Almaaqal University
College of Health and Medical Techniques

Lecture Notes in Medical Histology

For 2nd year students 2021-2022

Tutoring Team

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Lecture One P: Introduction

Broad Objectives

At the end of the course, a learner is expected to:

1. Understand the arrangement of cells and tissues in organs of the body
2. Understand the functions of cells and tissue

3. Recognize that histology is fundamental to anatomy, physiology, and pathology (pathohistology

Further, a learner is expected to:

1. Be able to list various components of the main body tissues.
2. Be able to describe the functions of cells found in various tissues of the body.
3. Be able to recognize and differentiate among various types of cells at the light and electron microscopic levels in stained material.
4. Be able to use knowledge about the physical characteristics of collagen and elastin in explaining the functions of tissue where these molecules occur in large quantities
5. Be able to recognize different types of connective tissue (*e.g.*, dense irregular, dense regular, loose, adipose) with examples where they are found in the body.
6. Be able to recognize a basement membrane (basal lamina) in sections or micrographs where the structure is present and understand its functions.

7. Be able to describe the main histological features of various body organs.

Syllabus of 2nd Year: Histology

مفردات المنهج النظري والعملي للأنسجة

Year of study	**Second**		
Subject	**Histology**		
Total hours	**Theory = 60 hours** **Practical= 60 hours** **Credit units= 6**		
Theory Topics	**Theory hours**	**Practical Topics**	**Practical hours**
Cell structure and types	2	Microscope: Study of parts, lines and uses	2
Epithelial tissue	4	Preparation of slides: Methods and material	2
Connective tissue	4	Epithelial tissue	4
Cartilage	2	Connective tissue	4
Bone and ossification	2	Cartilage	2
Blood and haemopoietic tissue (bone marrow)	2	Bone and bone marrow	2
Muscular tissue	2	Blood	2
Nervous tissue	2	Muscular tissue	2
Nervous system	2	Nervous tissue	2
Circulatory system	4	Nervous system	2
Lymphoid system	4	Circulatory system	2
Skin	2	Lymphoid system	4
Respiratory system	4	Skin	2
Digestive system	8	Respiratory system	4
Urinary system	2	Digestive system	8
Endocrine system	4	Urinary system	2
Male reproductive system	4	Endocrine system	**4**
Female reproductive system	4	Male reproductive system	**4**
Sense organs	2	Female reproductive system	**4**

Total	**60**	Sense organs	**2**
		Total	**60**

The teaching-learning process consists oF:

1. Standard lectures (maximum 30 sessions)
2. Discussion groups (optional but guided)
3. Lab.-based practical (maximum (30 sessions)
4. home assignment/Reports (Optional but guided

Assessment (الامتحانات والتقييم)

Based on theoretical and practical assessments PLUS additional tasks (reports, seminars)

First term: 20 Marks (12 Marks for theory exams and 8 Marks for practical examination)

Second term: 20 Marks (12 + 8)

Final exam: 60 Marks (40 + 20)

The major tools to learn histology are :

1. The slide

2. The microscope

And the major master **is your brain and how to use it.**

Definition of Histology

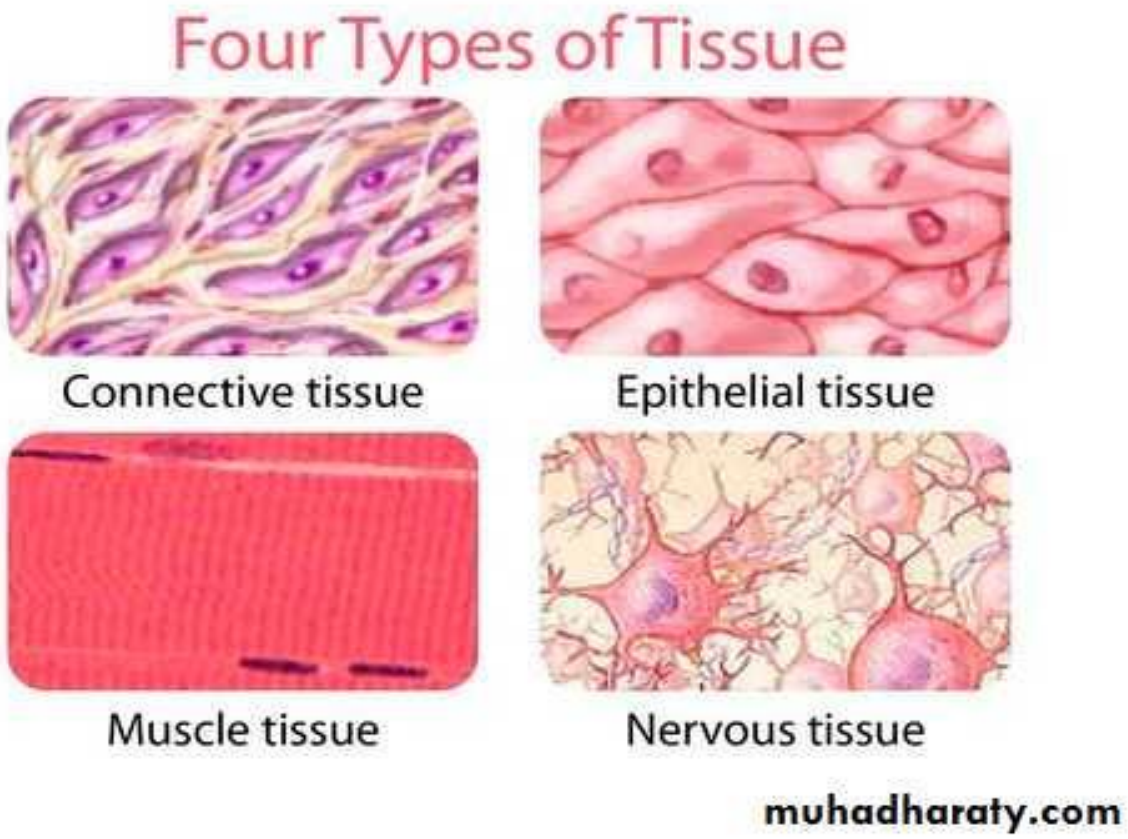
Is the branch of biology which studies the microscopic structure of biological tissues and the relation of different components to each other. Histology is a bridge between biochemistry, molecular biology, physiology, disease process and effect of disease

Reminder: Last year we briefly studied types of tissue/cells:

1. Epithelial tissues/cells
2. Connective tissues/cells

3. Muscle tissues/cells
4. Nervous tissues/cells

In this year, details of these tissues is the main subject of Histology

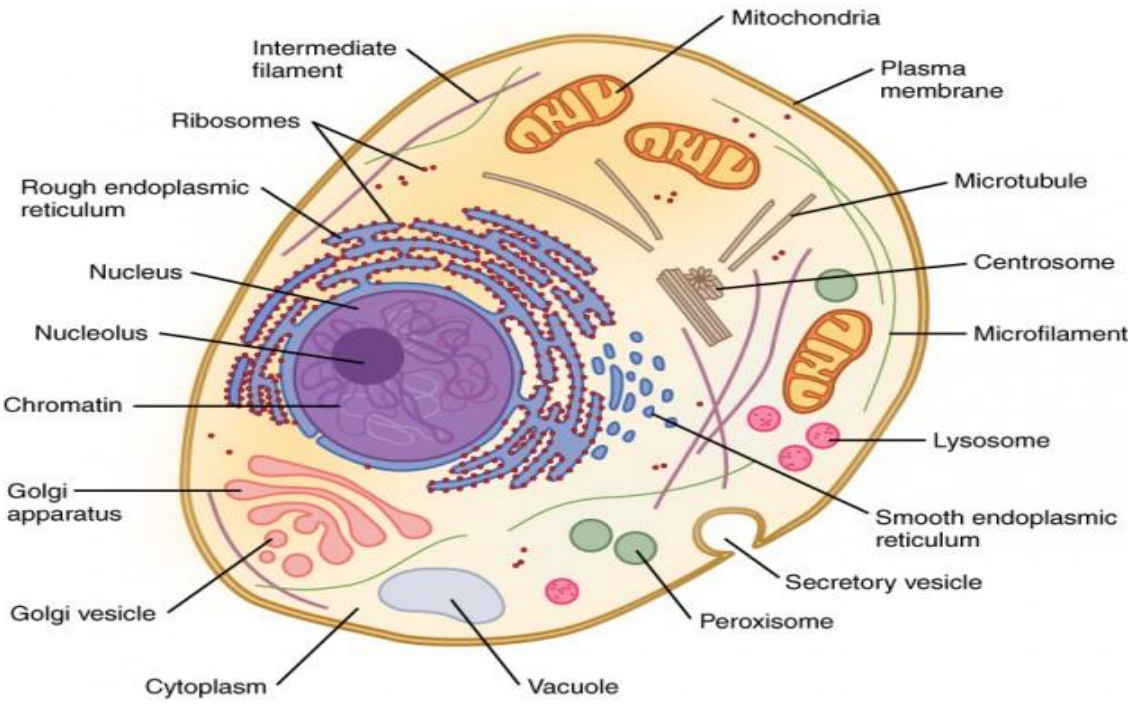


Epithelial = طلائي

Connective = رابط

Muscle (Muscular) =عضلي

Nervous =عصبي



The structure of a living cell

Few notes on transitional epithelial tissue

- It is a stratified epithelium consisting of multiple layers of cells.
- The shape of the cell changes according to the function of the organ.
- The layers of cells may look cubical or round when in a relaxed state, except the apical layer which seems to be flattened when stretched.
- The main site for this epithelium is the urinary bladder "urothelium".

The calls are arranged into Three groups:

1. Basal layer (rich in protein and mitochondria) attached to a basement membrane
2. Intermediate layer : high rate of proliferation (multiplication) and rich in Golgi apparatus
3. Apical layer (the superficial layer), lines the lumen, and protects the

underlying layer of cells against harmful waste material and pathogens from the lumen

Functions of the transitional epithelial tissue

1. Permeability barrier
2. Control of volume of the organ

Lecture Two: Epithelial tissue

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Samira TS Al-Ali (MSc anatomy and histology

Reference:

Junqueira's Basic Histology: Text and Atlas 14th edition

A human body is composed of four basic tissue types:

- Epithelial
- Connective
- Muscular
- Nervous tissues.

A. Each tissue consists from similarly specialized cells united in performing a specific function.

B. The basic tissues contains extracellular matrix (ECM) and cells

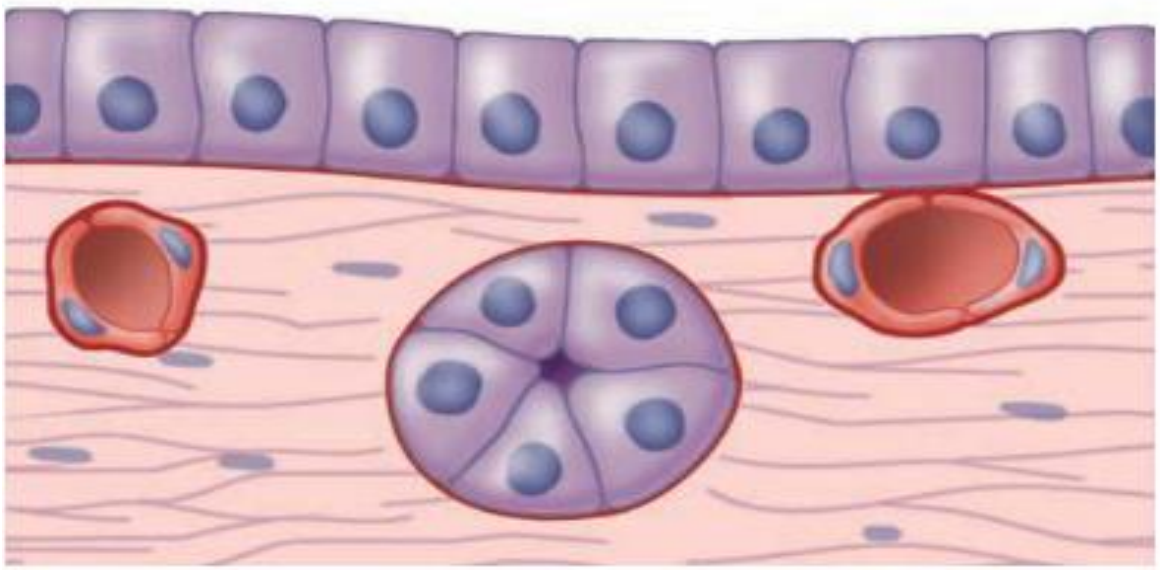
C. The proportion of ECM and cells is variable in different organs.

TABLE 4-1 Main characteristics of the four basic types of tissues.

Tissue	Cells	Extracellular Matrix	Main Functions
Epithelial	Aggregated polyhedral cells	Small amount	Lining of surface or body cavities; glandular secretion
Connective	Several types of fixed and wandering cells	Abundant amount	Support and protection of tissues/organs
Muscle	Elongated contractile cells	Moderate amount	Strong contraction; body movements
Nervous	Elongated cells with extremely fine processes	Very small amount	Transmission of nerve impulses

In general, each organ in the body is divided into
a. The **parenchyma (لحمة/نسيج حشوي)**, which is composed of the cells responsible for the organ's specialized functions, and
b. The **stroma (نسيج ساند أو سدى)**, the cells which have a supporting role in the organ.

FIGURE 4–1 Epithelia and adjacent connective tissue.



- Epithelial tissues are composed of closely aggregated polyhedral cells adhering strongly to one another and to a thin layer of ECM,
- They form cellular sheets that line the cavities of organs and cover the body surface.

- All substances that enter or leave an organ must cross this type of tissue

The principal functions of epithelial tissues:

1. Covering, lining, and protecting surfaces (eg, skin)
2. Absorption (eg, the intestinal lining)
3. Secretion (eg, glands)

Classification according to cell shape and layers

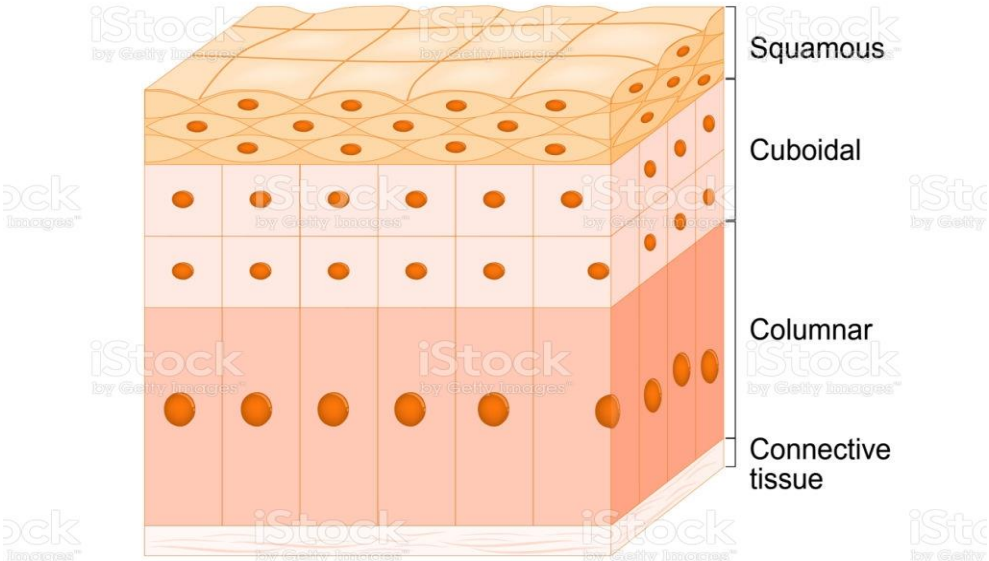
There are three principal cell shapes associated with epithelial cells:

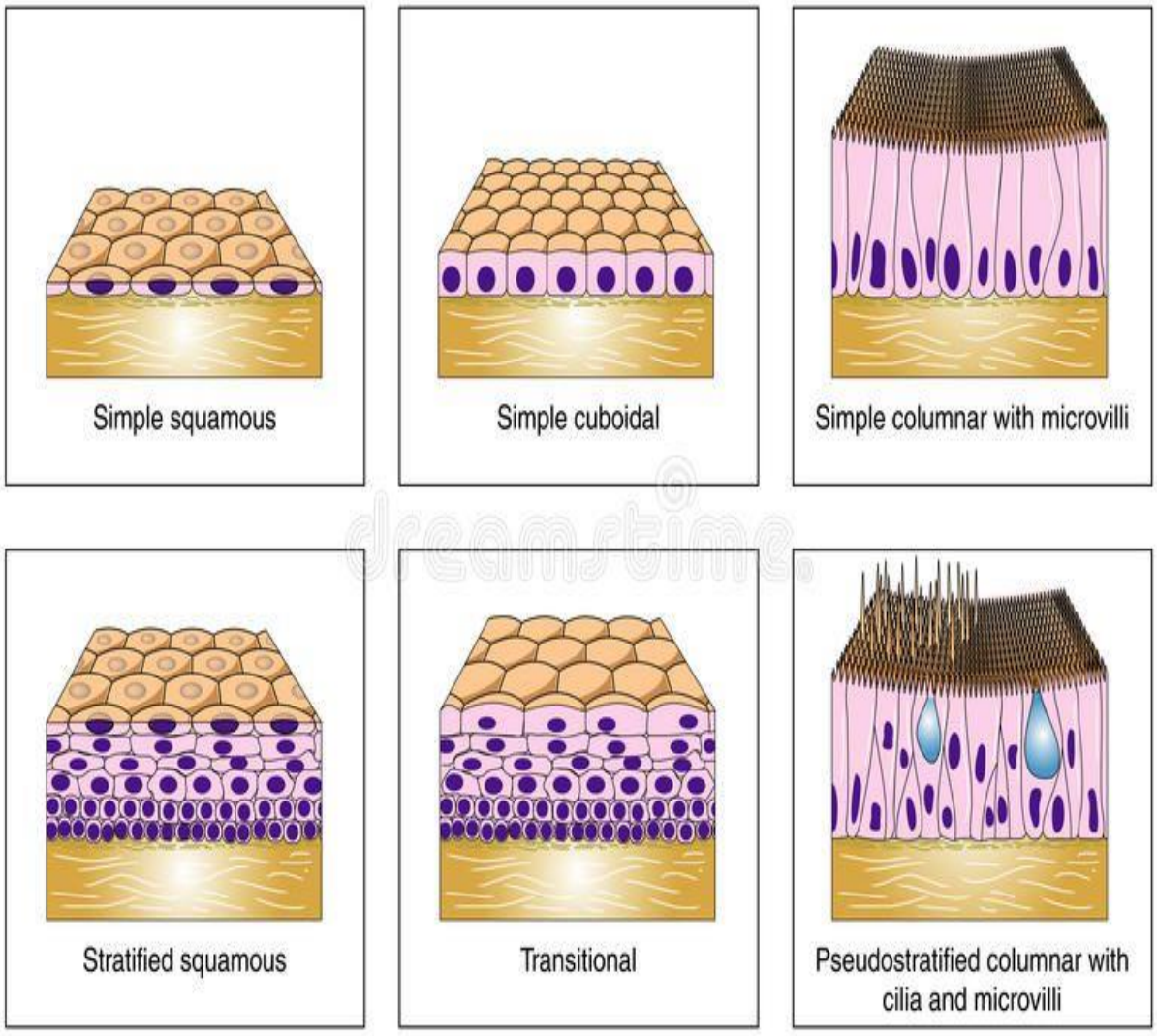
- squamous epithelium: Flattened and scale-like
- cuboidal epithelium: Like a cube and
- columnar epithelium: Having the shape of a column.
- There are three descriptions of layers:
- Simple: one layer
- Stratified(multilayers)
- Pseudostratified

Also there are keratinized epithelial cells in skin

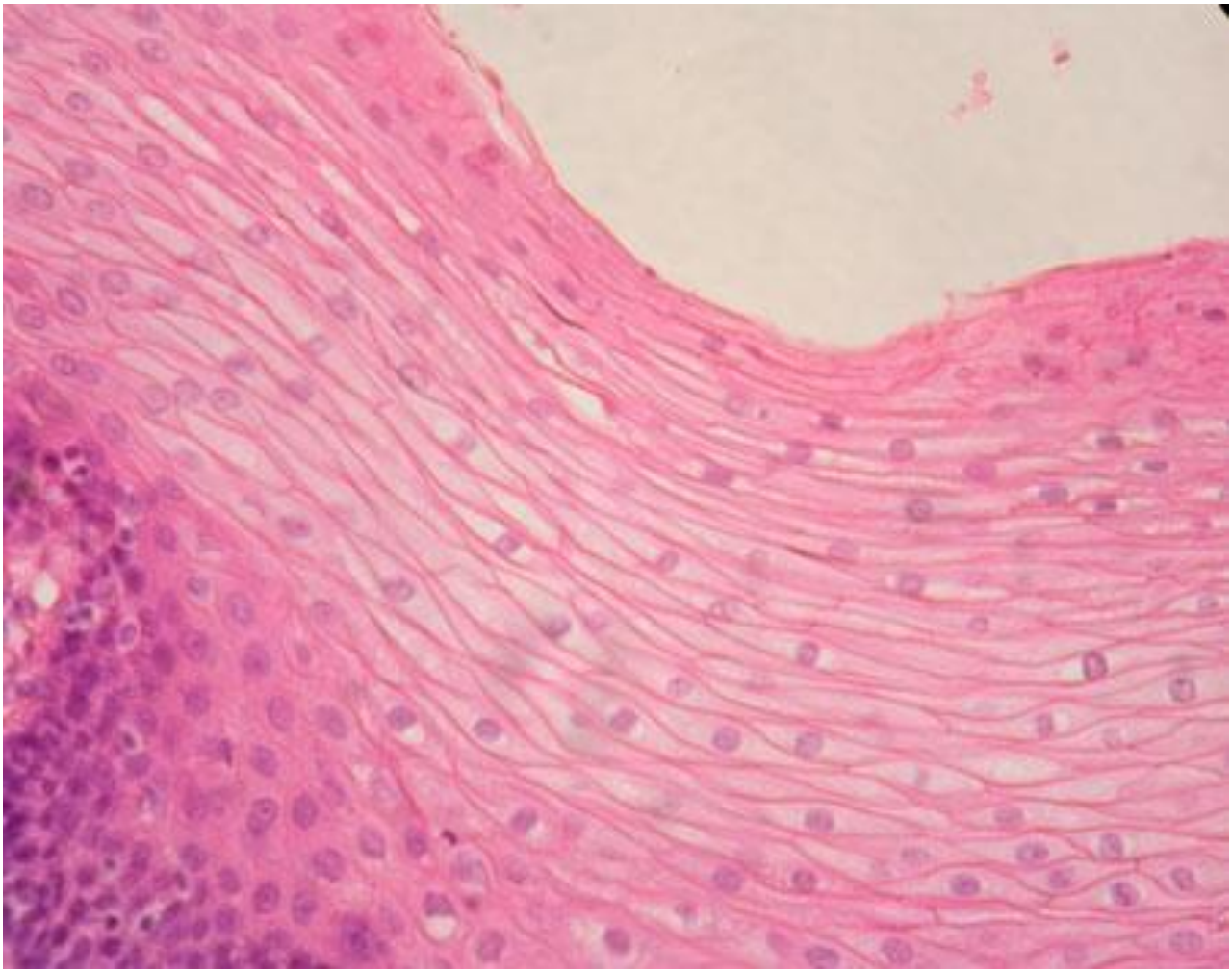
And transitional epithelial cells in Urinary bladder

EPITHELIAL CELLS

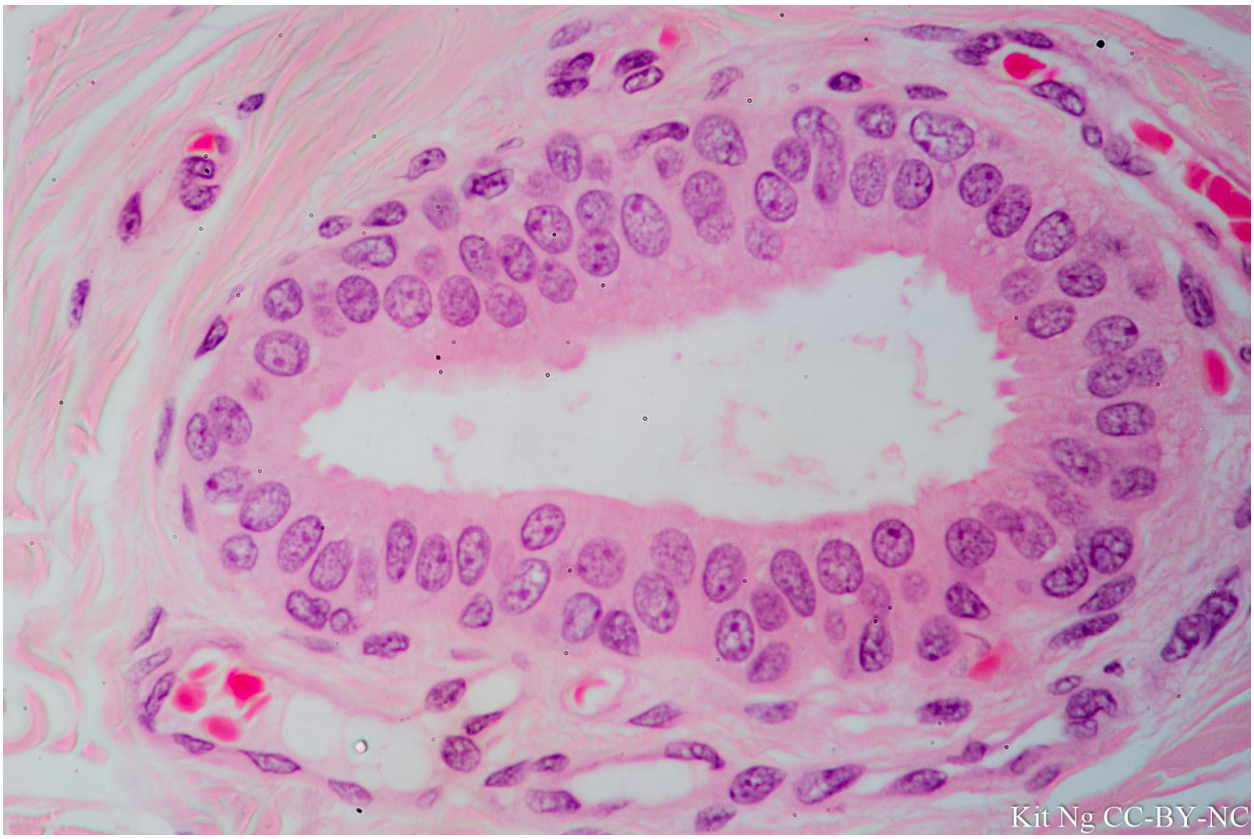




Different types of epithelial tissue

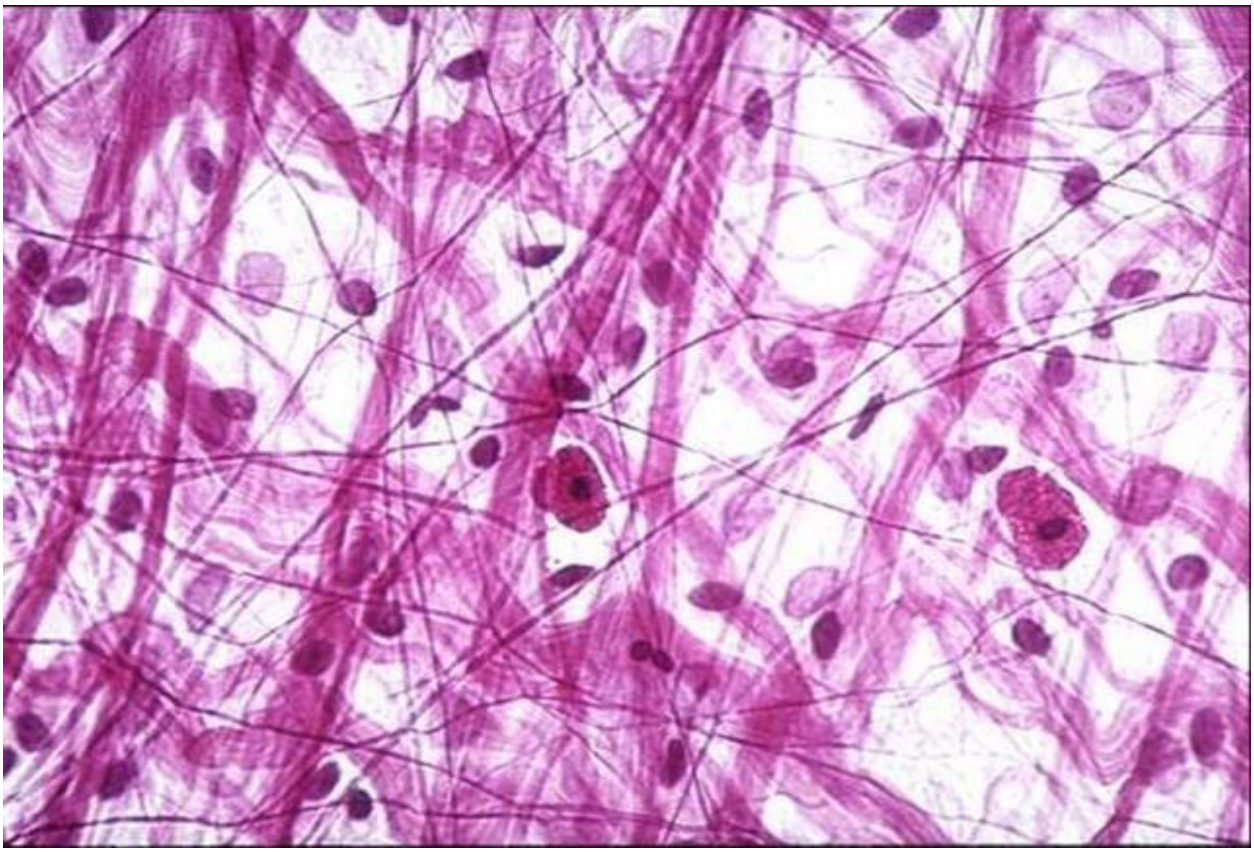


Stratified squamous tissue



Stratified cuboidal epithelial tissue

Lecture Three: Connective tissue



This slide shows the complexity of the connective tissue

Connective tissue is the most abundant and widely distributed of the primary tissues

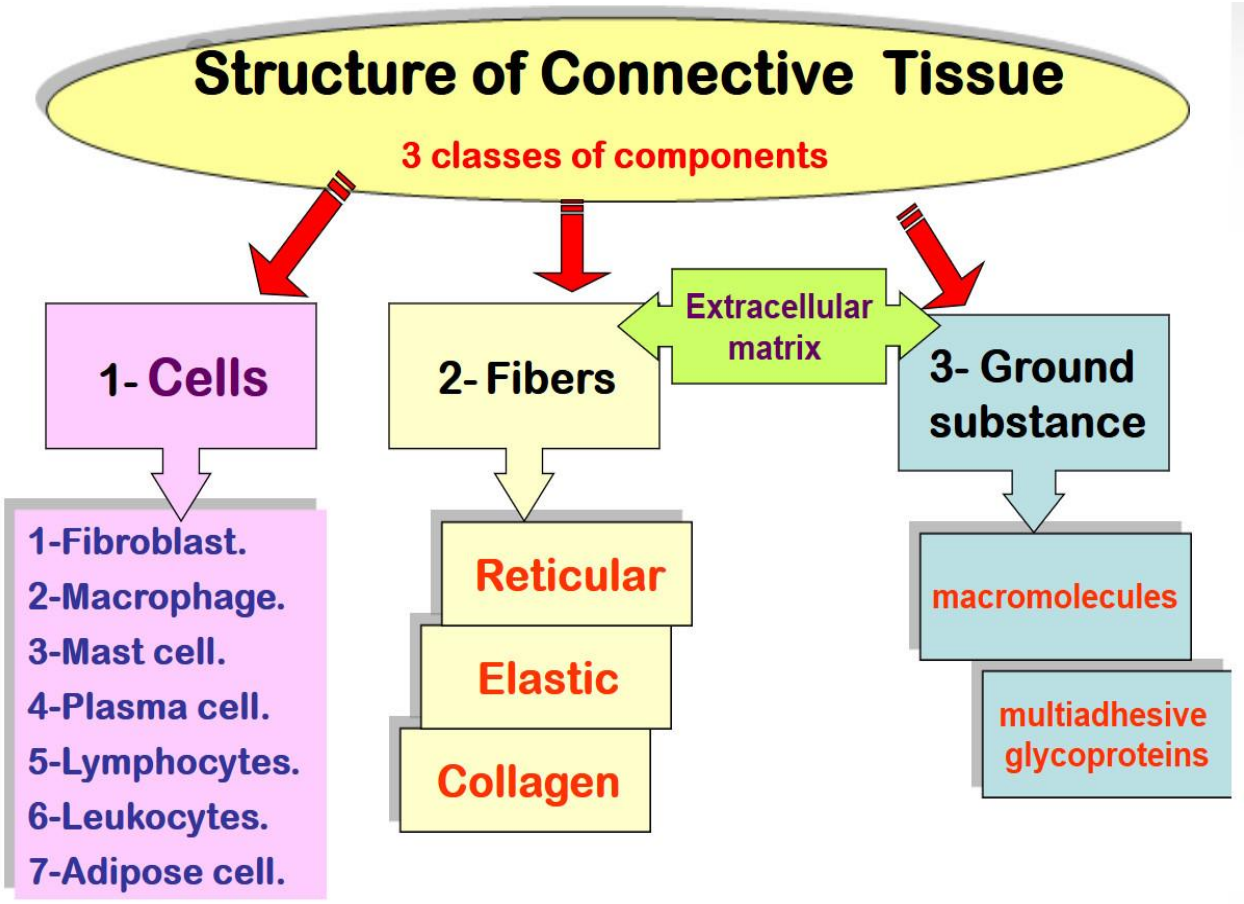
Connective tissue (CT)is divided into four main categories:

1. Connective tissue proper (Cells, Fibers and ground substance)
2. Cartilage –specialized CT
3. Bone – specialized CT
4. Blood – Specialized CT

Connective tissue proper has three main components:

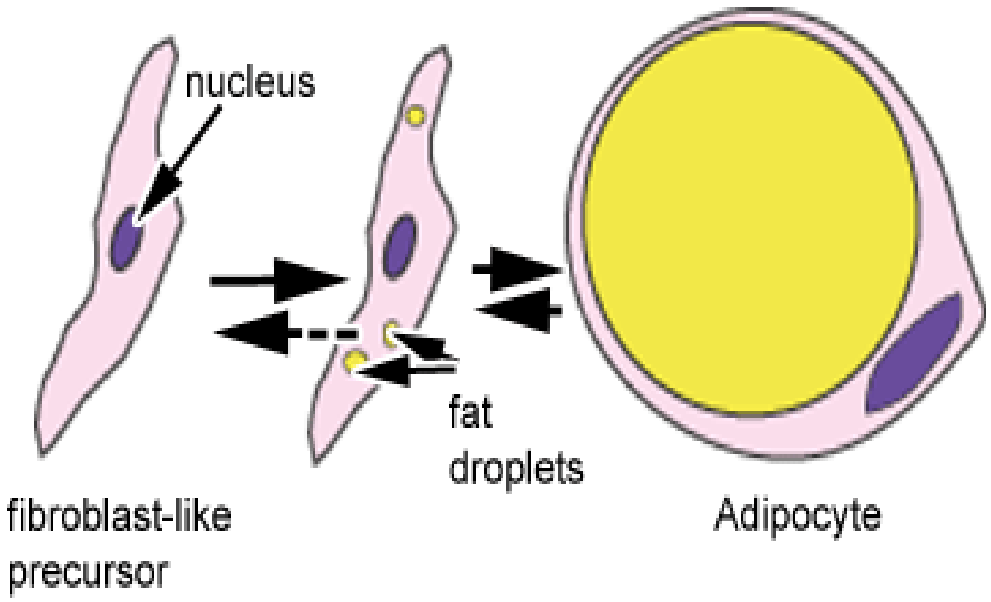
- Cells
- Fibers
- Ground substances

Together the ground substance and fibers make up the extracellular matrix.



The cells are of two groups:

Fixed cells – fibroblasts, fat cells.
Wandering cells – macrophages, plasma cells, mast cells and lymphocytes



Functions of connective tissue

- Supporting and moving
- Protecting organs (cranium and blood)
- Insulating and
- Storing reserve fuel (Adipose tissue and bones)
- Transporting substances within the body (blood)

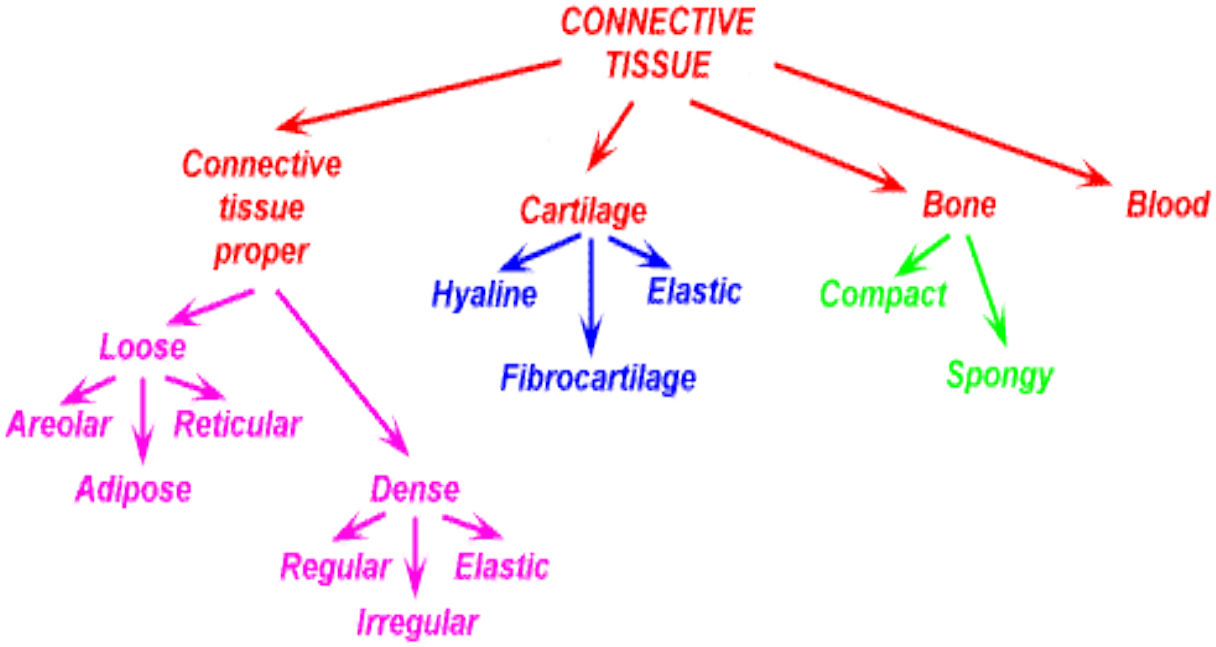
. Connecting tissues to one another (ligaments and tendons)

Fibers in connective tissues

1) Collagen fibers: are large fibrous proteins and are secreted into the extracellular space and they provide **high tensile strength to the matrix**

2) Elastic Fibers: are long, thin fibers that form branching network in the extracellular matrix. They help the connective tissue **to stretch and recoil.**

3) Reticular Fibers: are short, fine collagenous fibers that can branch extensively to form a delicate network. **(support)**



Connective tissue proper has two subclasses; Loose and Dense

Loose connective tissue is divided into:
1) Areolar
2) Adipose
3) Reticular
Dense connective tissue is divided into
1) Dense regular

2) Dense irregular
3) Dense elastic

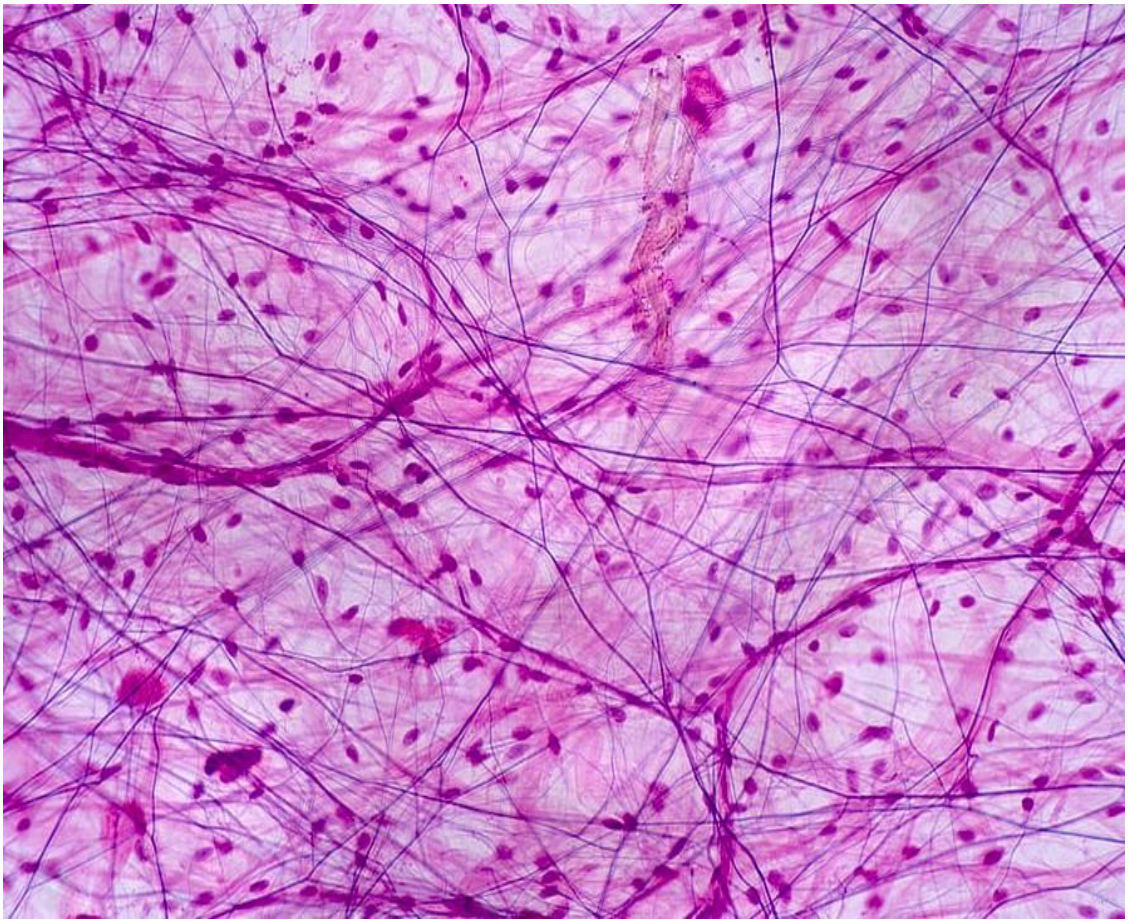
Loose connective tissue is distributed through the body as binding &packing material
The protein fiber are loosely arranged .
Contain fewer cells &fiber than the dense connective tissue but has more ground substance
Occupy the space between organs .

Areolar connective tissue

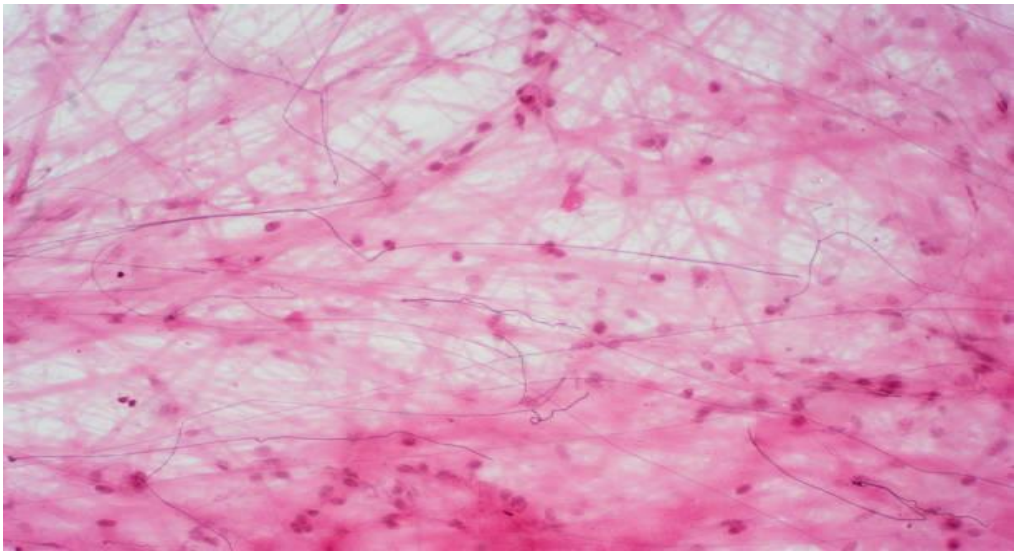
These tissues are widely distributed and serve as a universal packing material between other tissues.

The functions of areolar connective tissue

support
binding of other tissues.
Strength

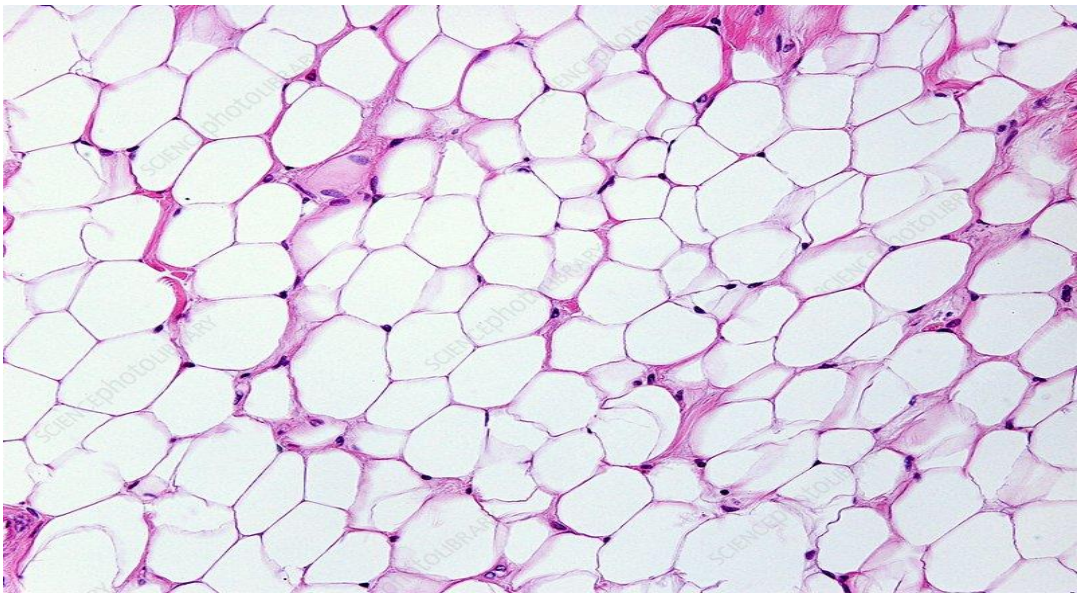


Areolar Connective Tissue



Reticular connective tissue

This tissue resembles areolar connective tissue, but the only fibers in its matrix are the reticular fibers, which form a delicate network. The reticular tissue is limited to certain sites in the body **e.g lymph nodes, spleen and the bone marrow.**



Adipose tissue or body fat

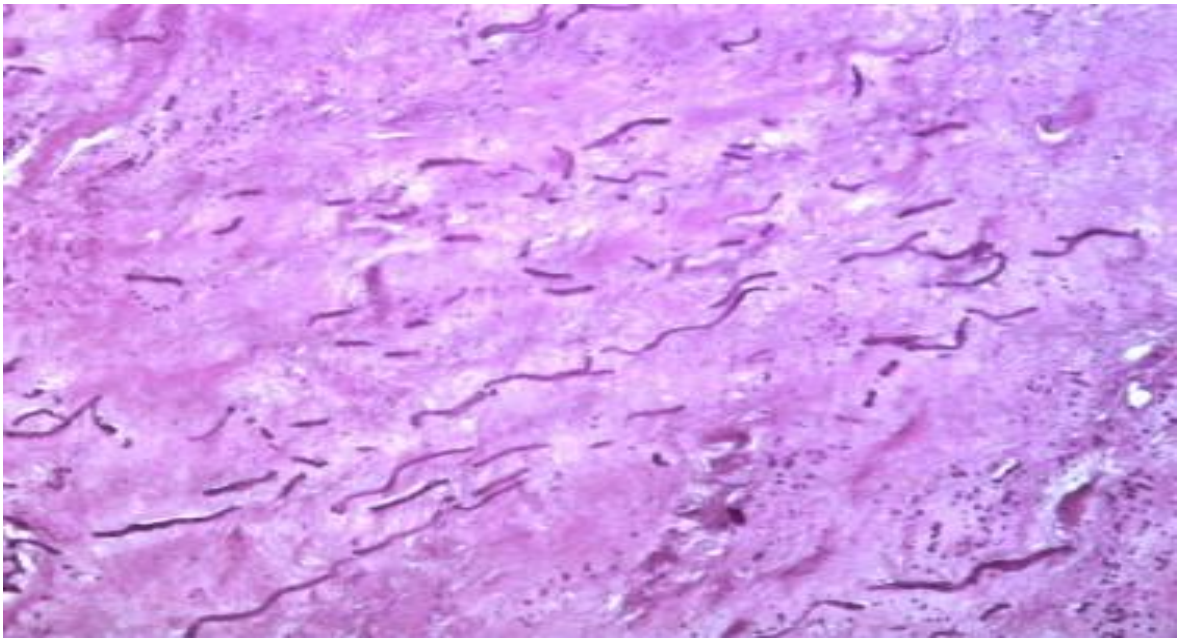
This is loose connective tissue composed of adipocytes. It is composed of 80% Fat. **It a store of** energy in the form of lipids and reduce heat loss in skin .

The two types of adipose tissue :
white adipose tissue , present in adults &has less blood supply.
brown adipose tissue, present in infant &has extensive blood supply.
Dense connective tissue :
Consists of density packed fibers with little space between fibers .

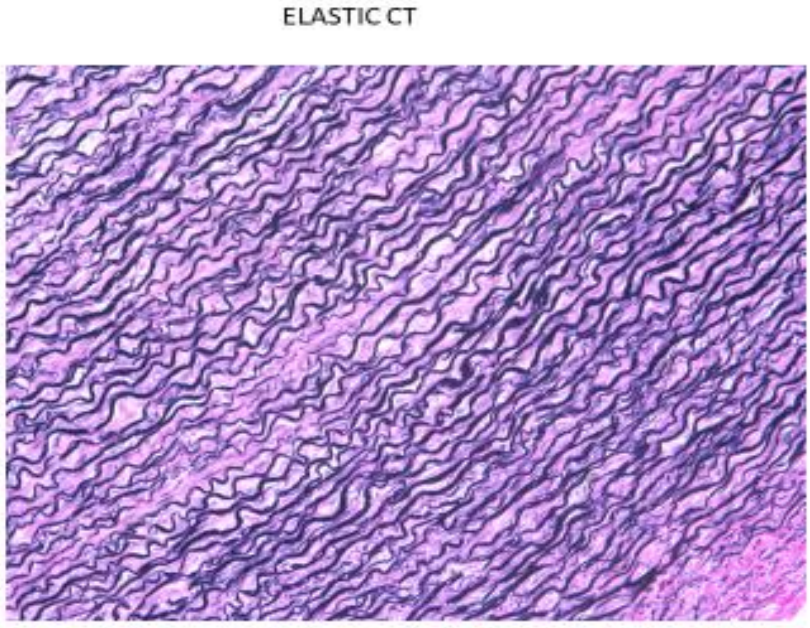
Dense regular connective tissue
This consists of closely packed bundles of collagen, fibers running in the same direction. These collagen fibers are slightly wavy ,resist stretching & give strength .
This tissue found in tendon (connect muscle to bone)
& ligaments (connect bone to bone)

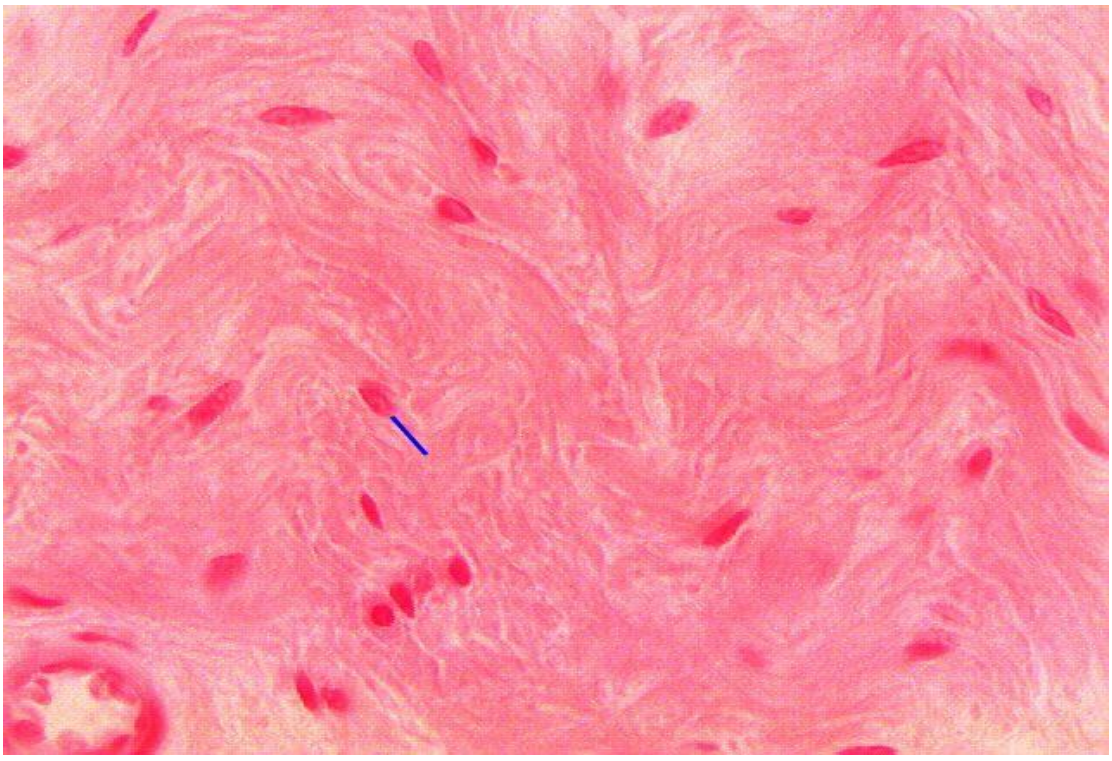
Dense Irregular tissue
This has the same structural elements as dense regular tissue, but the bundles of collagen Fibers are much thicker and arranged **irregularly** .
This tissue is found in areas where tension is exerted from many different directions, eg skin and in the joint .

Elastic connective tissue
The main fibers that form this issue are elastic in nature. These fibers allow the tissues to recoil after stretching. This is especially seen in the arterial blood vessels and walls of the bronchial tubes.

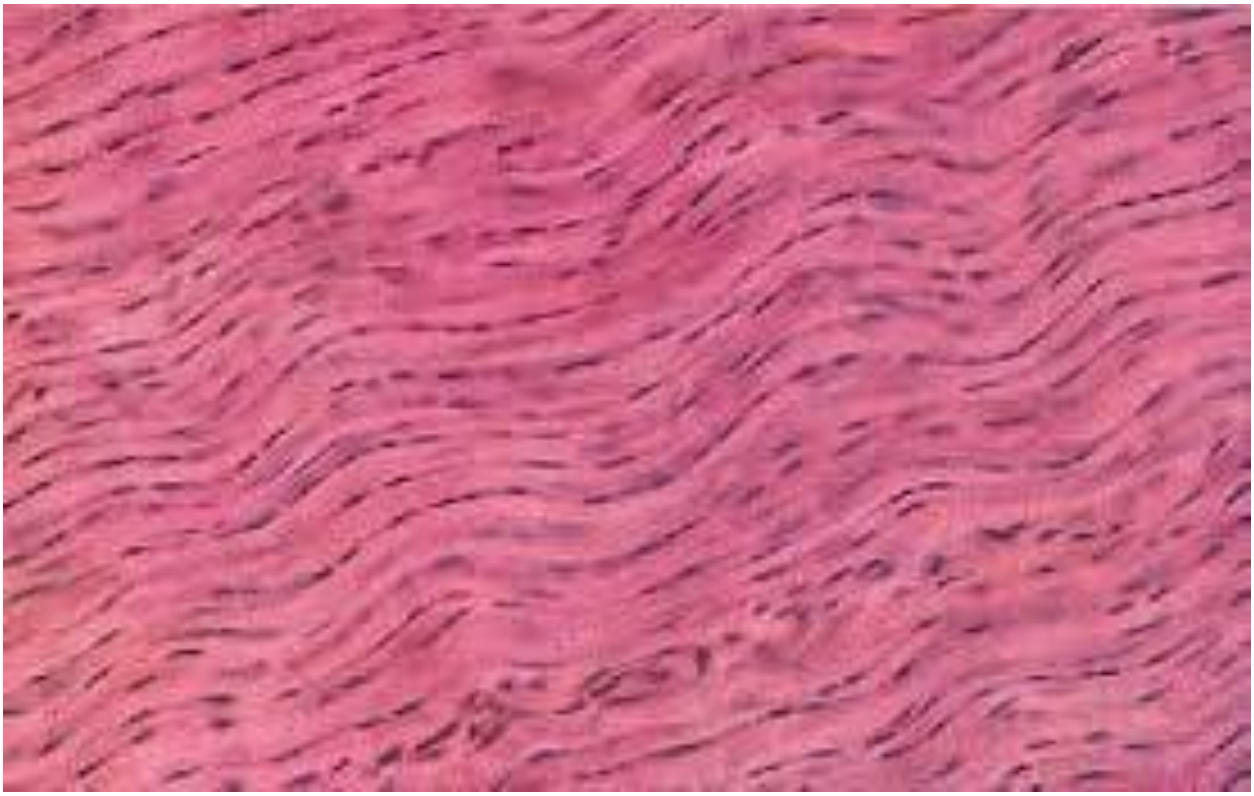


Elastic connective tissue





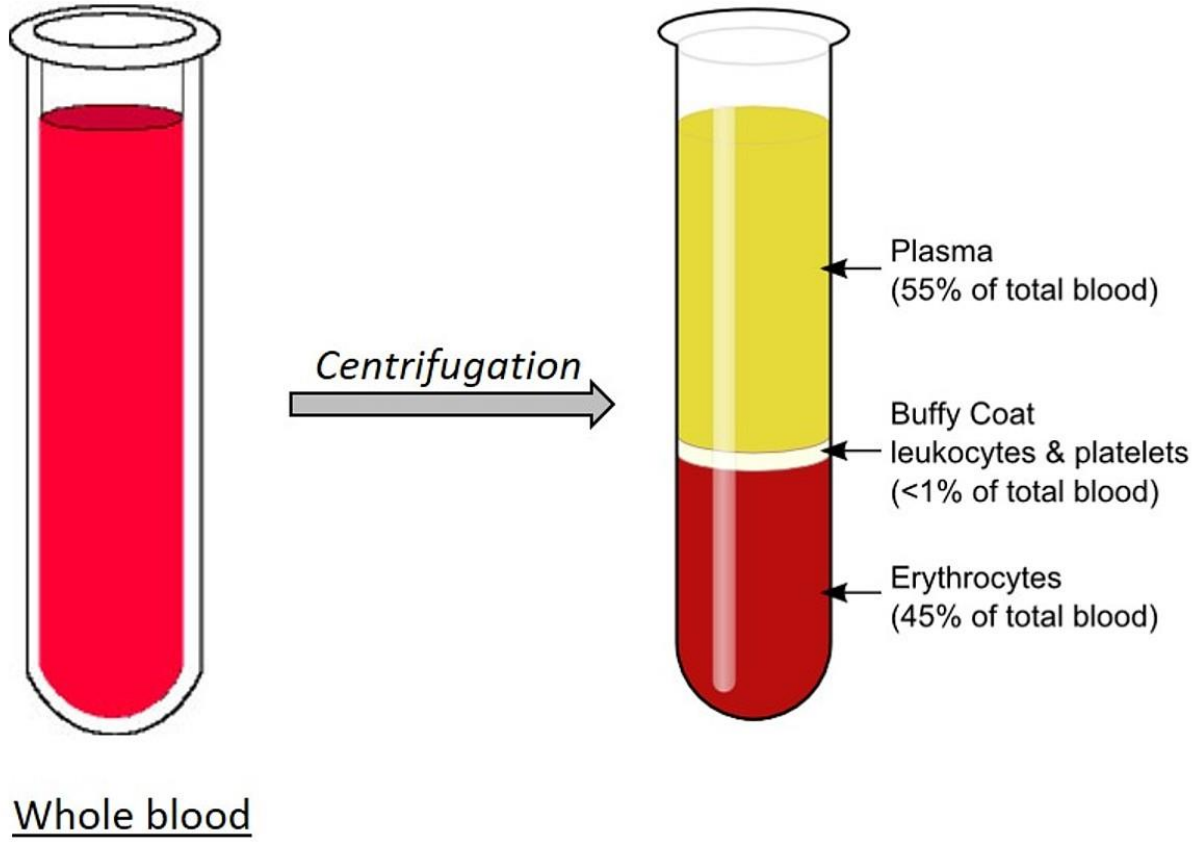
Dense irregular



Dense regular connective tissue

Lecture Four: Blood

blood is a specialized connective tissue consisting of **cells** and fluid called **plasma**. The bone marrow produces all blood cells. The blood circulates in the vascular system of a human.



Functions of blood

1.Supply of nutrient to cells
2.Transportation of O2 &CO2 in the body
3.Protects from infection
4.Removing waste material e.g urea ,CO2
5.Clotting
6.Regulation of body Temp.

Physical characteristics of blood

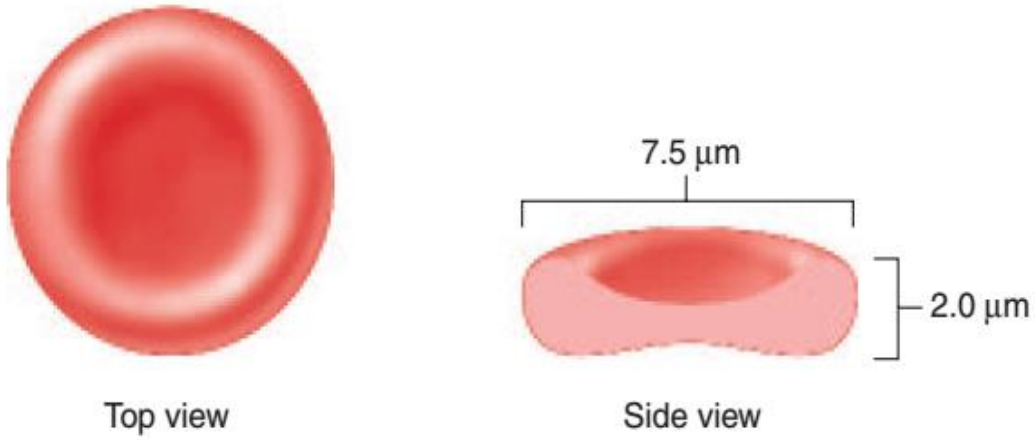
Thicker than water
8% of total body weight
In males 5-6 liters, in females 4-5 liters.
Normally has a pH of about 7.4

Components of blood

1.Blood cells (45%)
Red blood cells (erythrocytes)
White blood cells (leucocytes)
Platelets (thrombocytes)
2. Plasma (55%)

Characteristics of RBCs

Biconcave shape
Elastic cell membrane
No nucleus
95% of RBC consist of hemoglobin (red pigment).
Formed in red bone marrow
Average life is 4 months
The main function of RBC is to transport O2 &CO2



White blood cells (leukocytes)

They are colorless
Much larger than red blood cells
Formed in the bone marrow
Only 2% of total WBC population circulating in blood at a time (rest in the skin, lungs, and spleen)

Function of WBCs

These are the cells of the immune system that are involved in protecting the body against infectious diseases

Types of WBC

- Granulocytes

These WBC have granules in their cytoplasm

Granulocytes include neutrophils, eosinophils, and basophils

- Agranulocytes

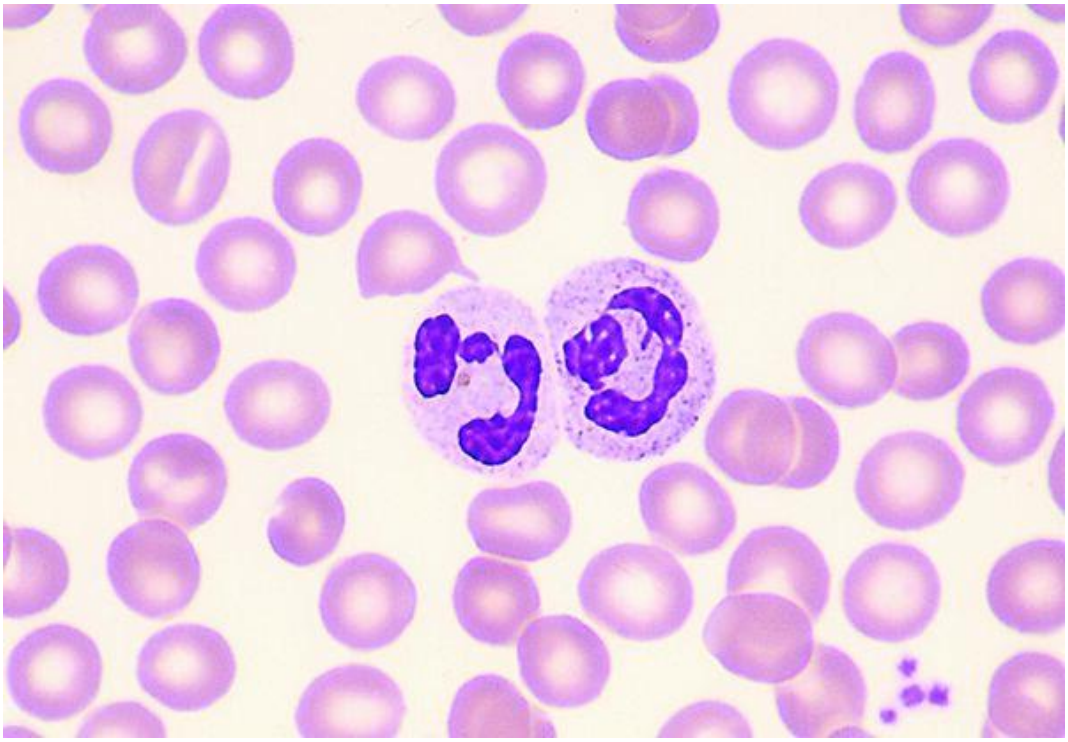
These are without granules in their cytoplasm

They include monocytes and lymphocytes

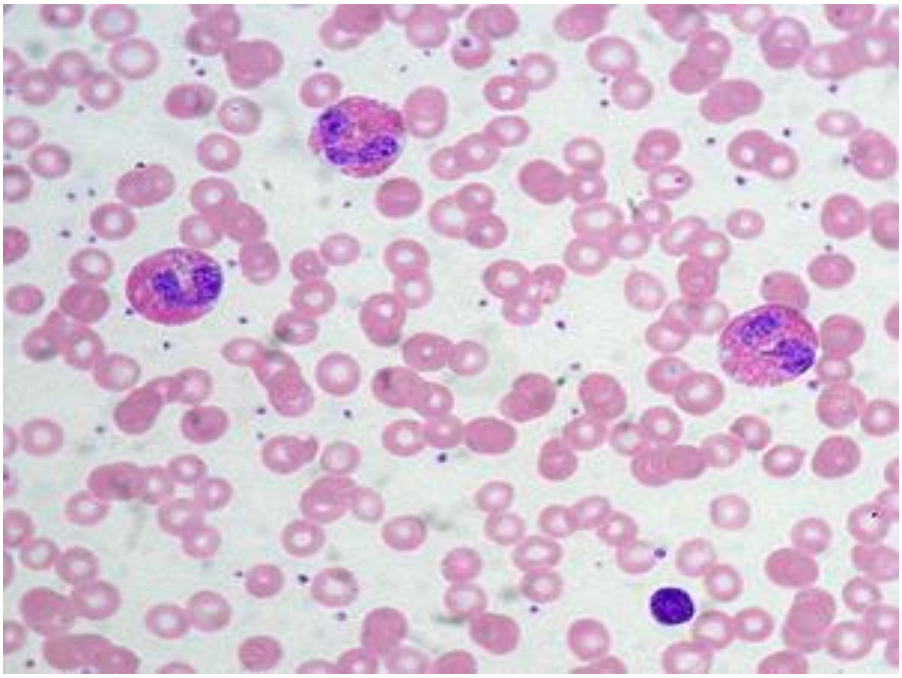
The most common type of white blood cell is the neutrophil, which accounts for 55 to 70 % of the total white blood cell count .They have a multi-lobed nucleus, which consists of three to five lobes connected by slender strands.
The other major type of white blood cell is a lymphocyte. There are two main populations of these cells. T lymphocytes help regulate the function of other immune cells and directly attack various infected cells and tumors. B lymphocytes make antibodies, which are proteins that specifically target bacteria, viruses, and other foreign materials. Lymphocytes are round cells that contain a single, large round nucleus.

Normal distribution of WBCs (%)

- neutrophil 55 to 70 %
- lymphocyte 20 to 40 %
- Monocyte 2 to 8 %
- Eosinophil 1 to 4 %
- Basophil 0.5 -1 %



Neutrophils

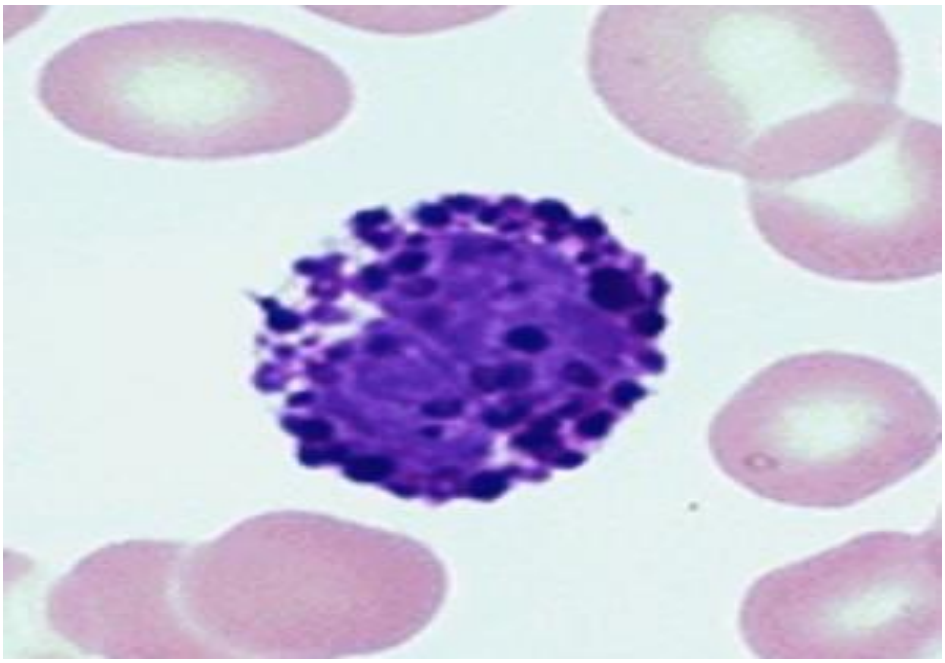


Eosinophil

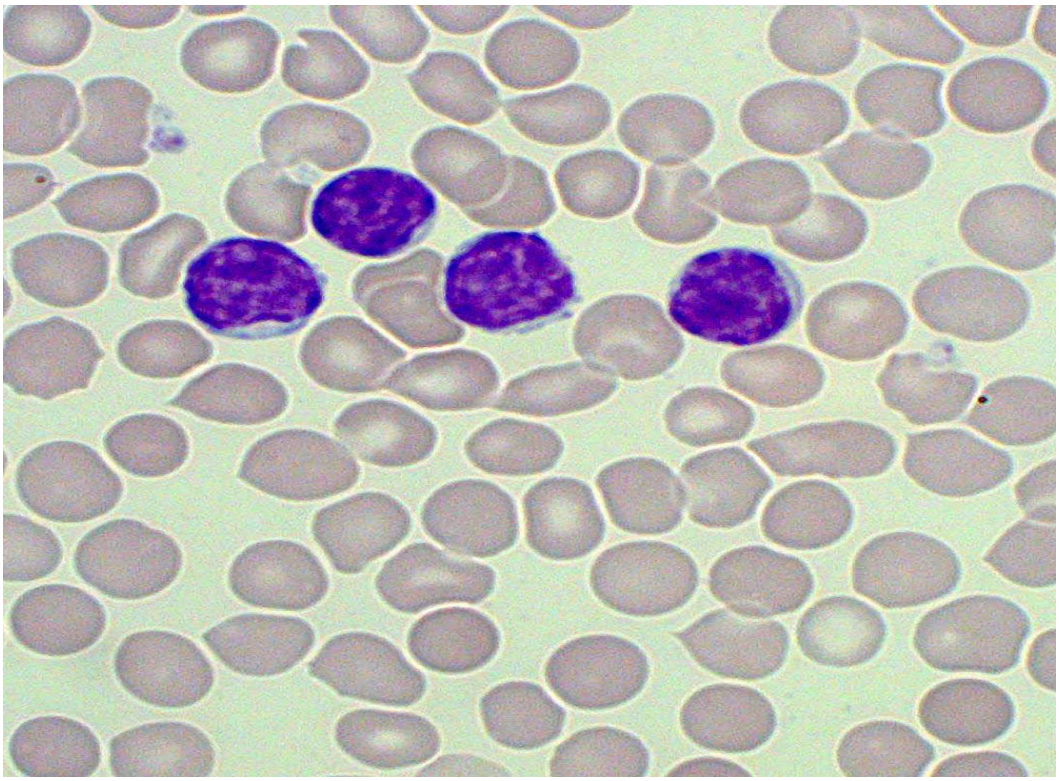
Basophil

less than 0.5% of the total count

contain **coarse, dark blue** granules. The nucleus is bi- or tri-lobed, but it is hard to see because of the number of coarse granules that hide ***it.It is responsible for immune system &allergic reaction .***



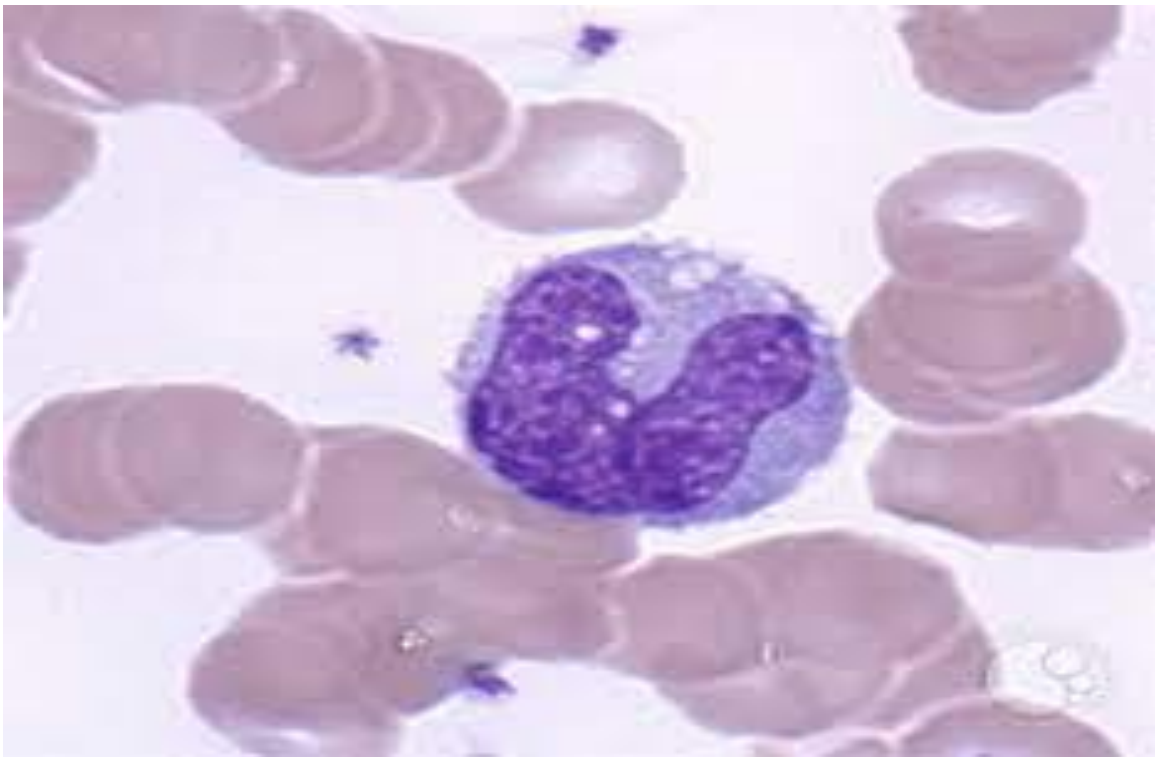
Lymphoctes



Monocytes

Monocytes are the largest cells of the blood , and they make up about 7 percent of the leukocytes. The nucleus is relatively big and tends to be indented or folded rather than multi-lobed.

It is arise in bone marrow. Monocytes leave the bone marrow and circulate in the blood. After a period of hours, the monocytes enter the tissues, where they develop into macrophages



Platelets

- Also called thrombocytes
- Platelets are not cells, they are fragments of large cells
- Nucleus is absent
- Random shaped
- 2-4 micron size(**smallest cells of blood**)
- Normal platelet count is 150 000-400 000 per microliter of blood .
- Platelets have a lifespan of only 5 to 9 days
- Platelets are formed in the bone marrow

Functions

- Formation of blood clots and stops bleeding .

Plasma

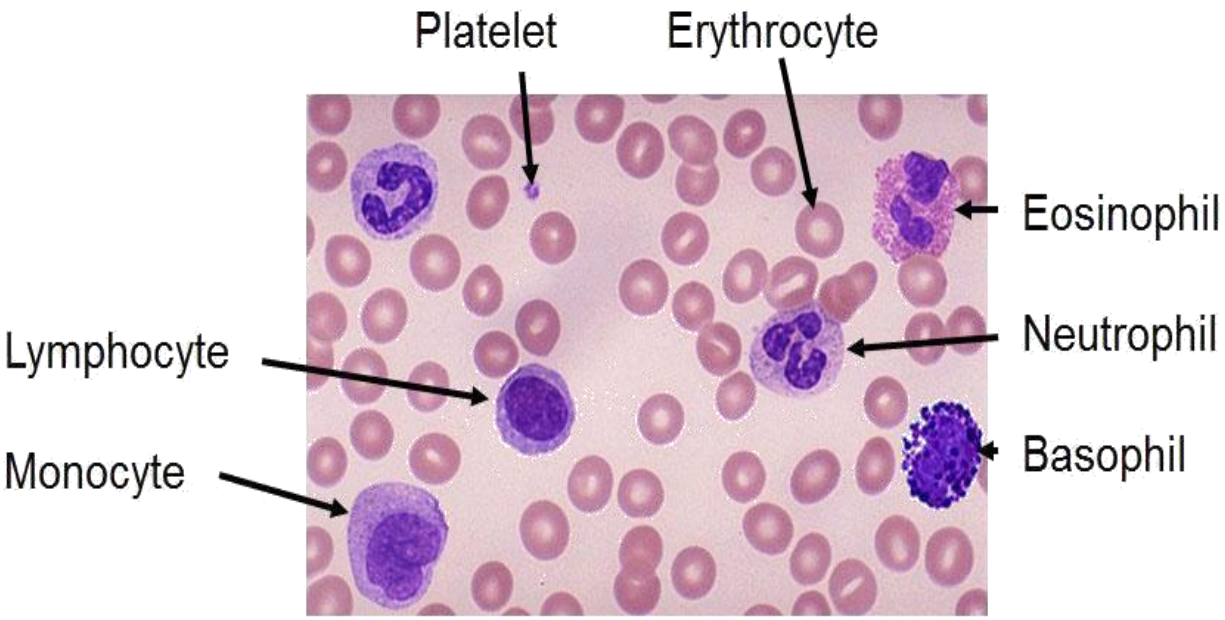
Plasma : 92%water, it contains:

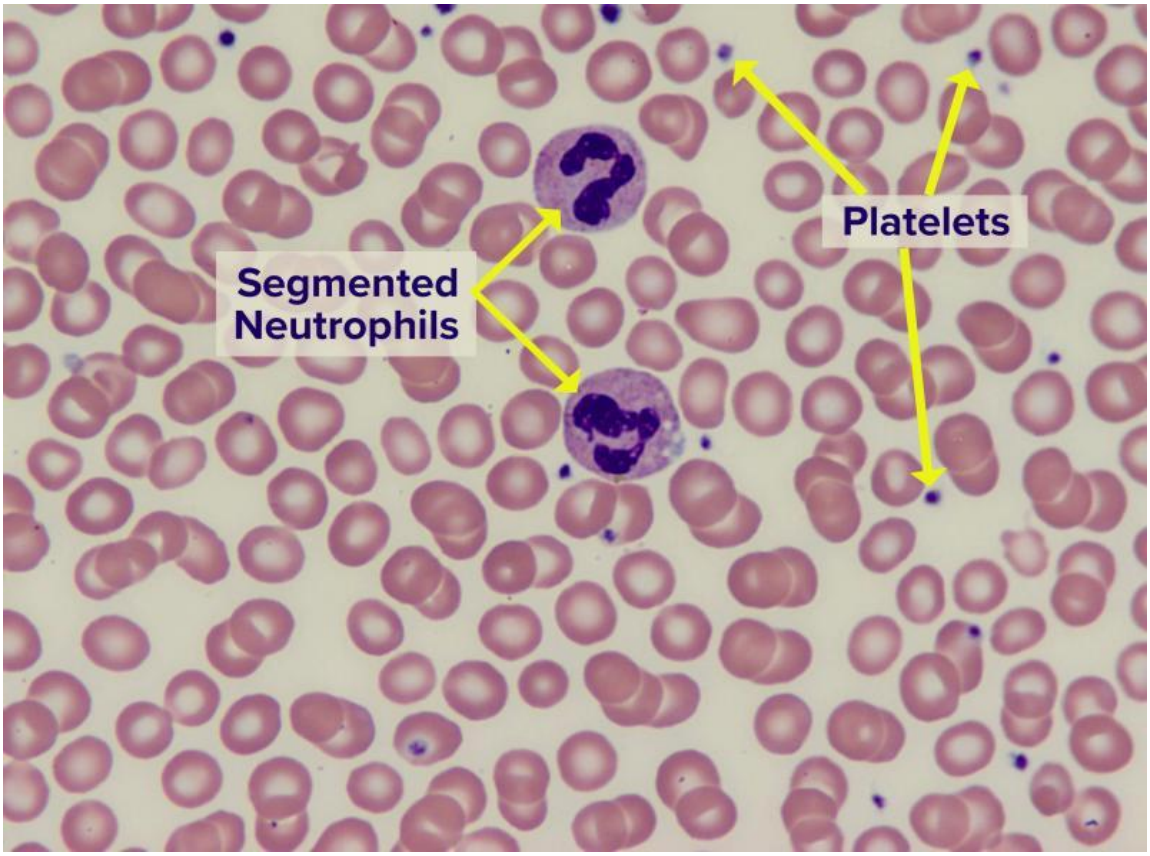
- Glucose
- Hormones
- Proteins
- Mineral salts
- Fats
- Vitamins

Functions

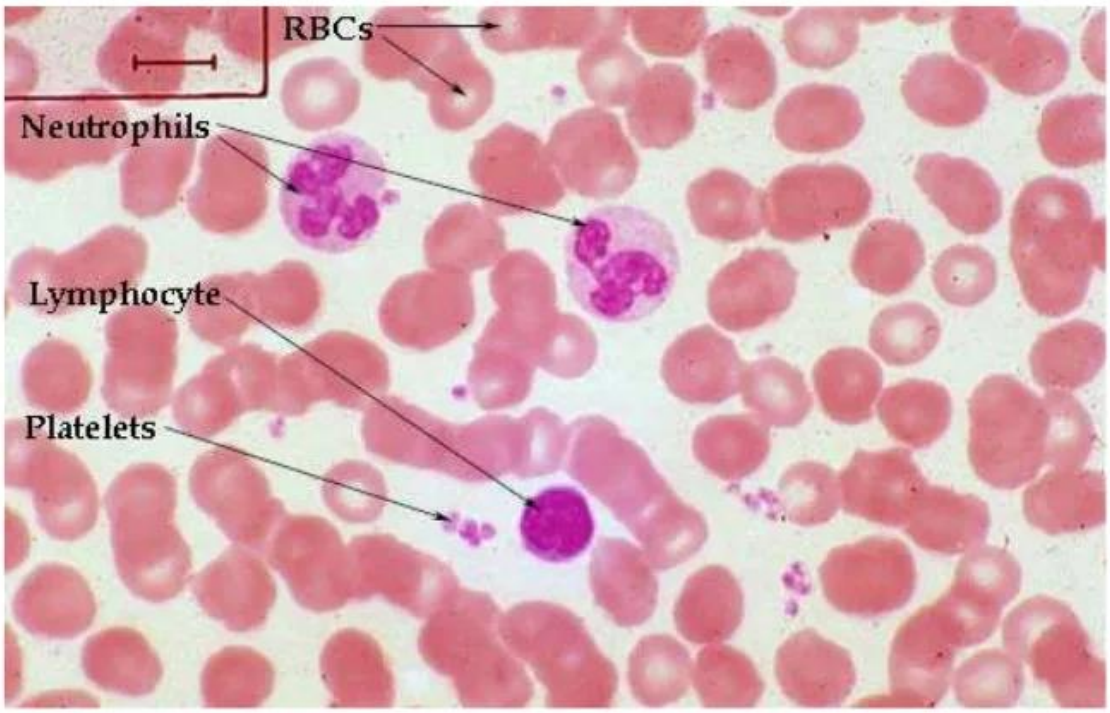
- Plasma helps maintain blood pressure
- Regulates body temperature
- It contains minerals, salts, hormones and proteins that perform important functions in the body
- PH buffering

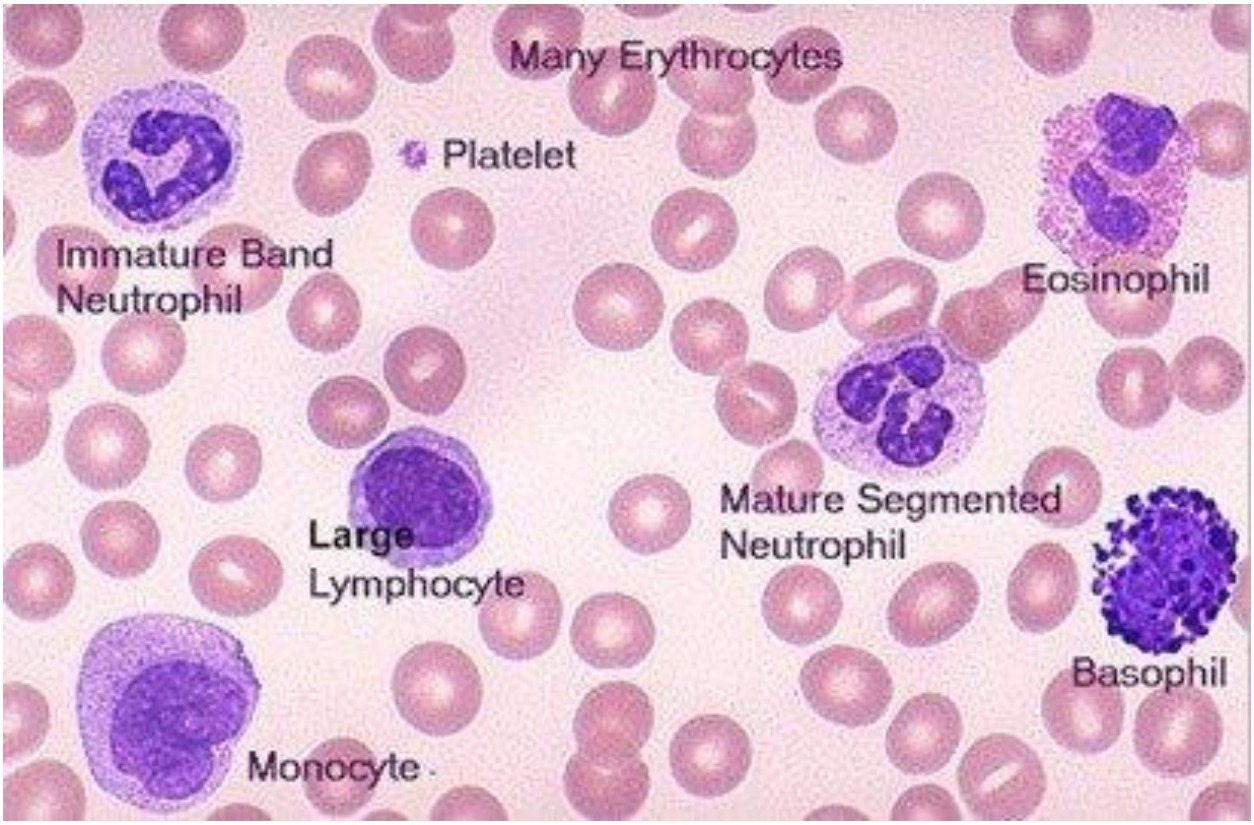
Slides for further learning




Segmented
Neutrophils
Platelets

Peripheral-blood-smear




Many Erythrocytes
Platelet
Immature Band Neutrophil
Eosinophil
Mature Segmented Neutrophil
Large Lymphocyte
Basophil
Monocyte

Lecture Five: Cartilages

Components of cartilage

- Cells
- Fiber: collagen elastic .
- Ground substance (chondroitin sulphate, keratin sulphate and hyaluronic acid)

The perichondrium

- It is a dense sheath of connective tissue covering the cartilage except *articular cartilage &fibro cartilage* .
- Has 2 layers outer fibrous (vascular)&inner chondergenic layer **(cellular)**.
- Has cells which can regrow cartilage to some extent if the cartilage is damaged.

Cells

They are derived from undifferentiated mesenchymal cells
Chondroblasts multiply to
Chondrocytes
Older chondrocytes
Chondrocytes are more in numbers and found in lacunar spaces either individually or in groups of 2-4 cells.
Chondrocytes produce fibers and ground substance
Old mature chondrocytes do not multiply

Fibers

They are collagen fibers :

- Thick fiber have cross striation.
- Thin fibers form 3 dimensional network.
- Collagen –stability and strength.
- Fibers constitute about 40%of dry weight of the cartilage.

GROUND SUBSTANCE

- It is described as amorphous (shapeless) ,extracellular material which serve as a diffusion medium in the space around the cells &fibers .
- Mucopolysaccharid (chondroitin sulphate ,keratin sulphate &hyaluronic acid)

Lecture Six: Bones

Jenan Y Taha

Bone is a specialized connective tissue consisting of cells embedded in an abundant hard intercellular material (matrix). Bone matrix is 90 to 95% composed of collagen fibers, and the remainder is ground substance The matrix is hardened by the binding of inorganic mineral salt, calcium phosphate.

Types of bone cells

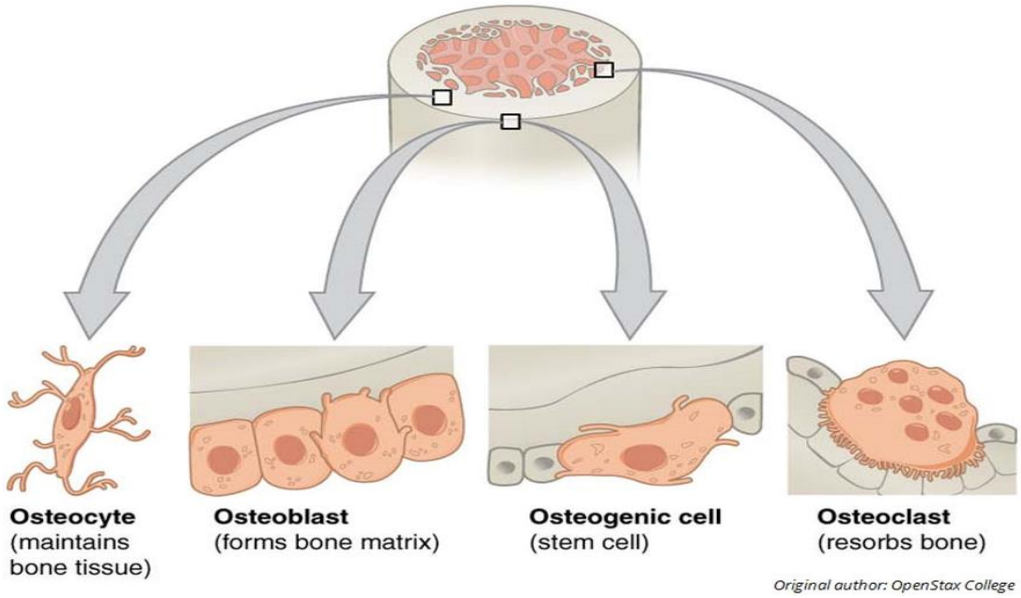
Osteoblast. Found within the bone, its function is to form new bone tissue.

Osteoclast. A very large cell formed in bone marrow, its function is to absorb and remove unwanted tissue.

Osteocyte. Found within the bone, They monitor the minerals and proteins to regulate bone mass.

Blood cells. Found in bone marrow, its function is to produce new blood cells.

Fat cells are also found within the bone marrow



Bone functions:

Support and shape of the body.

Protection of the major organs of the body .
Lipid and mineral storage.
Development and storage of blood cells

Structure of Bone

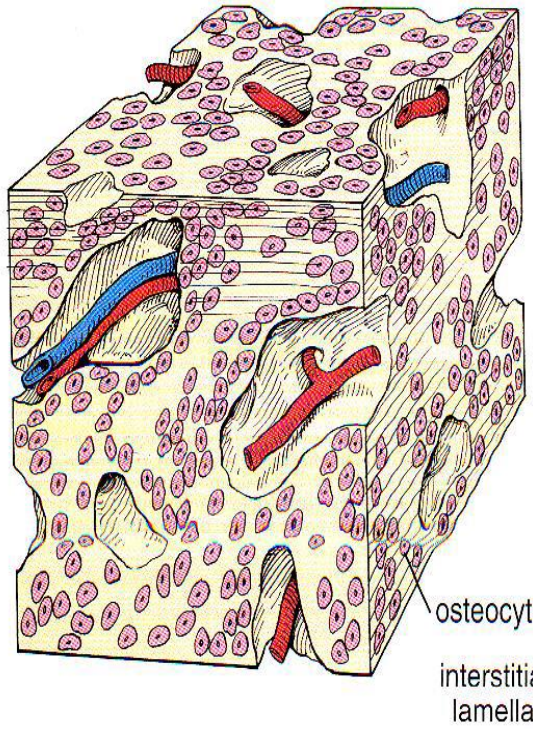
Under the microscope, bone can be divided into two types:

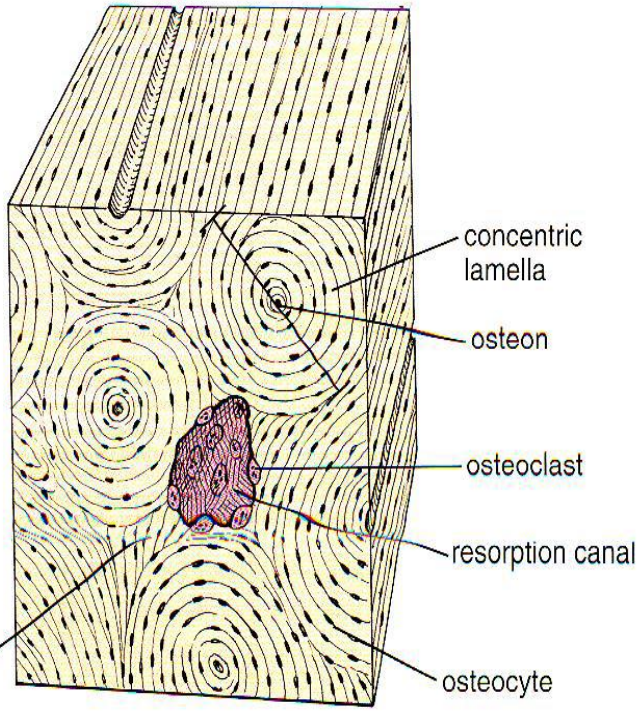
--Woven bone (primary bone) – Appears in embryonic development and fracture repair, as it can be laid down rapidly. It consists of osteoid (unmineralised ECM), with the collagen fibers arranged randomly. It is a temporary structure, soon replaced by mature lamellar bone.

--Lamellar bone (secondary bone) – The bone of the adult skeleton. It consists of highly organized sheets of mineralized osteoid. This organized structure makes it much stronger than woven bone.

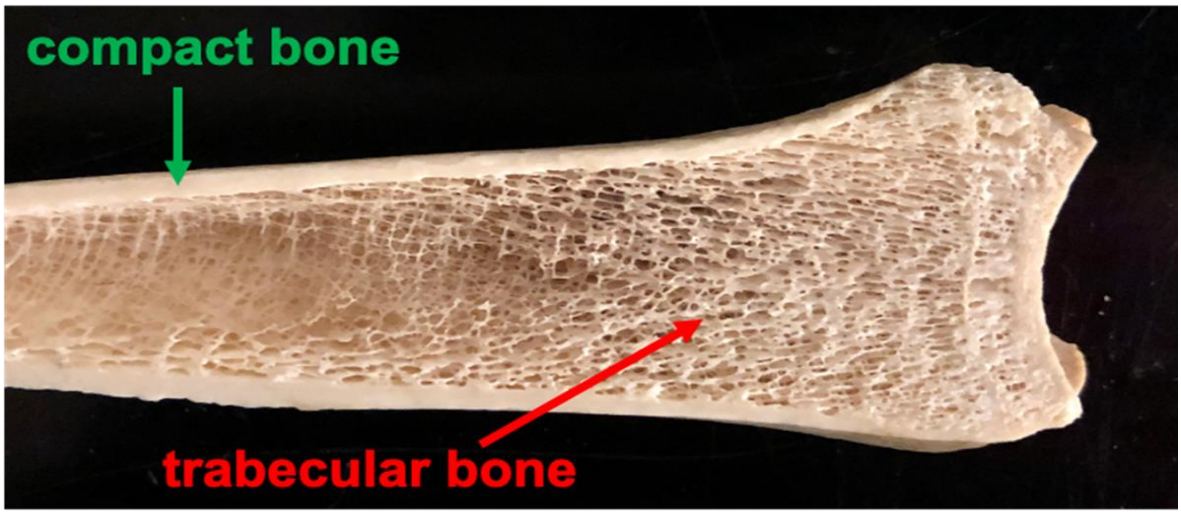
In both types of bone, the external surface is covered by a layer of connective tissue, known as the **periosteum**. A similar layer, the **endosteum** line the internal surface of the bone

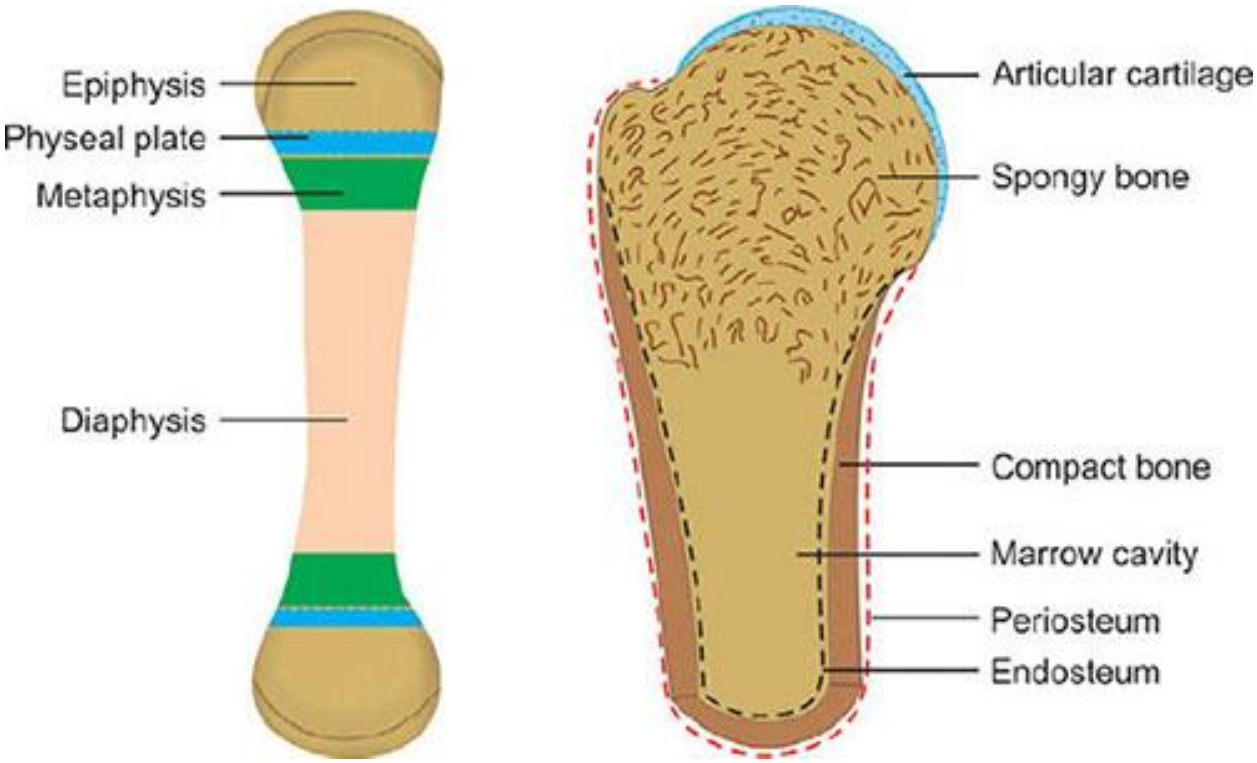
Lamellar bone can be divided into two types. The outer is known as **compact bone** – this is dense and rigid. The inner layers of bone are marked by many interconnecting cavities and is called **spongy bone**





Woven bone **Lamellar bone**





Drawing of bone structure

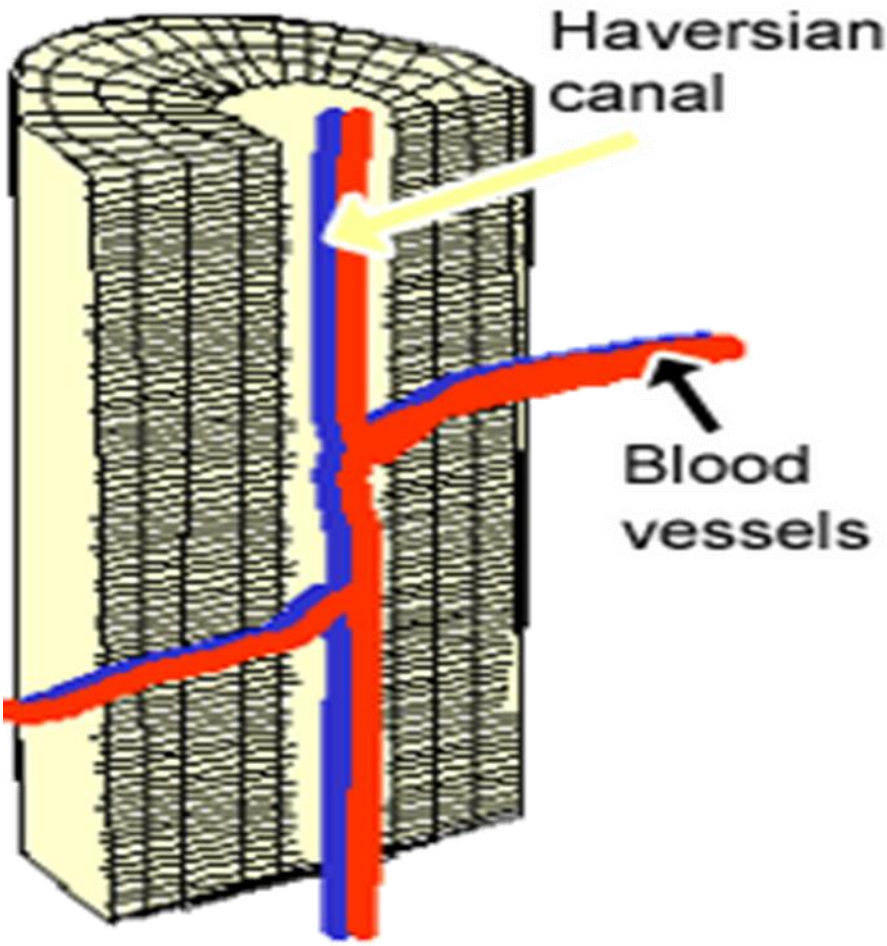
Compact Bone

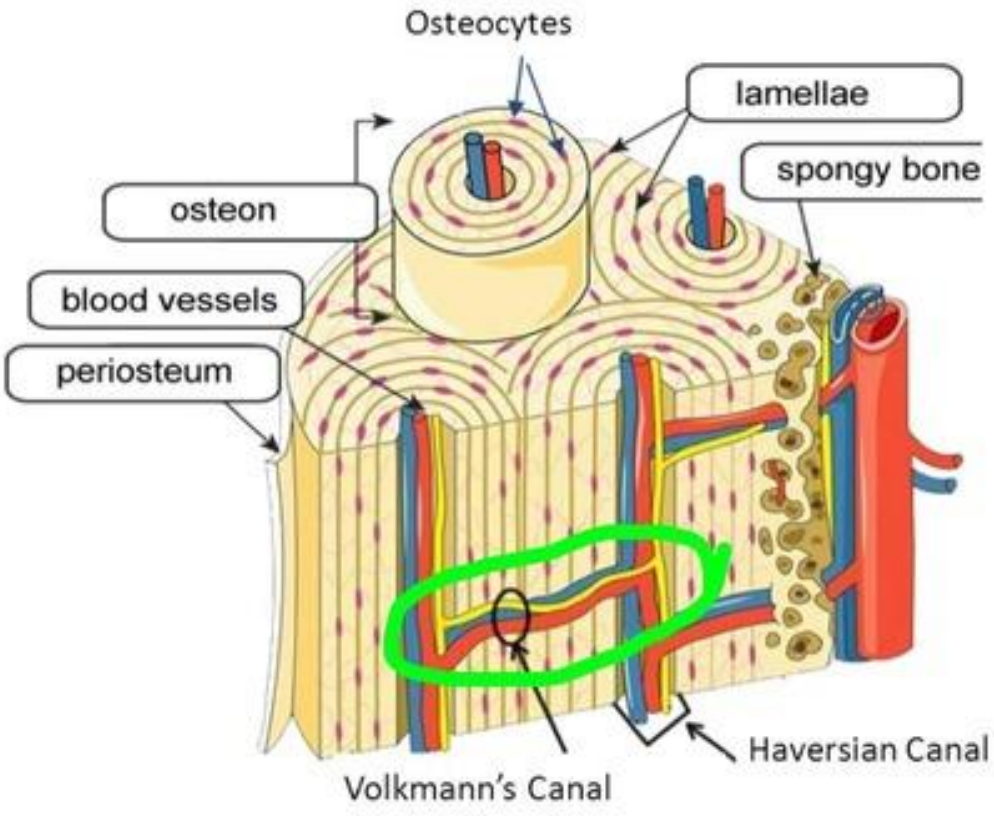
Compact bone forms the harder, outer tissue of bones which represents 80% of the total bone mass, The cortical bone gives bone its smooth, white, and solid appearance.

. In this type of bone, the lamellae are organized into packed concentric circles, which surround a vertical **Haversian canal** (which transmits small blood vessels, nerves and lymphatic vessels). This entire structure is called an **osteon** and is the functional unit of bone.

The Haversian canals are connected by horizontal **Volkmann's canals** – these contain small vessels that anastomose (join) with the arteries of the Haversian canals. The Volkmann's canals also transmit blood vessels from the periosteum.

Osteocytes are located between the lamellae, within small cavities (known as lacunae). The lacunae are interconnected by a series of interconnecting tunnels, called **canaliculi**

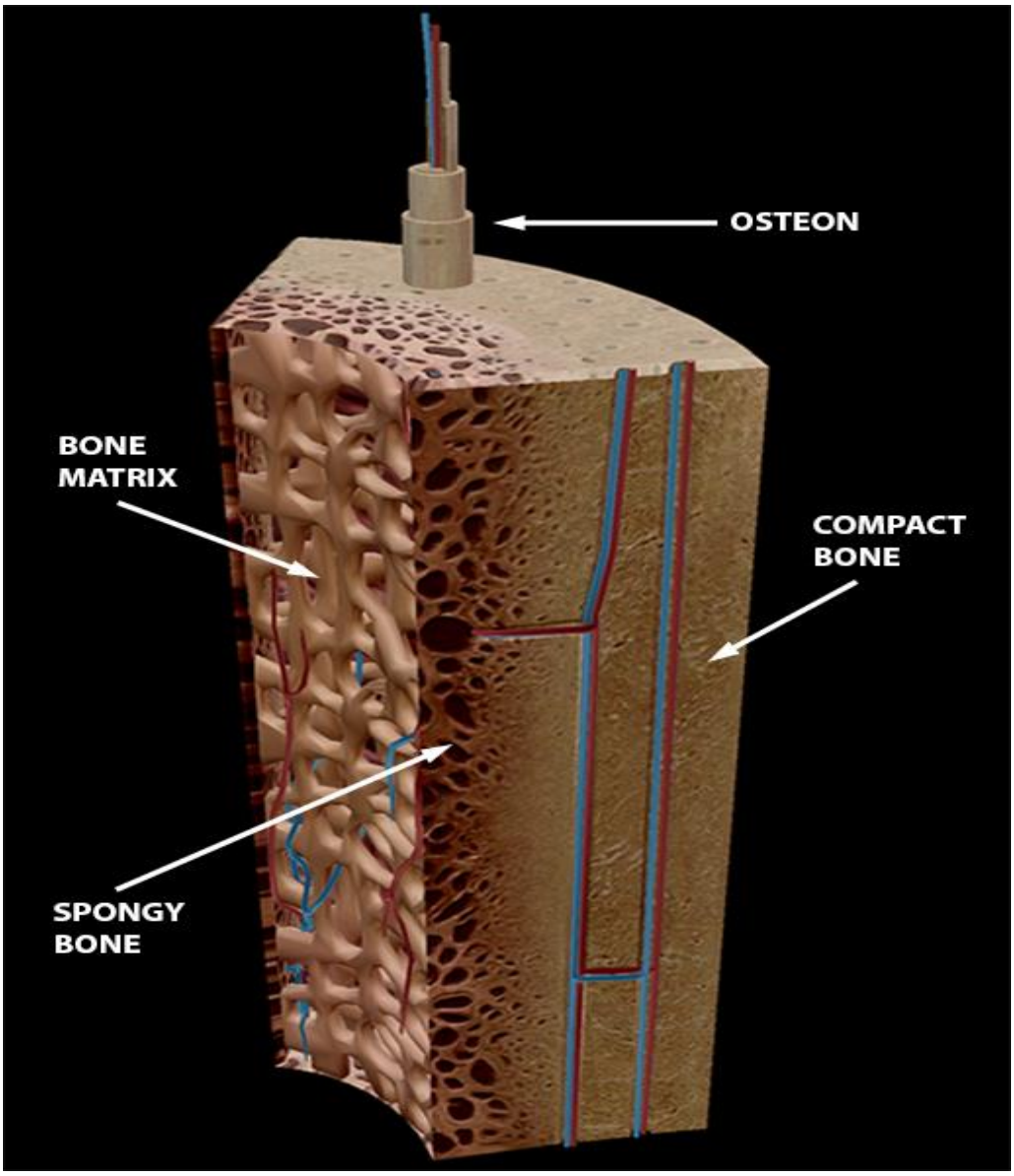


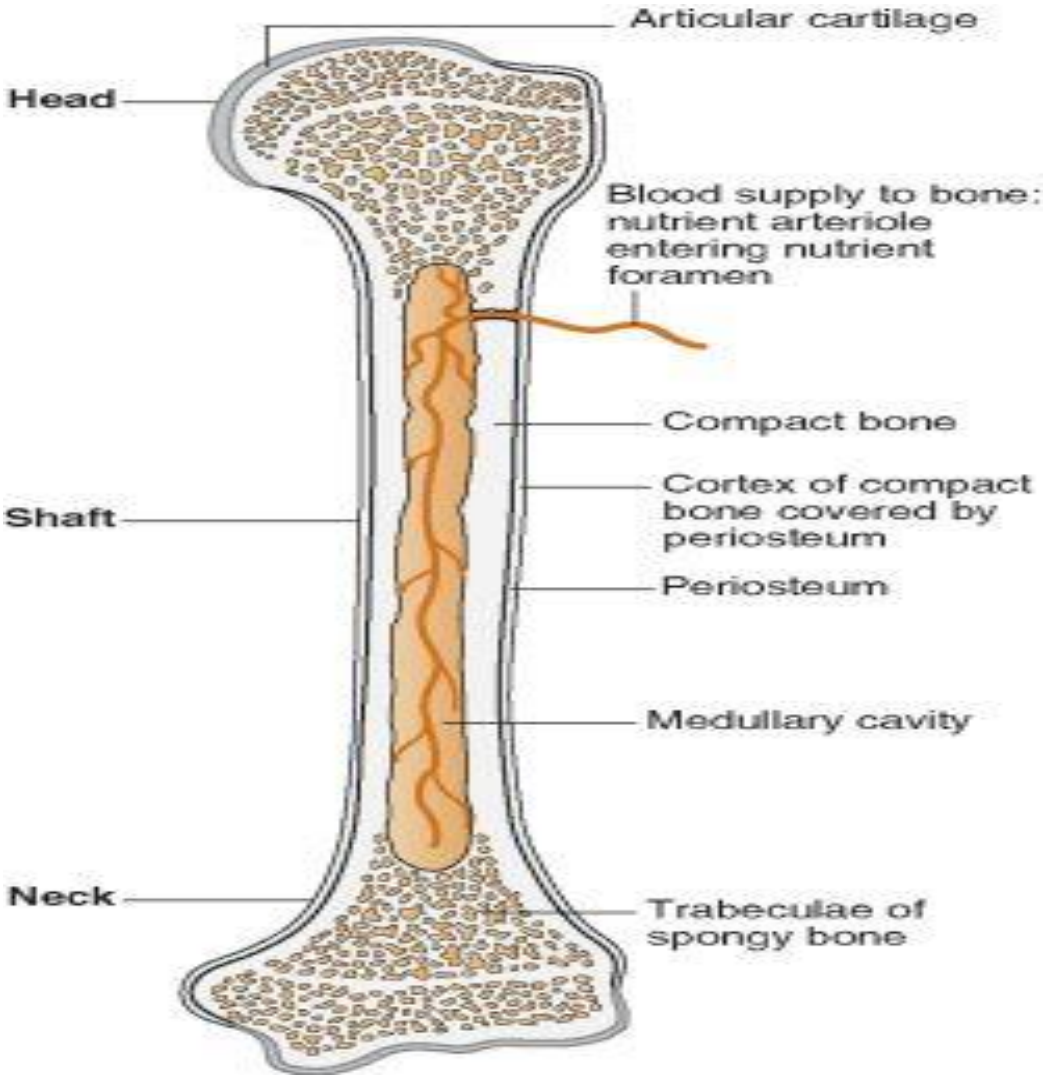


Spongy bone makes up the interior of most bones and is located deep to the compact bone. constituting about 20% of total bone mass .It is also called trabecular or cancellous bone or spong bone .

Is typically found at the ends of long bones, near joints and in the interior of vertebrae. . The primary anatomical and functional unit of cancellous bone is the trabecula . It contains many large spaces – this gives it a honeycombed appearance.

The spaces between trabeculae are often filled with **bone marrow**. Yellow bone marrow contains adipocytes and **red** bone marrow consists of haematopoietic stem cells. **This type of bone does not contain any Volkmann's or Haversian canal .**


OSTEON
BONE
MATRIX
COMPACT
BONE
SPONGY
BONE


Articular cartilage
Head
Blood supply to bone: nutrient arteriole entering nutrient foramen
Compact bone
Cortex of compact bone covered by periosteum
Shaft
Periosteum
Medullary cavity
Neck
Trabeculae of spongy bone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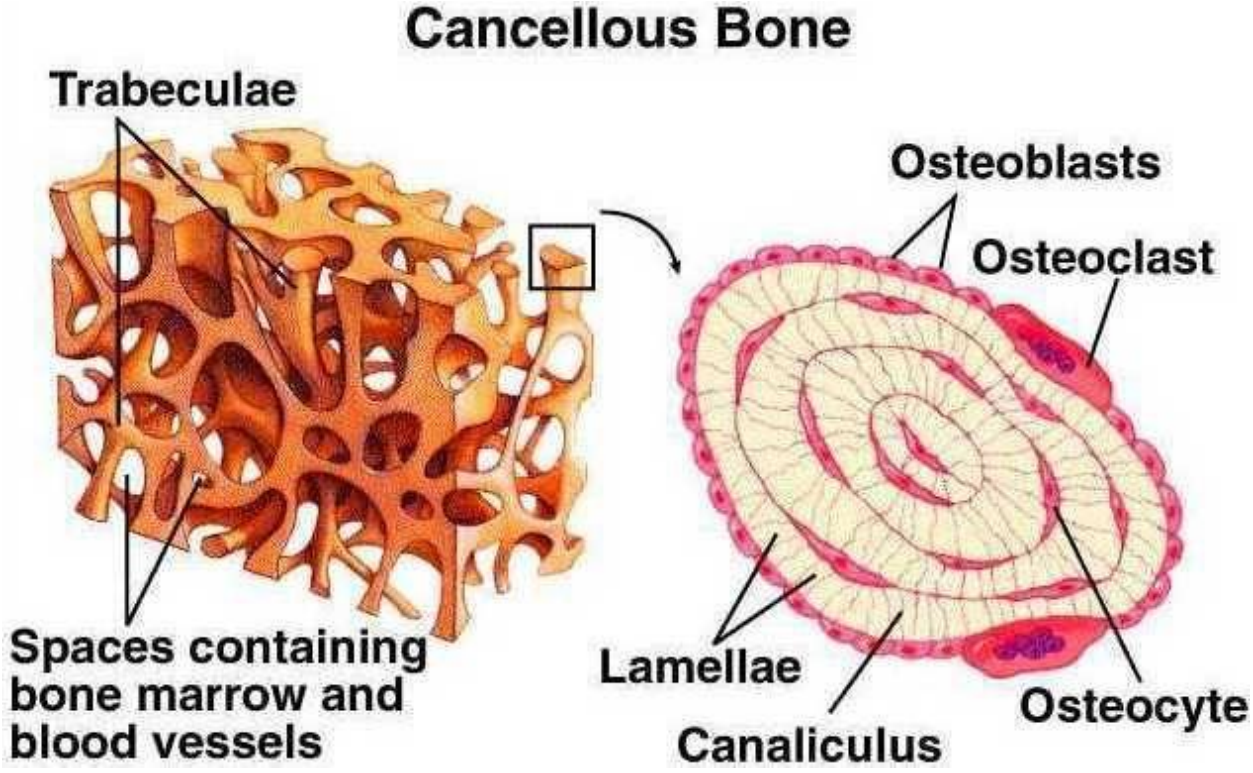
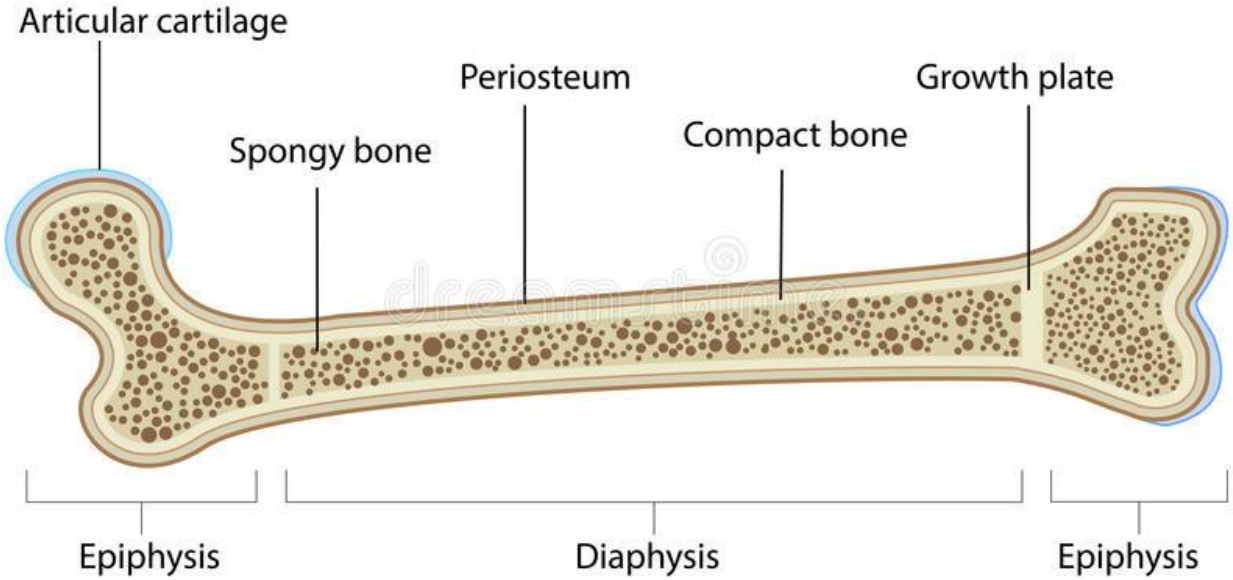

Cancellous Bone
Trabeculae
Spaces containing bone marrow and blood vessels
Osteoblasts
Osteoclast
Lamellae
Canaliculus
Osteocyte


Articular cartilage
Spongy bone
Periosteum
Compact bone
Growth plate
Epiphysis
Diaphysis
Epiphysis

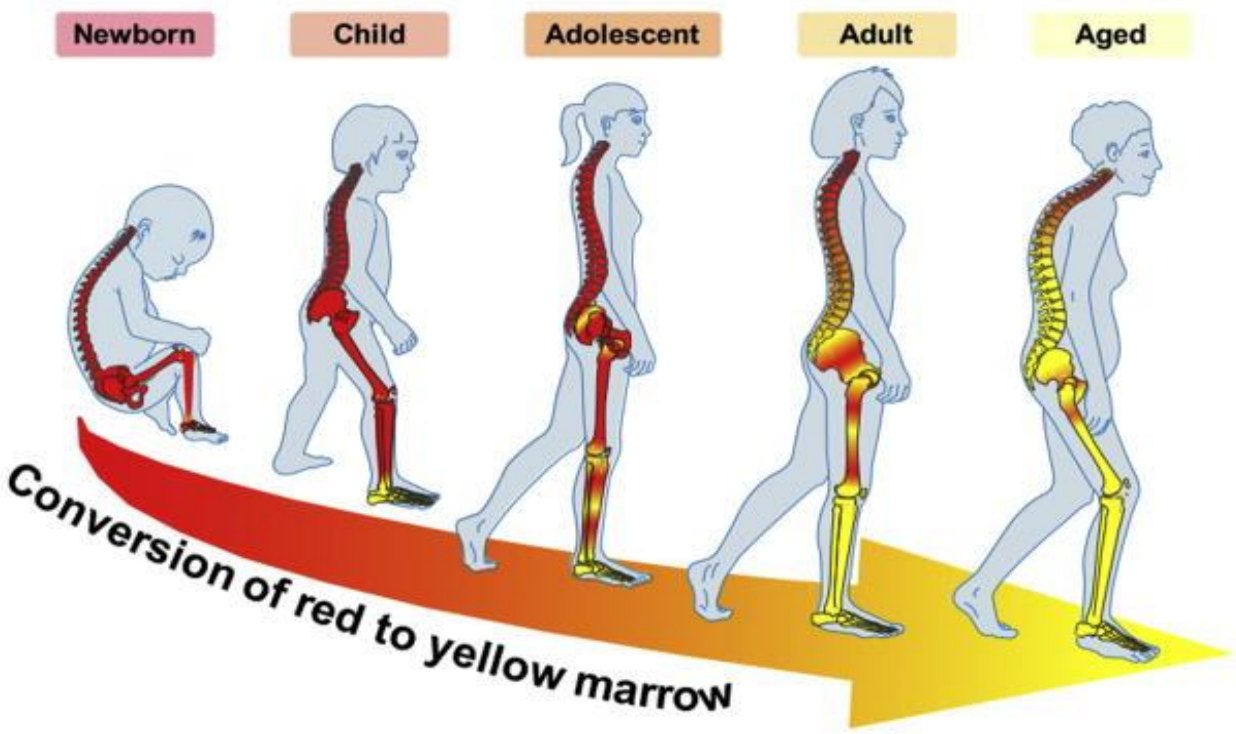
Bone marrow

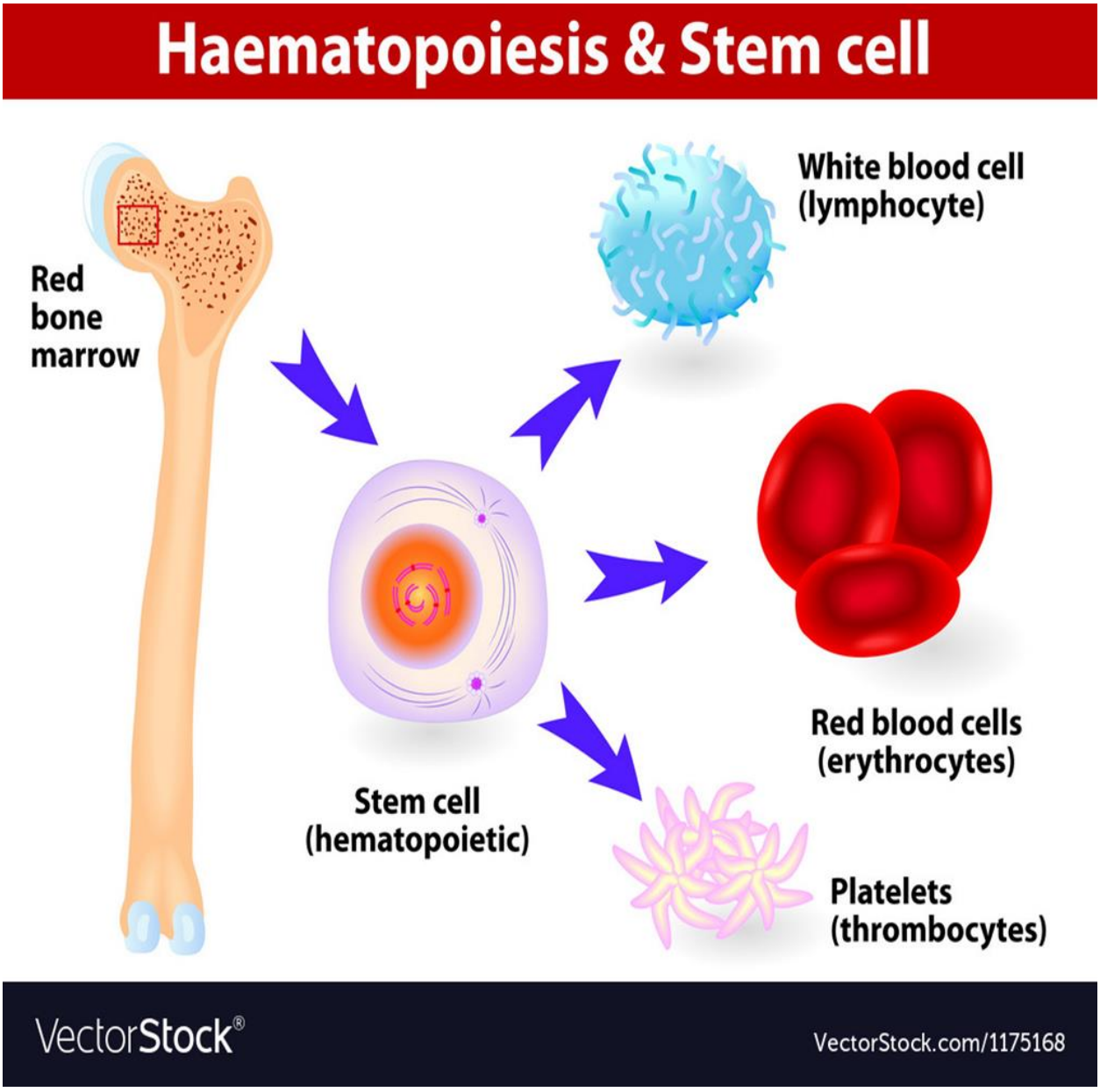
It is found in the medullary canal of long bones& cavities of cancellous (spongy bone). It is of two types:

Red bone marrow due to blood .

Yellow bone marrow due fat cells.

IN newborns all bone marrow is red




Haematopoiesis & Stem cell
Red bone marrow
White blood cell (lymphocyte)
Stem cell (hematopoietic)
Red blood cells (erythrocytes)
Platelets (thrombocytes)
VectorStock®
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Lecture Seven: Muscles

MUSCLES TISSUE

Muscle tissue is composed of cells differentiated for optimal use of the universal cell property termed contractility. Microfilaments and associated proteins together generate the forces necessary for cellular contraction, which drives movement within certain organs and the body as a whole. Nearly all muscle cells are of mesodermal origin and they differentiate mainly by a gradual process of lengthening with simultaneous synthesis of myofibrillar proteins.

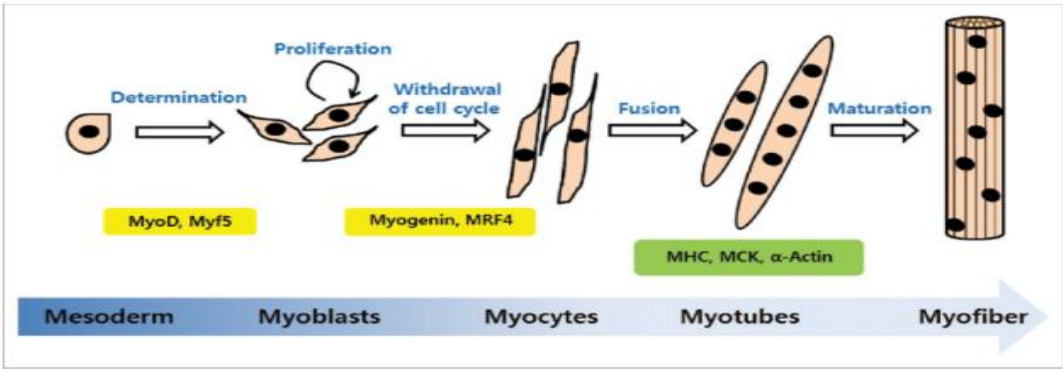
Types of muscles:

Based on the differences in the shape of muscle cells, functional characteristics and the structure of each type is adapted to its physiologic role. And the arrangement of myofilaments, muscles are classified as one of the three types: skeletal, cardiac, or smooth muscles.

1-Skeletal muscles:

Skeletal muscle is composed of bundles of muscle fibers of very long , cylindrical, multinucleated cells with diameters of 10-100 um .that show cross-striations. Their contraction is quick, forceful, and usually under voluntary control. Caused by the interaction of thin actin filaments and thick myosin filaments .whose molecular configuration allows them to slide upon one another. The forces necessary for sliding are generated by weak interactions in the bridges between actin and myosin .

Multinucleated results from the fusion of embryonic mesenchymal cells called myoblasts . The long oval nuclei are usually found at the periphery of the cell under the cell membrane. This characteristic nuclear location is helpful in discriminating skeletal muscle from cardiac and smooth muscle, both of which have centrally located nuclei.

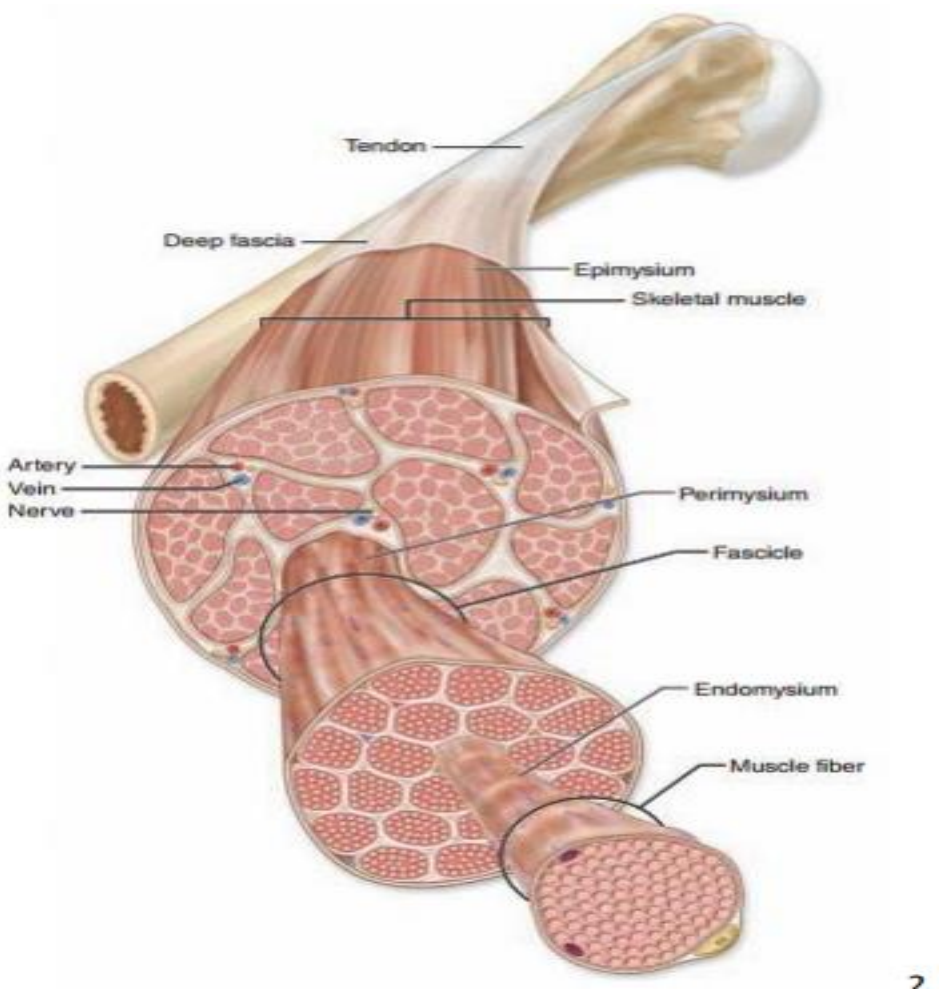


مراحل تكوين الليف العضلي

Organization

Muscle tissue is composed of cells differentiated for optimal use of the universal cell property termed contractility. Microfilaments and associated proteins together generate the forces necessary for cellular contraction, which drives movement within certain organs and the body as a whole. Nearly all muscle cells are of mesodermal origin and they differentiate mainly by a gradual process of lengthening with simultaneous synthesis of myofibrillar proteins.

Most muscles taper off at their extremities and connective tissue components of the epimysium show continuity with tendons through myotendinous junctions . as shown in the figure….



Structure of a myofibril: a series of sarcomeres.

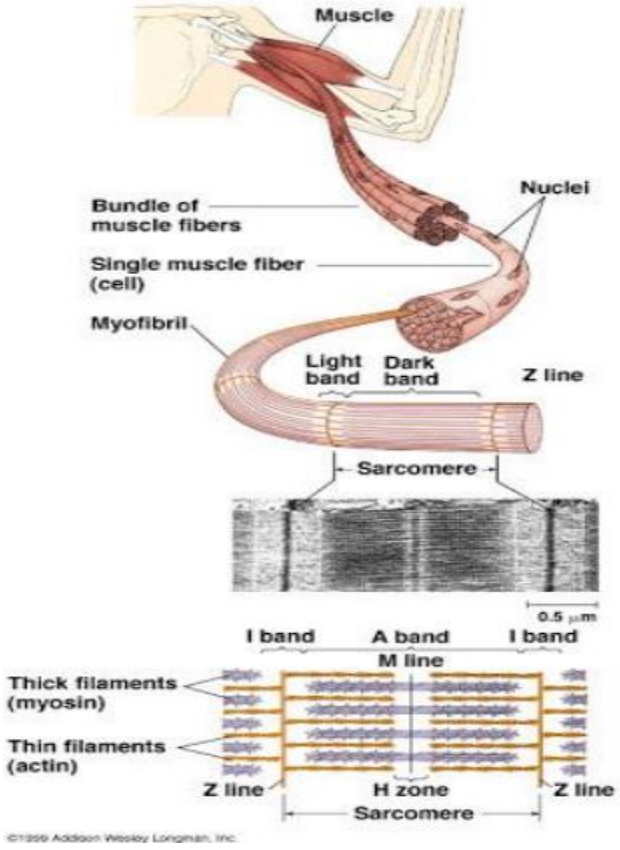
(a): Diagram indicates that each muscle fiber contains several parallel bundles called myofibrils.

(b): Each myofibril consists of a long series of sarcomeres which contain thick and thin filaments and are separated from one another by 2 discs.

(c): Thin filaments are actin filaments with one end bound to a-actinin, the major protein of the Z disc.

Thick filaments are bundles of myosin, which span the entire A band and are bound to proteins of the M line and to the Z disc across the | bands by a very large potein called titin , which has spring-like domains.

(d): The molecular organization of the sarcomeres has bands of greater and lesser protein density, resulting in staining differences that produce the dark and light-staining bands seen by light microscopy and TEM.



Muscle Fiber Types:

Skeletal muscle fibers of humans are classified into three types based on their physiological, biochemical, and histochemical characteristics . All three fiber types are normally found throughout most muscles.

*** Type I or slow**, red oxidative fibers contain many mitochondria and abundant myoglobin, a protein with iron groups that bind O2 and produce a dark red color. Red fibers derive energy primarily from aerobic oxidative phosphorylation of fatty

acids and are adapted for slow, continuous contractions over prolonged periods, as required for example in the postural muscles of the back.

• **Type lla or fast,** intermediate oxidative-glycolytic fibers have many mitochondria and much myoglobin, but also have considerable glycogen. They utilize both oxidative metabolism and anaerobic glycolysis and are intermediate between the other fiber types both in color and in energy metabolism. They are adapted for rapid contractions and short bursts of activity, such as those required for athletics.

***Type llb or fast,** white glycolytic fibers have fewer mitochondria and less myoglobin, but abundant glycogen, making them very pale in color. They depend largely on glycolysis for energy and are adapted for rapid contractions, but fatigue quickly. They are typically small muscles with a relatively large number of neuromuscular junctions, such as the muscles that move the eyes and digits.

The classification of fiber types in muscle biopsies has clinical significance for the diagnosis of muscle diseases, or myopathies.

2- Cardiac muscles

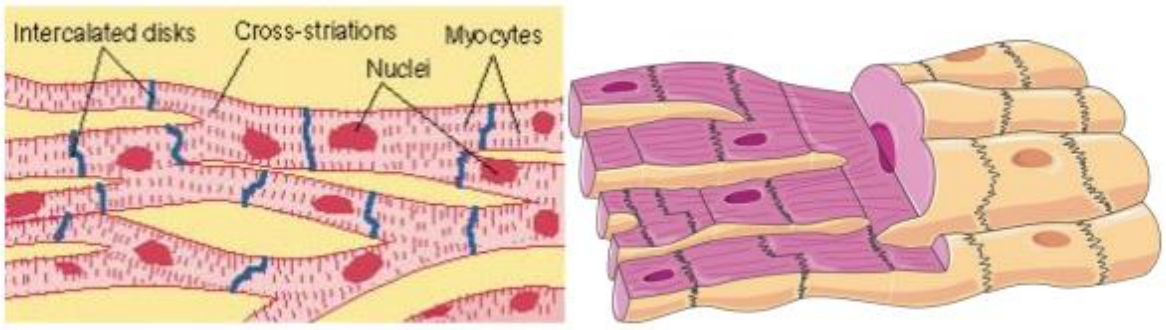
Cardiac muscle composes the heart walls and is found in the large veins entering it. There is considerable structural resemblance to skeletal muscle. AIthough each contraction is followed by a moment of rest, the heart beats rhythmically, tirelessly, and endlessly from a very early embryonic stage until death.

Cardiac muscle also has cross-striations and is composed of elongated, branched individual cells that lie parallel to each other . Consequently, the heart consists of tightly knit bundles of cells, interwoven in a fashion that provides for a characteristic wave of contraction that leads to a wringing out of the heart ventricles. Contration of cardiac muscle is involuntary, vigorous, and rhythmic.

Unlike multinucleated skeletal muscle, however, each cardiac muscle cell possesses only one or two centrally located pale-staining nuclei. Surrounding the muscle cells is a delicate sheath of endomysium containing a rich capillary network.

A unique and distinguishing characteristic of cardiac muscle Is the presence of dark-staining transverse lines that cross the chains of cardiac cells at irregular intervals . These intercalated discs represent the interface between adjacent muscle cells where many junctional complexes are present.

The structure and function of the contractile proteins in cardiac cells are essentially the same as in skeletal muscle. Cardiac muscle cells contain numerous mitochondria, which occupy 40°/o or more of the cytoplasmic volume, reflecting the need for continuous aerobic metabolism in heart muscle. By comparison, only about 2°/o of skeletal muscle fiber is occupied by mitochondria. Fatty acids, transported to cardiac muscle cells by lipoproteins, are the major fuel of the heart and are stored as triglycerides in numerous lipid droplets seen in many cardiac muscle cells. Glycogen particles may also be present. Lipofuscin pigment granules are often found near the nuclei of cardiac muscle cells.



SMOOTH MUSCLE:

Smooth muscle fibers are elongated, tapering, and nonstriated cells, each of which is enclosed by a thin basal lamina and network of reticular fibers. The connective tissues serve to combine the forces generated by each smooth muscle fiber into a concerted action, eg, peristalsis in the intestine.

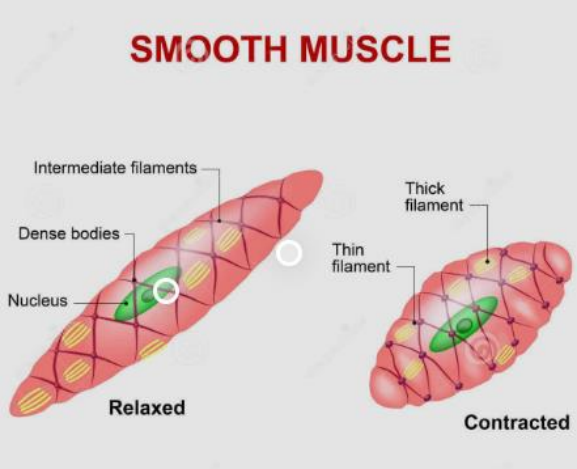
Smooth muscle cells may range in length from 20 um in small blood vessels to 500 um in the pregnant uterus. Each cell has a single nucleus located in the center of the cell' s broadest part.

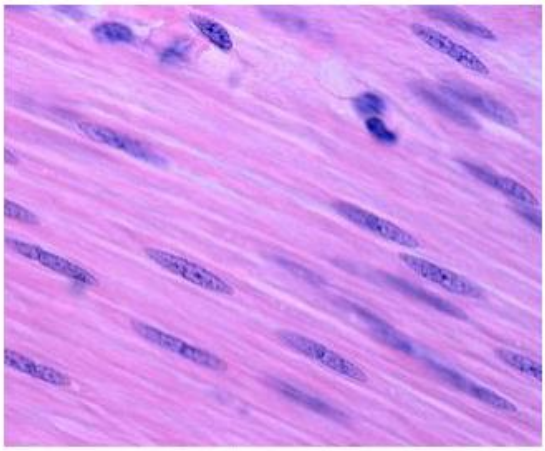
Contraction of smooth muscle is not under voluntary control, but is regulated by autonomic nerves, certain hormones, and local physiological conditions such as the degree of stretch.

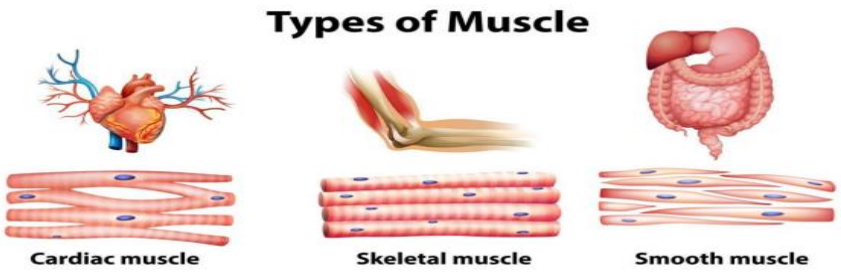
Smooth muscle forms a prominent component of hollow tubular organs of gastrointestinal, respiratory, and urogenital systems. It occurs in the walls of all but the smallest blood vessels. Small groups of smooth-muscle fibers are found but the

smallest blood vessels. Small groups 0f Smooth-muscle fibers are found in the skin, notably associated with hair follicles.

The nerve supply of smooth muscle in such regions as the intestines is rather sparse. Not every muscle cell receives a nerve ending. Integration of one cell with another appears to be effected through the gap junctions. The smooth muscle cells of blood vessels have simple nerve endings that are more numerous than in most other organs.







Review questions

In each of the following, select the best one answer:

1.

2.

3.

4.

5. The smallest cell in blood is:

a. Red blood cell

b. Monocyte

c. Platelet

d. Lymphocyte