Hyaline Cartilage: In the articular cartilages of long bones, sternum, ribs, larynx, trachea and hyoid apparatus.

Fibrous Cartilage: It has well developed fibres in the matrix. It contains white fibres and yellow fibres. Its colour is glistening white and appearance is opaque. It is more firm.

Location Of Fibrous Cartilage: White fibrous cartilage is present in the intervertebral discs and pubic symphysis. While yellow elastic cartilage is present in the pinna, external auditory canal, epiglottis and tip of nose.

Calcified Cartilage: When the matrix shows the presence of calcium carbonate granules, then the cartilage is called calcified cartilage. It is white in colour and opaque in appearance. It is had and nonelastic.

Location Of Calcified Cartilage: In the suprascapula of pectoral girdle.

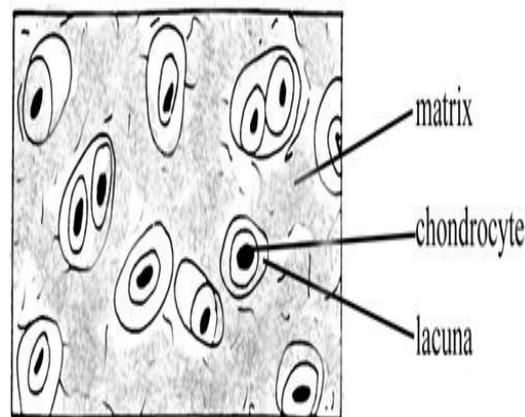
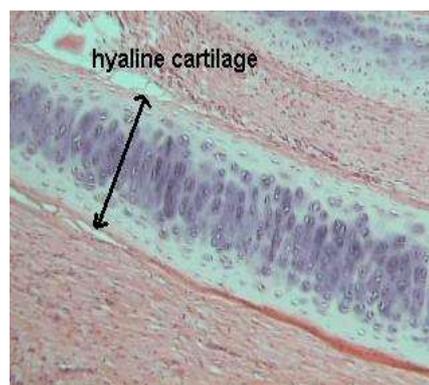
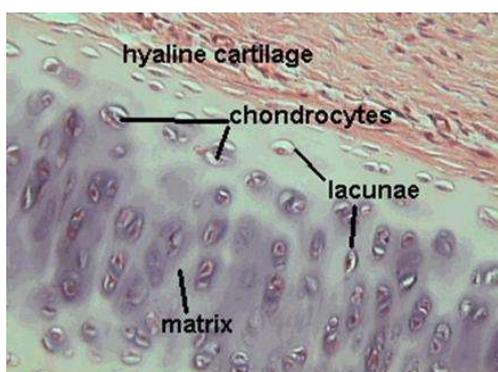


FIGURE: Showing hyaline cartilage.



Microscopic view of hyaline

b) Bone ^[1]

Bone is the hardest tissue in the body and supports various organs.

Structure: A typical bone comprises of periosteum, matrix, endosteum and bone marrow. The entire outer surface of bone is covered by a thick and tough sheath called the **periosteum**. Periosteum contains blood vessels. The periosteum also has **osteoblast** which produce new bone material. The **matrix** is composed of a protein called **ossein**. The main salts found in matrix are calcium carbonate, calcium phosphate, sodium chloride, and magnesium phosphate. The matrix of bone occurs as layers called **lamellae**. The **Haversian canals** present in the matrix is a characteristic feature of the mammalian bone. Each haversian canal contains an artery, a vein, a lymph vessel, a nerve, some bone cells, all packed in with connective tissue. The haversian canals are connected by transverse channels called the **volkmann's canals**. Many inactive bone cells called **osteocytes** are present in the matrix. The wall of the marrow cavity is lined by a membrane called the **endosteum**. In long bones such as humerus, femur etc. a cavity called **bone marrow cavity** is present inner to the endosteum. The bone marrow cavity is filled with a soft and semisolid fatty neurovascular tissue termed as **bone marrow**. The **red bone marrow** is red and is present in the spongy parts of the bone called **epiphysis**. It produces red blood corpuscles. **Yellow bone marrow** is present in the **shaft** of long bones. It is yellow in colour and has much fatty tissue.

c) Blood ^[1]

Blood is a mobile connective tissue. It is the softest tissues of the body. It is a slightly alkaline fluid having pH 7.4.

Composition: Blood is composed of a watery fluid called plasma and floating bodies termed formed elements (blood corpuscles). Plasma is a alkaline non-living intercellular substance.

Plasma is composed of water (about 90- 92%) , mineral salts (chlorides, bicarbonates, sulphates, phosphates,calcium,iron,magnesium), nutrients (glucose, fatty acid, phospholipid, cholesterol,fats), plasma proteins (albumin, globulin, prothrombin, fibrinogen), excretory substances (ammonia, uric acid, urea, creatine), dissolved gases (oxygen, carbon-dioxide), anticoagulant (heparin), hormones , vitamins.

Functionsof plasma : Transport, retention of fluid in blood, maintenance of blood pH, body immunity, prevention of blood loss, conduction of heat.

Formed elements or blood corpuscles are of three types: **Erythrocytes/** red blood corpuscles (**RBCs**), **leucocytes/**white blood corpuscles (**WBCs**) and **thrombocytes/**platelets. **Erythrocytes** are more numerous, smaller and longer lived cells. RBCs of man are circular, biconcave and enucleated. They occur only in blood vessels. They don't possess cell organelles. They have a protein known as haemoglobin. They carry oxygen and carbon-dioxide. They are produced by yolk sac, liver , spleen and bone marrow. WBCs are larger, fewer, short lived cells than RBCs. WBCs are rounded but change their shape. They retain cell organelles. They lack haemoglobin. They are colourless. They are of 5 types viz. lymphocytes, monocytes, eosinophils, basophils and neutrophils. They act as soldiers and scavengers. They are produced by bone marrow, lymph nodes, spleen ,tonsils. Platelets are colourless, rounded or oval, non-nucleated fragments of the cells. They help in blood clotting. They are produced by bone marrow.

REFERENCES:

- 1) Structural Organisation In Animals-Animal Tissues, Trueman's Elementary Biology, K.N.Bhatia et a., Edition 2016, pp. 168-213
- 2) PV's Human Anatomy And Physiology-I, S.S. Randhawa et al., Edition 2017
- 3) Bones, Blood , Epithelial tissue, Textbook Of Human Histology, Second Edition, pp. 66-137