Connective tissue

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Connective tissues

- Connective tissue is the most abundant and widely distributed tissue in the body .

- While some connective tissues are specialized (bone , blood), all organs have some amount of connective tissue in them which hold their parenchyma together

Characteristics of connective tissue

- More matrix than cells
- Derived from mesoderm in embryo – mesenchyme and mucous connective tissue
- Vascularized
- Can replicate (healing and repair)
- Is not present on free surfaces or body cavities
- innervated

Functions of connective tissues

- Enclosing and separating organs
- Connecting tissues to one another (ligaments and tendons)
- Supporting and moving (Joints and cartilage)
- Storing (adipose tissue and bones)
- Cushioning and insulating (adipose tissues)
- Transport and protection (blood)
- Protection (cranium and sternum)

Components of connective tissue

- Connective tissues differ widely but still made up of three fundamental components
  - Cells
  - Protein fibers
  - Ground substance

- Protein fibers and ground substance are collectively called as extracellular matrix.

- The composition and structure of extracellular matrix determine function and characteristic of connective tissue

Cells of connective tissues

- There are *specialized cells in connective tissue which form and maintain extracellular matrix*. They may be Immature cell with name ending in - **blast.** These cells can reproduce and form the matrix. May be Mature cell names end in -**cyte**. These cells have a reduced ability to divide and maintain matrix. May be for remodeling of matrix , names end in **clasts**.

- The cells of connective tissue can be grouped into:
  - **Fixed cells** - appear in tissues in stable numbers
  - **Wandering cells** - found in tissues only in response to infection or injury

Fibroblasts:

- large, flat cells with branching processes present in all the general connective tissues
- usually are the most numerous.
- Fibroblasts migrate through the connective tissues, secreting the fibers and certain components of the ground substance of the extracellular matrix.

Macrophages

- develop from monocytes
- have an irregular shape with short branching projections and are capable of engulfing bacteria and cellular debris by phagocytosis.
- *Fixed macrophages* reside in a particular tissue; examples include alveolar macrophages in the lungs or splenic macrophages in the spleen.
- *Wandering macrophages* have the ability to move throughout the tissue and gather at sites of infection or inflammation to carry on phagocytosis.

Plasma cells

- small cells that develop from B lymphocyte.
- Plasma cells secrete antibodies, proteins that attack or neutralize foreign substances in the body.
- Although they are found in many places in the body, most plasma cells reside in connective tissues, especially in the gastrointestinal and respiratory tracts.
- They are also abundant in the salivary glands, lymph nodes, spleen, and red bone marrow.

Mast cells

- abundant alongside the blood vessels that supply connective tissue.
- produce histamine, which dilates small blood vessels as part of the inflammatory response.

- Cells specific to a particular type of connective tissue:
  - **Adipocytes** - store triglycerides. Insulate and cushion
  - **Osteocytes (osteoblasts)** - bone
  - **Chondrocytes (chondroblasts)** - Cartilage
  - **leukocytes and erythrocytes -** blood

Extracellular Matrix of connective tissue

GROUND SUBSTANCE

- component of a connective tissue between the cells and fibers.
- The ground substance may be viscous (as in blood), semisolid (as in cartilage), or solid (as in bone).
- supports cells, binds them together, stores water, and provides a medium for exchange of substances between the blood and cells.
- plays an active role in how tissues develop, migrate, proliferate, and change shape.

- It primarily consists of protein and carbohydrate molecules and variable amounts of water.

- The protein and carbohydrates are mainly present in form of proteoglycans and glycoproteins.

  - Proteoglycan = Protein core + glycosaminglycan
  - Glycoprotein= Protein + oligosaccharide

- Also present in the ground substance are adhesion proteins , which are responsible for linking components of the ground substance to one another and to the surfaces of cells. E.g. fibronectin which bind collagen fiber and ground substance together

Protein fibers

Three types of protein fibers

1: **Collagen fibers**

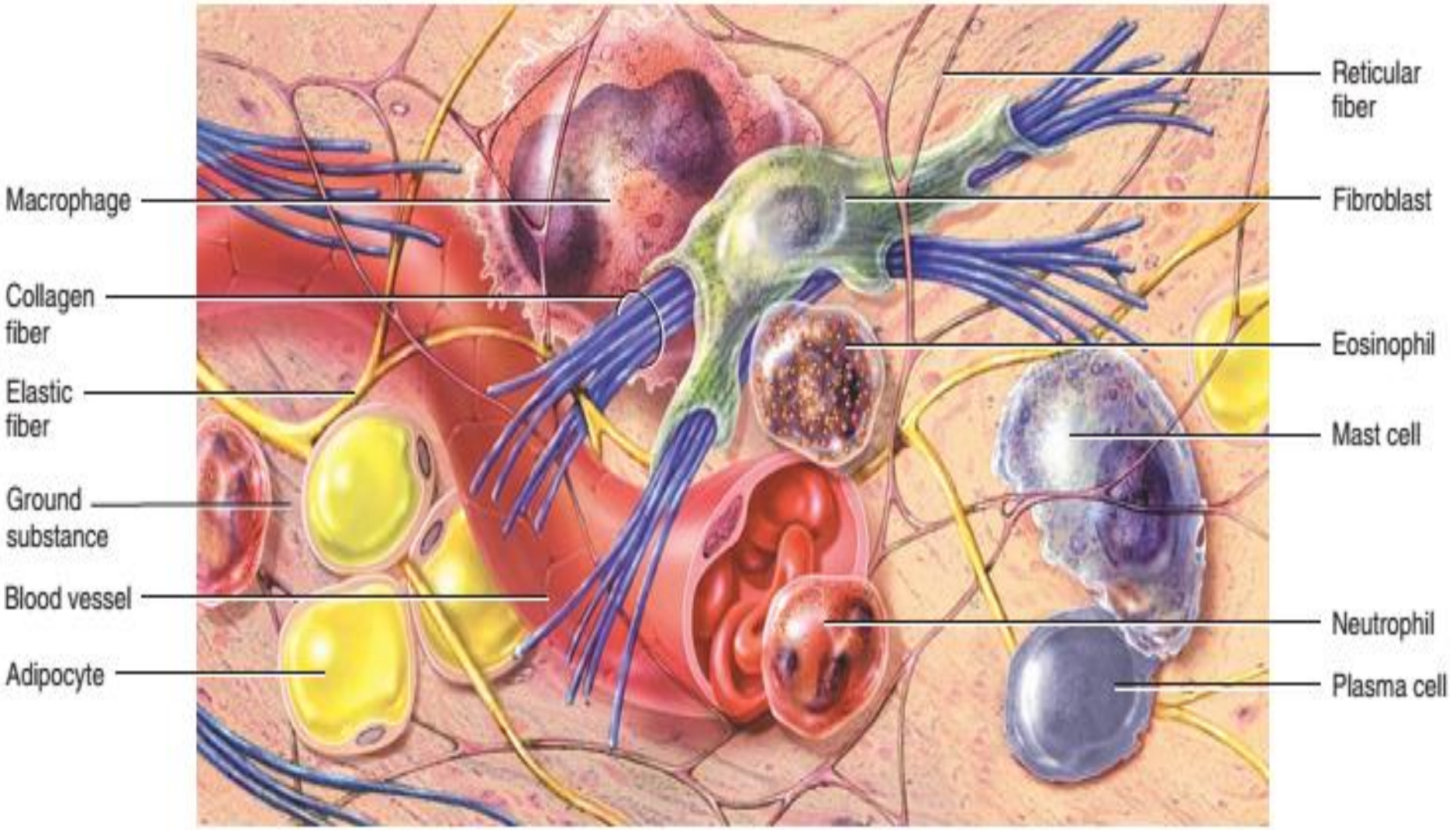
- made up of collagen.
- Collagen fibers are tough and only slightly elastic.
- They often occur in bundles with the fibers parallel to one another, which gives great tensile strength.
- Make different association in different tissues., as in cartilage molecular arrangement allows it to draw more water as compared to bone.
- Collagen is found in most connective tissues, esp. bone, tendons, and ligaments.

2: Elastic fibers

- are composed of a protein called elastin and glycoprotein framework called fibrilin.
- They are very stretchy and branch and join to form a network.
- Can stretch upto 150 times its relaxed size
- They provide strength to tissues, but allows the tissue to be flexible and stretchy. They are found in skin, blood vessels, and lungs

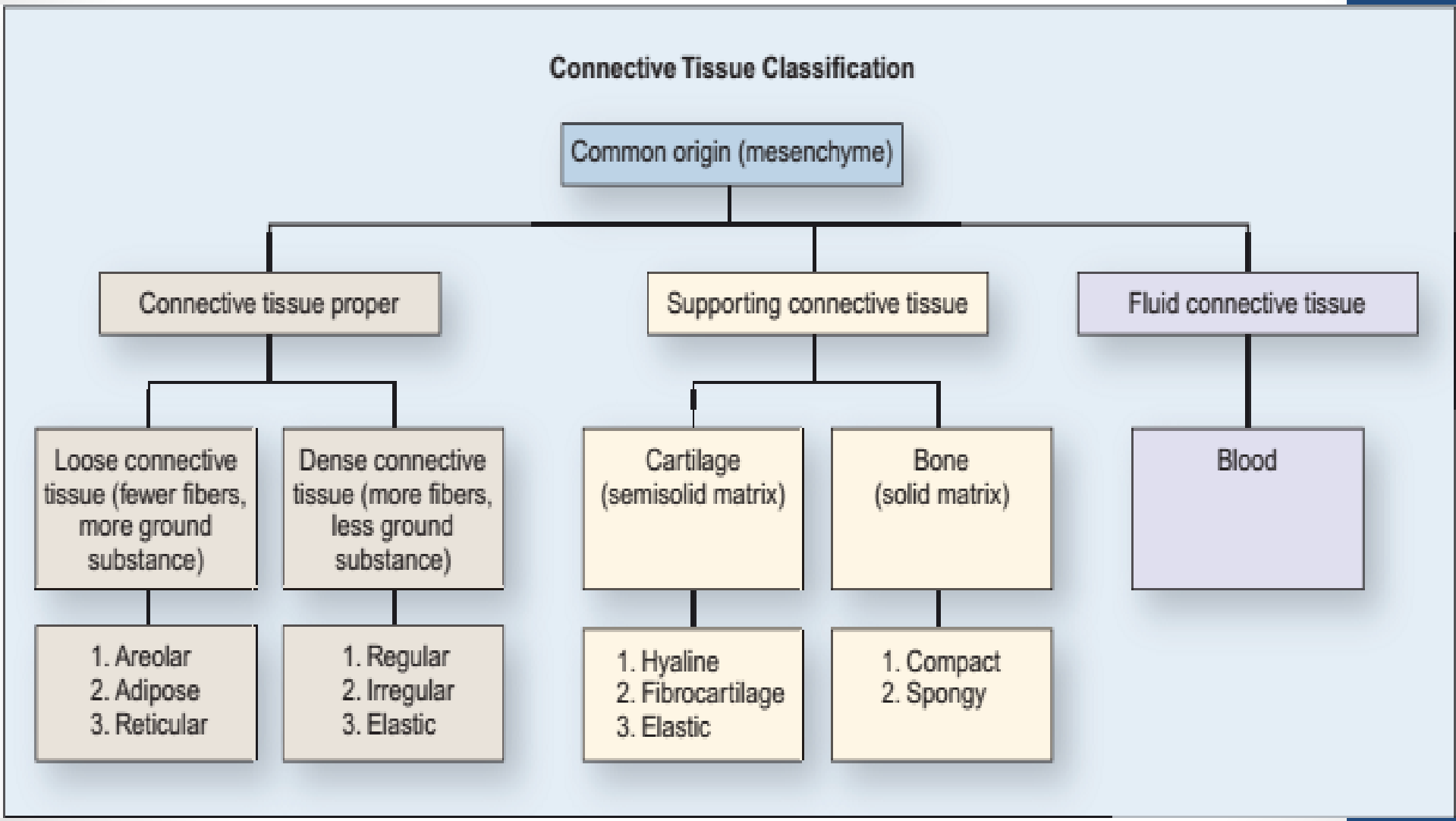
3: Reticular fibers.

- Made up of collagen but are thinner as compared to collagen fibers and are arranged in branching network (not in parallel rows as are collagen fibers) .
- They form a spongelike framework , stroma, for such organs as the spleen and lymph nodes
- Also present in blood vessels, nervous tissue, muscles and adipose tissue where it provide support


Reticular fiber
Macrophage
Fibroblast
Collagen fiber
Eosinophil
Elastic fiber
Mast cell
Ground substance
Blood vessel
Neutrophil
Adipocyte
Plasma cell

Individual with Marfan syndrome.

Classification of connective tissue



Connective tissue proper

- Connective tissue proper includes those types of connective tissues that exhibit a variable mixture of both connective tissue cell types and extracellular protein fibers suspended within a viscous ground substance.
- It generally has higher protein fiber content
- These connective tissue types differ with respect to their numbers and types of cells and the relative properties and proportions of their fibers and ground substance.
- Its main function is to bind cells and tissues into organ and organ system.

Supporting connective tissue

- The supporting connective tissue have a strong and durable framework that protects and supports the soft body tissues.
- The extracellular matrix in supporting connective tissue contains many protein fibers and a ground substance that ranges from semisolid to solid.
- Bones and cartilage are supporting connective tissue. The cartilage has a semisolid extracellular matrix, while bone has a solid extracellular matrix.

Fluid connective proper

- Fluid connective tissue contain cell and cell fragments, dissolved protein fibers and watery ground substance.
- Blood is fluid connective tissue

Connective tissue proper

Loose connective tissue

- Distributed throughout the body as a binding and packing material
- The protein fibers in loose connective tissue are loosely arranged rather than tightly packed together.
- Contains relatively fewer cells and protein fibers than dense connective tissue but has more ground substance.
- The cells of loose connective tissue are predominantly fibroblasts, with collagenous and elastic fibers dispersed throughout the ground substance
- Occupies the spaces between and around organs.
- It binds the skin to the underlying muscles and is highly vascular, providing nutrients to the skin. Loose connective tissue that binds skin to underlying muscles is known as fascia .

- It also surrounds blood vessels and nerves, where it provides both protection and nourishment.

- The irregular arrangement of this tissue provides flexibility, yet strength, in any direction

- There are three types of loose connective tissue:
  - areolar connective tissue
  - adipose connective tissue
  - reticular connective tissue

Areolar connective tissue

- Areolar connective tissue is highly variable in appearance and the least specialized connective tissue in the body .
- It has a loosely organized array of collagen and elastic fibers and an abundant distribution of blood vessels.
- consists of
  - fibers (collagen, elastic, reticular) arranged randomly
  - several kinds of cells (fibroblasts, macrophages, plasma cells, adipocytes, mast cells, and a few white blood cells)
  - semifluid ground substance (hyaluronic acid, chondroitin sulfate, dermatan sulfate, and keratan sulfate).

- The fluidity of ground substance and loose arrangement of fibers facilitate tissue protection by accommodating the stress in its loose structure.
- The elastic fibers ensure independent movement.
- Present everywhere in body including subcutaneous layer deep to skin, superficial region of dermis of skin, mucous membranes, around blood vessels, nerves, and body organs.
- Its functions are strength, elasticity, support.

Adipose connective tissue

- Made up of adipocytes that are specialized for storage of triglycerides (fats) as a large, centrally located droplet.
- Cell fills up with a single, large triglyceride droplet, and cytoplasm and nucleus are pushed to periphery of cell. With weight gain, amount of adipose tissue increases.

- It has two types: White adipose tissue which is present in adults and has less blood supply and Brown adipose tissue present in infants and have extensive blood supply.

- Function: Reduces heat loss through skin, serves as an energy reserve, supports and protects organs. In newborns, BAT generates heat to maintain proper body temperature.

- Present throughout the body; abdominopelvic cavity, around kidney, subcutaneous tissue.

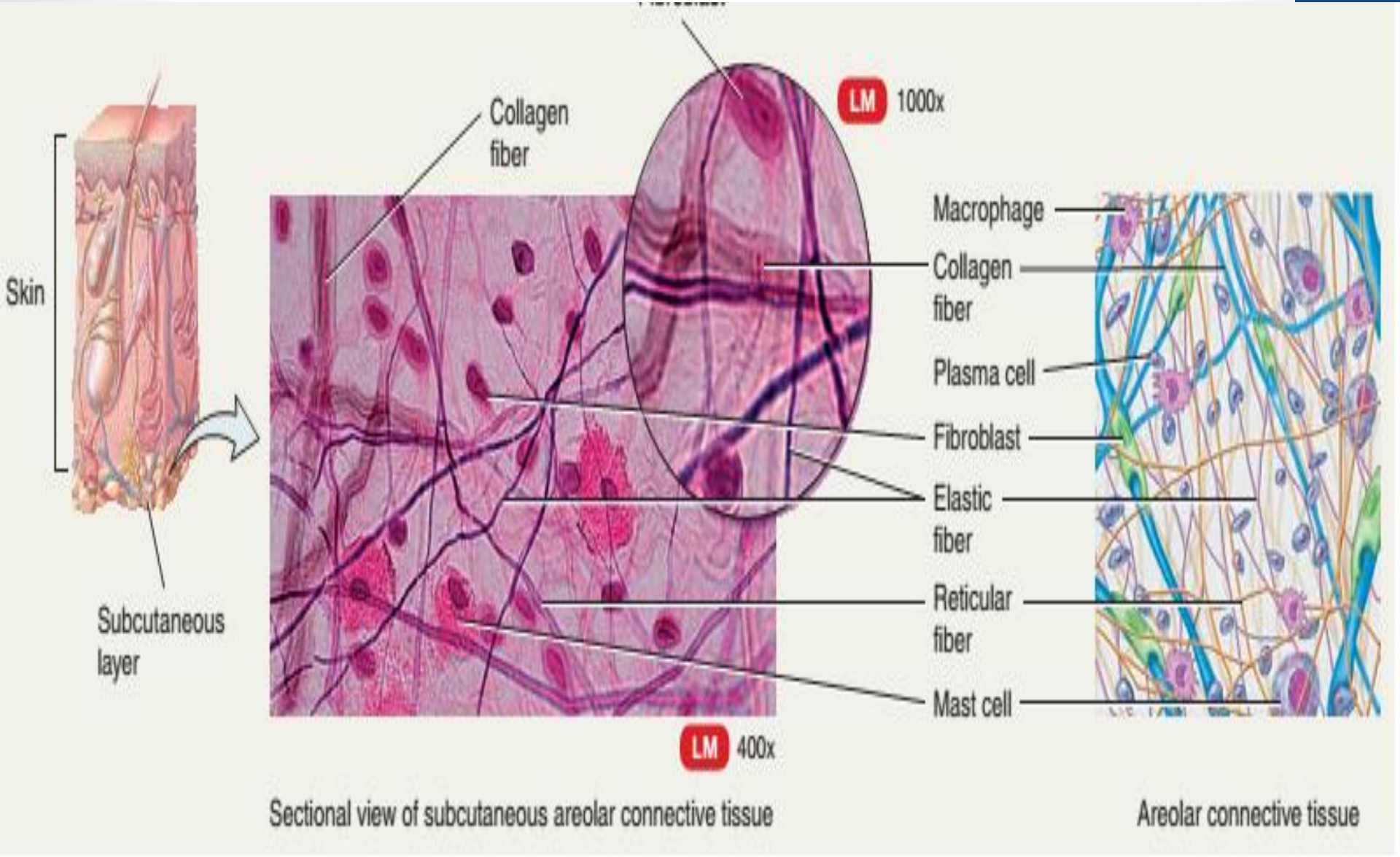
Reticular connective tissue

- Reticular connective tissue contains a meshwork of reticular fibers, on which fibroblast and leukocytes are suspended.

- Has very little ground substance.

- Mainly present in hematopoietic system; spleen, lymph nodes, bonemarrow

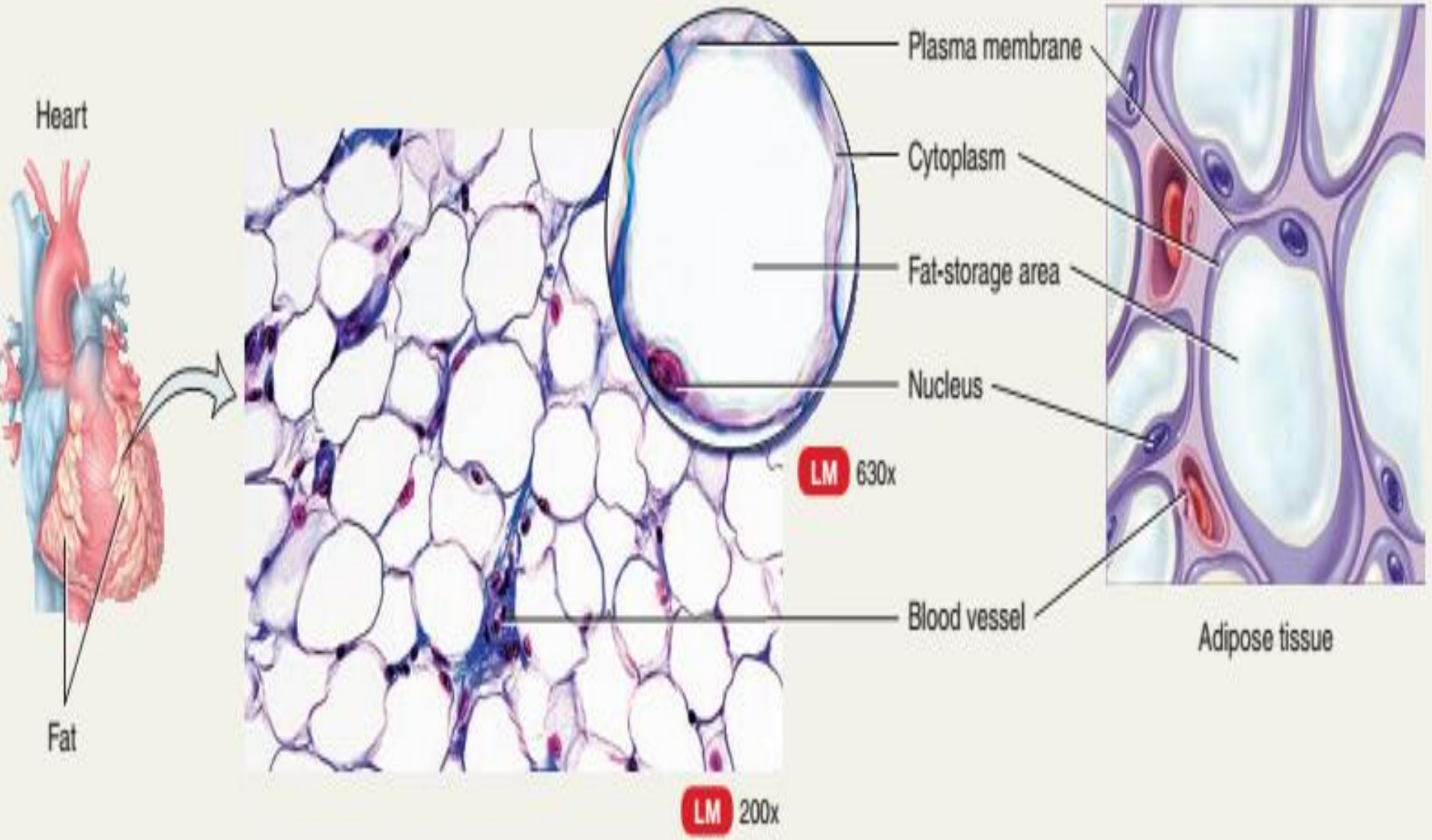
- Functions: Forms stroma of organs, filters and removes worn-out blood cells in spleen and microbes in lymph nodes



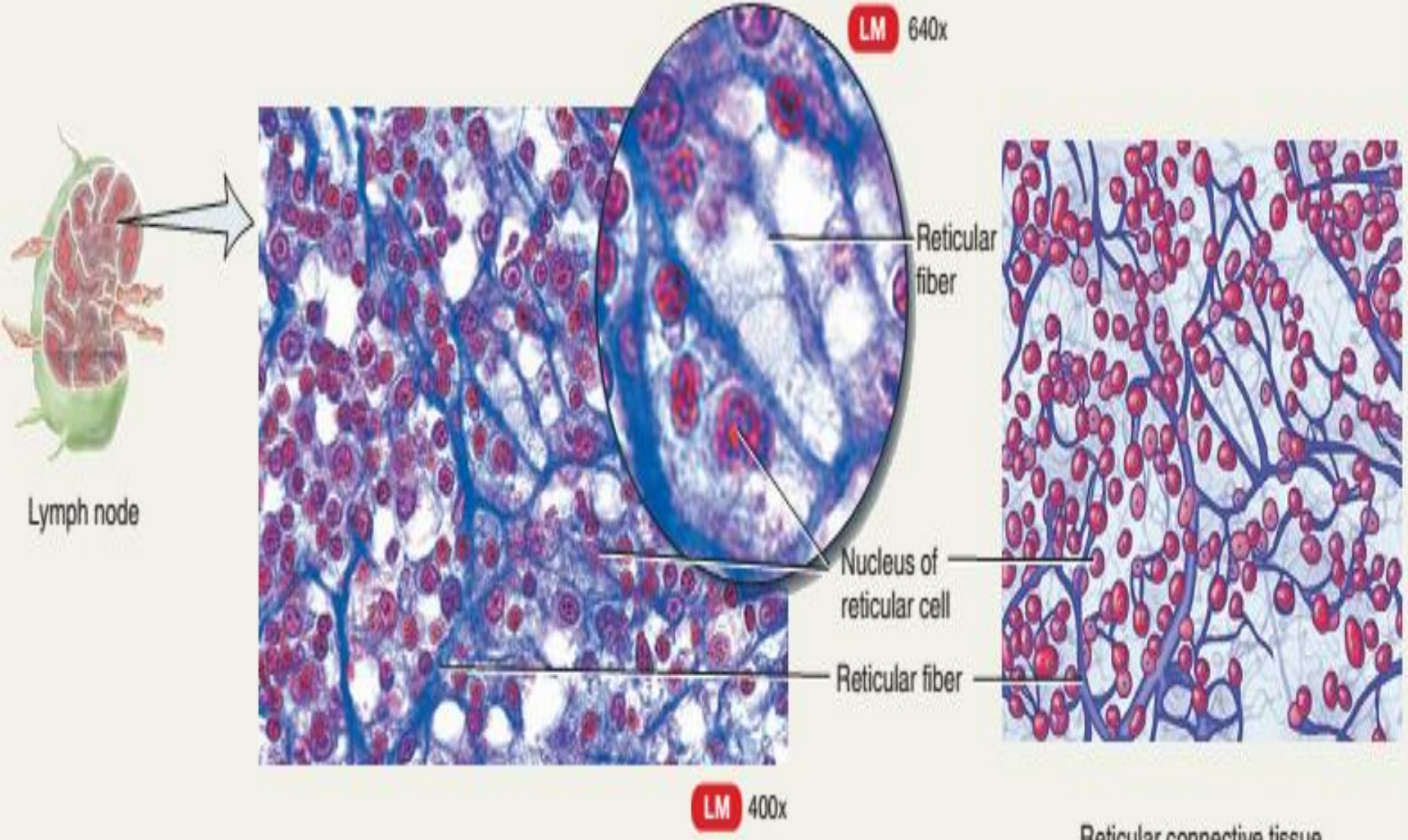
Sectional view of subcutaneous areolar connective tissue

Areolar connective tissue

body temperature.



Sectional view of adipose tissue showing adipocytes of white fat and details of an adipocyte

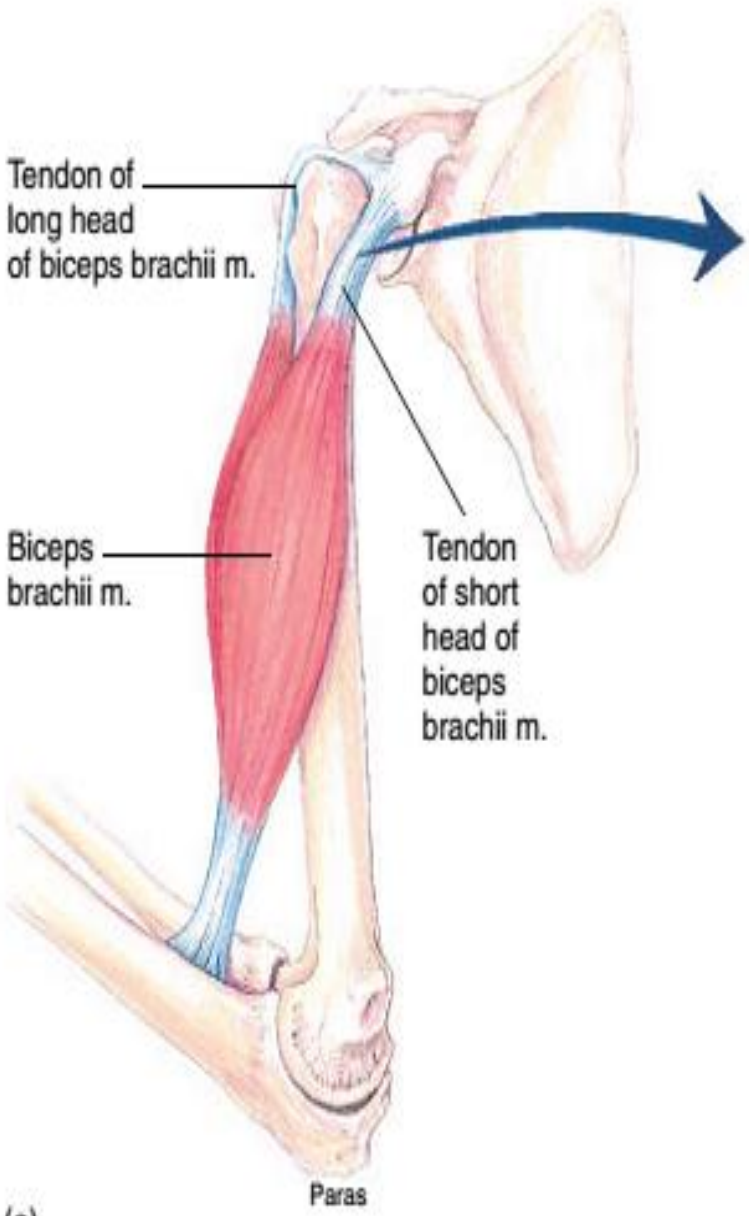

LM 640x
Reticular fiber
Nucleus of reticular cell
Reticular fiber
LM 400x
Lymph node
Sectional view of reticular connective tissue of a lymph node
Reticular connective tissue

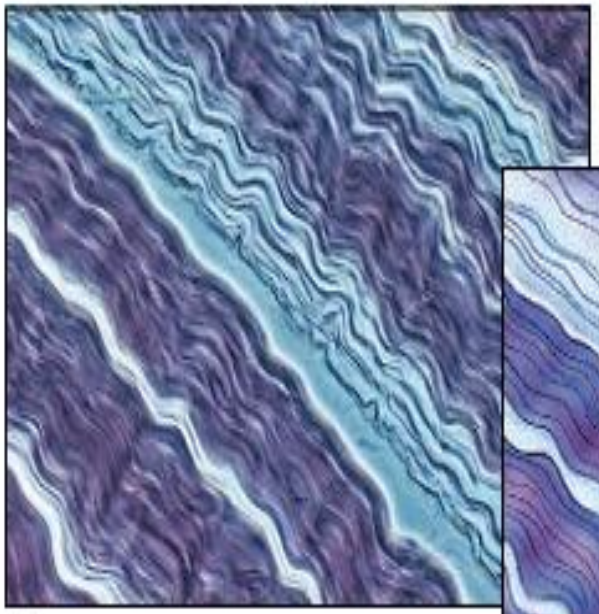
Dense connective tissue

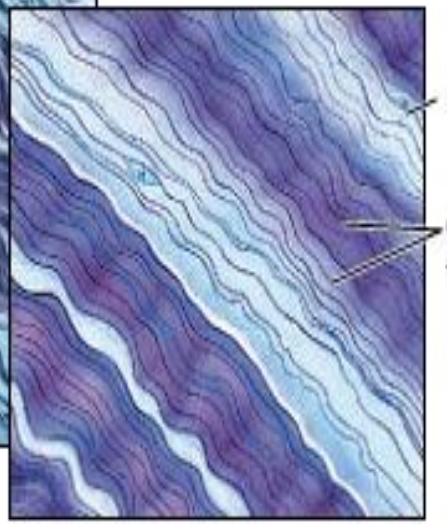
- Dense connective tissue consists of densely packed fibers with relatively little space between the fibers.
- Has proportionately high protein fiber than ground substance.
- Also called collagenous connective tissue because of abundance of collagen fibers.
- Further divided into three categories.
  - Dense regular connective tissue
  - Dense irregular connective tissue
  - Elastic connective tissue.

Dense regular connective tissue

- Has densely packed collagen fibers in the extracellular matrix that are oriented predominantly in one direction which resist stretching and give strength in direction of orientation
- Has silvery white appearance and sometimes called white fibrous connective tissue.
- Dense regular connective tissue occurs where strong, flexible support is needed
- Has few blood vessels which is reason behind its slow healing properties.
- Make structures such as tendons, which connect muscles to bones , and most ligaments, which connect bones to bones


Tendon of long head of biceps brachii m.
Biceps brachii m.
Tendon of short head of biceps brachii m.
Paras
(a)


(b)


Fibroblast
Collagenous fibers
(c)

Dense Irregular connective tissue

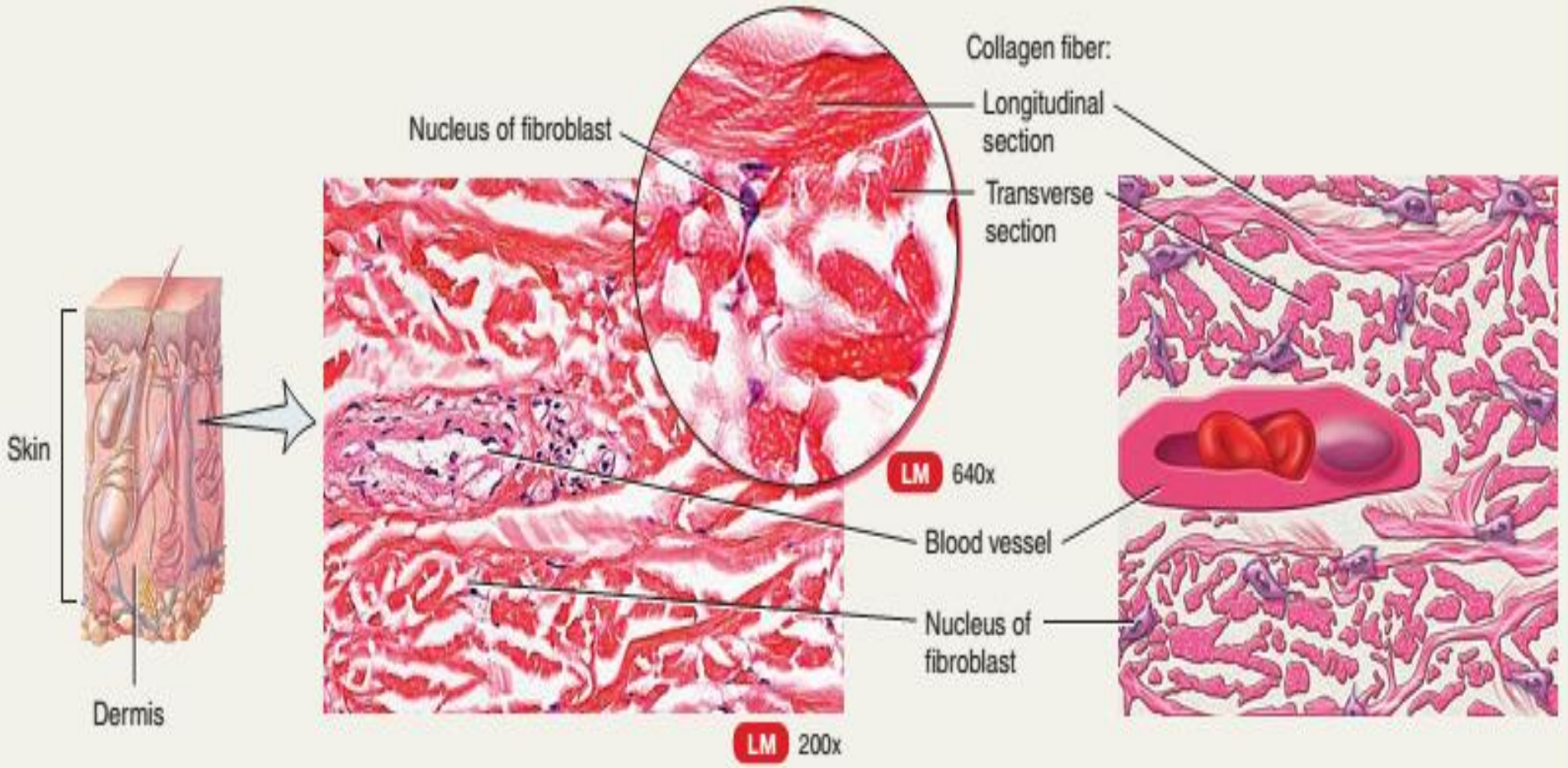
- Dense irregular connective tissue is characterized by large amounts of densely packed collagenous fibers that extend in all directions and are interwoven to provide tensile strength in any direction

- bundles of collagen fibers appear in clumps throughout the tissue, rather than arranged in parallel as seen in dense regular

- The components of dense irregular c.t are same as that of dense regular c.t they differ in arrangement. The multidirectional interwoven framework of collagen fiber offer tensile strength in all directions

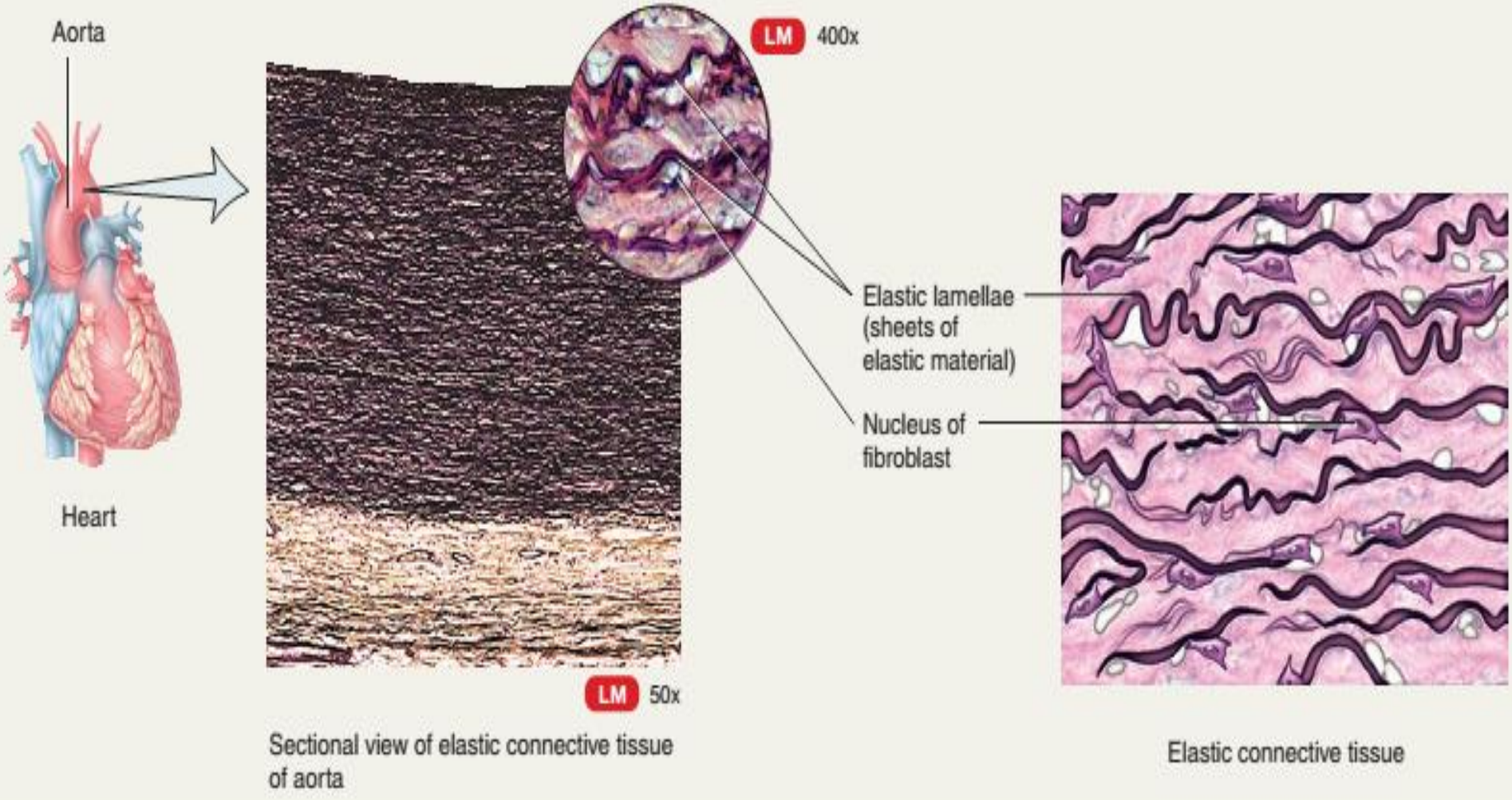
- found in the dermis of the skin and the submucosa of the GI tract.

- It also forms the fibrous capsules of organs and joints permits them to withstand applied forces from any direction.


Collagen fiber:
Longitudinal section
Transverse section
Nucleus of fibroblast
Skin
Dermis
LM 640x
Blood vessel
Nucleus of fibroblast
LM 200x
Sectional view of dense irregular connective tissue of reticular region of dermis
Dense irregular connective tissue

Elastic connective tissue

- Elastic connective tissue is composed primarily of elastic fibers and yellowish in color .
- They can be stretched to one and a half times their original lengths and will snap back to their former size.
- Has sparse ground substance. The elastic fiber is packed in parallel bundles (arrangement is more like dense regular connective tissue)
- Elastic connective tissue is found in the walls of large arteries, in the vocal cords, and in the trachea and bronchial tubes of the lungs.



Sectional view of elastic connective tissue of aorta

Elastic connective tissue

Supporting connective tissue

CARTILAGE

- Cartilage is strong and resilient among different connective tissue types, and it provides flexible support
- Cartilage can endure considerably more stress than loose and dense connective tissues.
- Made up of
  - Chondrocytes
  - Chondroitin sulfate + Proteoglycans
  - Collagen fibers + elastin fibers
- The chondrocytes are the mature cartilage cells that occupy small spaces in extracellular matrix called lacunae.
- The chondroitin sulfate with other substances of ground substance gives it flexibility and resilience.
- The collagen fibers give it strength.

- It does not have nerve and blood supply. Because of inefficient blood supply it heals slowly after trauma and injury.

- Cartilage is found in areas of the body that need support and must withstand deformation, such as the tip of the nose or the external part of the ear

- Most cartilage has a covering called perichondrium which is mainly made up of dense irregular connective tissue but also has cellular portion which contain chondroblasts.

- Cartilage makes most of the embryonic skeleton. It is gradually replaced by bones during embryonic development and after birth. It persist in growth plates of the bones and allows bone to increase in length.
- There are three types of cartilage:
  - Hyaline cartilage.
  - Fibrocartilage
  - Elastic cartilage

HYALINE CARTILAGE

- named for its clear, glassy microscopic appearance, which contains usually invisible fine collagen fibers
- Most abundant type of cartilage found in the body.

Structure

- Small collagen fibers are evenly dispersed in the matrix, making the matrix appear transparent; the chondrocytes are found in lacunae, within the firm but flexible matrix

Function

- Allows the growth of long bones
- provides rigidity with some flexibility in the trachea, bronchi, ribs, and nose;
- forms smooth and flexible articulating surfaces;
- forms the embryonic skeleton

Location

- Growing long bones, cartilage rings of the respiratory system, costal cartilage of ribs, nasal cartilages, articulating surface of bones, embryonic skeleton.

FIBROCARTILAGE

Structure

- Have collagen fibers similar to those in hyaline cartilage which are arranged in thick bundles
- Lack perichondrium

Function

- flexible and capable of withstanding considerable pressure (strongest of all cartilage)
- connects structures subjected to great pressure. Act as shock absorber

Location

- Intervertebral disks, symphysis pubis, articular disks (e.g., knee and temporomandibular joints)

ELASTIC CARTILAGE

Structure

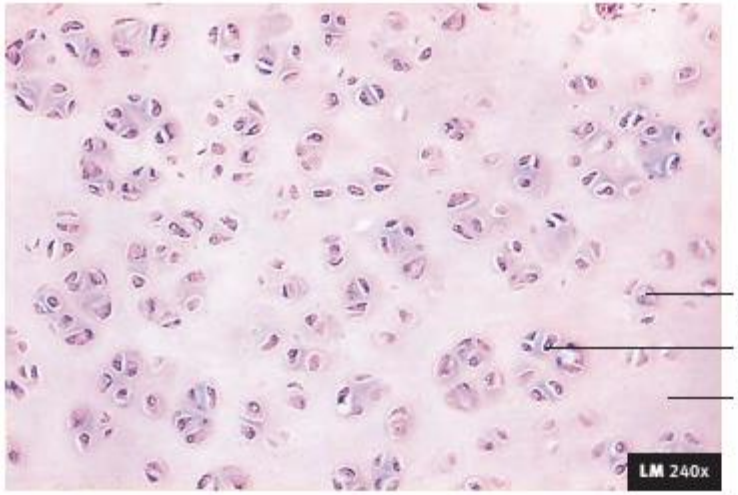
- Chrondrocytes embedded in extracellular matrix which contain elastic fibers
- Perichondrium is present

Function

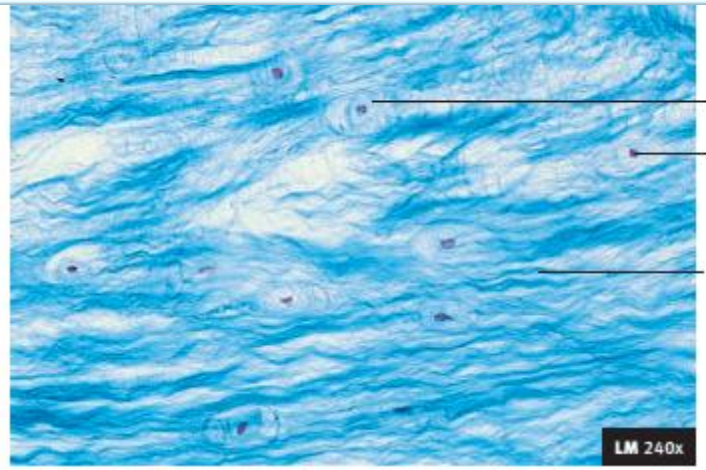
- Provides rigidity with even more flexibility than hyaline cartilage
- maintains shape of certain structures.

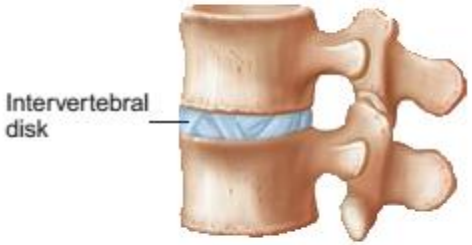
Location

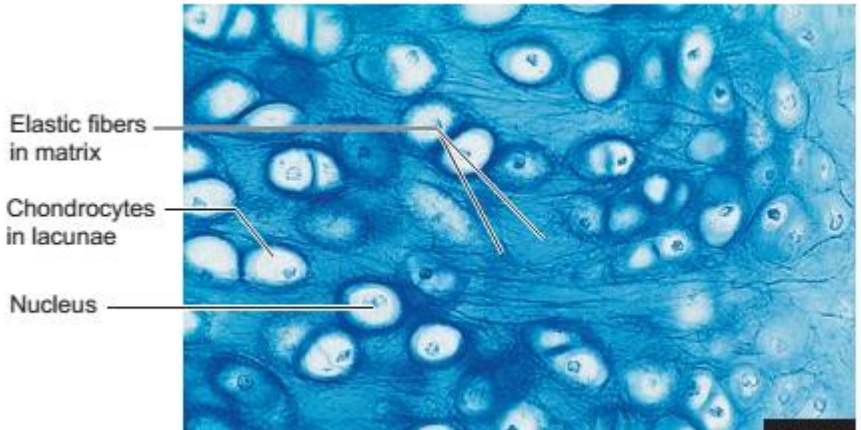
- External ears, epiglottis, auditory tubes


Chondrocyte in a lacuna
Nucleus
Matrix
LM 240x


Bone
Hyaline cartilage


Chondrocyte in lacuna
Nucleus
Collagen fibers in matrix
LM 240x


Intervertebral disk


Elastic fibers in matrix
Chondrocytes in lacunae
Nucleus

BONE

- Bone is a hard connective tissue that consists of living cells and a mineralized matrix.
- The strength and rigidity of the mineralized matrix enable bones to support and protect other tissues and organs of the body.
- Four types of cells are present in bones: osteogenic , osteoblasts, osteocytes, osteoclasts.
- The matrix of bone has organic and inorganic component .
- The organic portion (collagen fibers and different protein-carbohydrate molecules), makes about one-third of the dry weight of bone.
- The inorganic portion make up two- third of its dry weight. It is a mixture of calcium and phosphorus. (hydroxyapatite).

- The organic portion of the matrix imparts tensile strength while the inorganic portion imparts compressional strength.

- All bones (except surfaces of joints of long bones) are covered by dense irregular connective tissue called periosteum. Periosteum serve as a site for attachment of ligaments and tendons.

- Bone has rich vascular supply and is site for active metabolic activity.

- Bone serves many functions including support, protection, storage (minerals, triglyceride), hemopoiesis

Classification:

- Based on porosity two types of bone connective tissue exists.
  - Compact bone
  - Spongy bone
- Both bones are found in all bones of the body.
- 80% is compact bone 20% is spongy in all skeleton system.

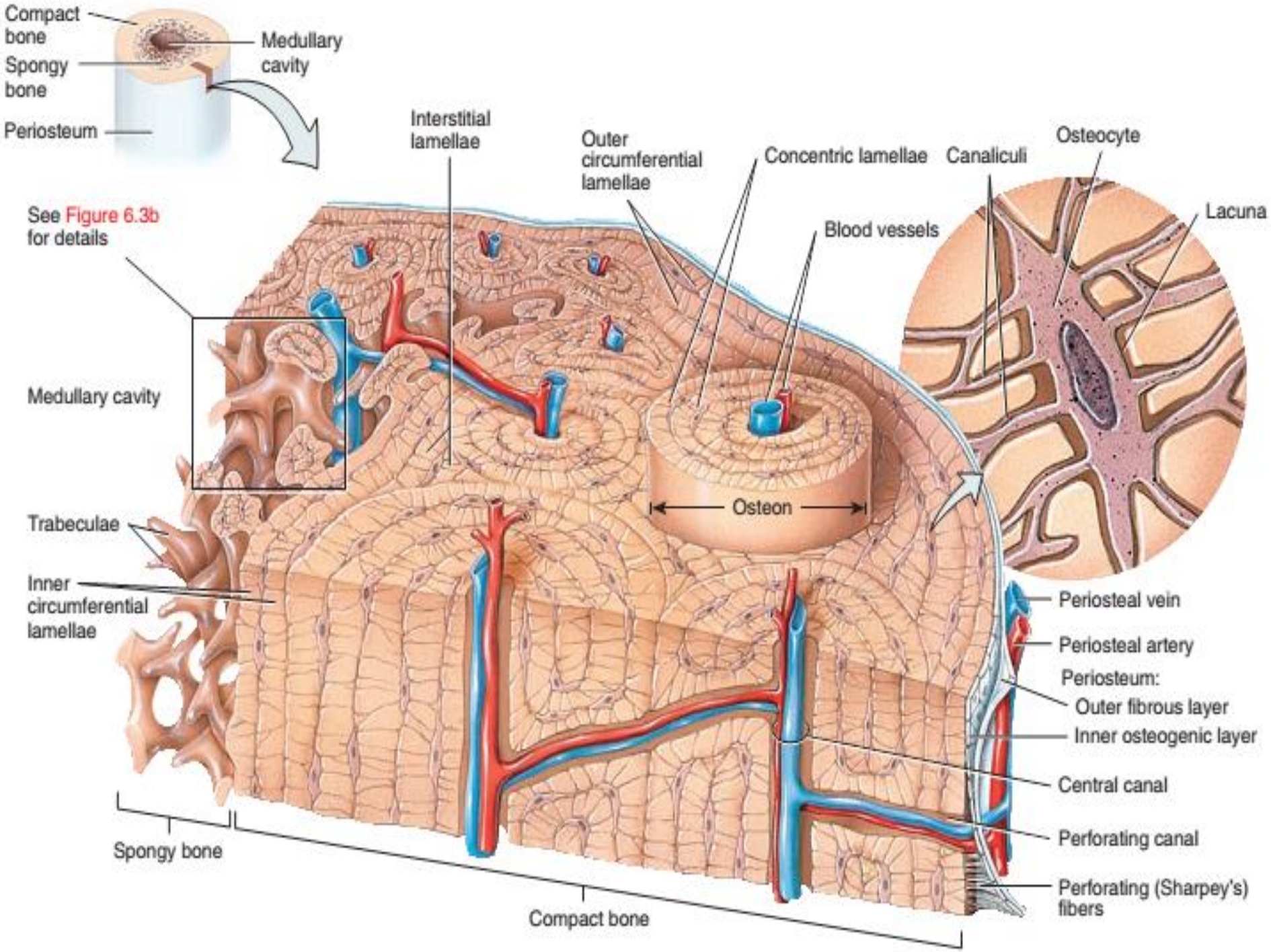
Compact bone

- Makes outer hard shell of the bone and has more matrix than spaces

- The basic unit of compact bone is an osteon or haversian system. Each osteon has four parts

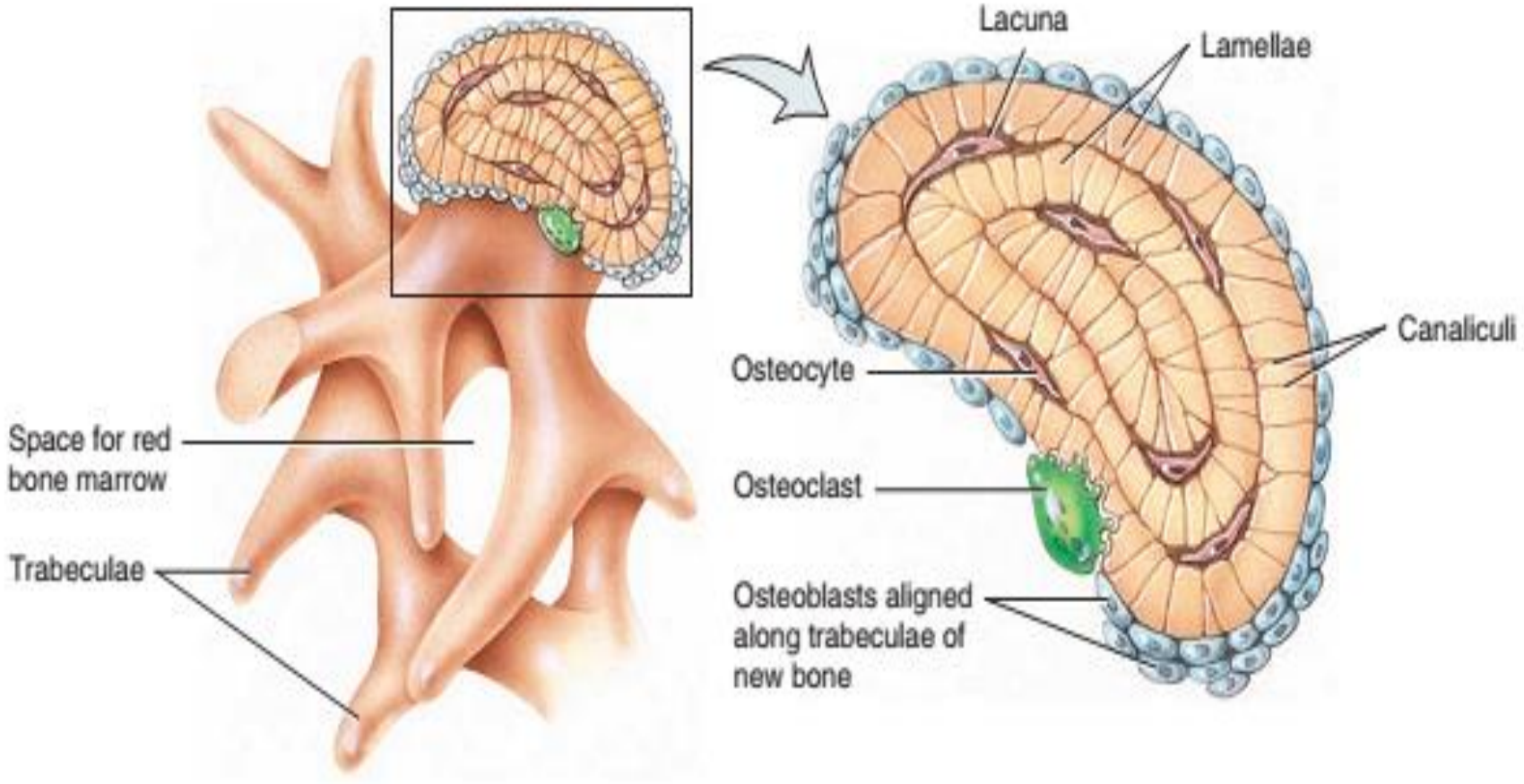
  - **The lamellae** ; concentric rings of extracellular matrix that consist of mineral salts (mostly calcium and phosphates). The lamellae are responsible for the compact nature of this type of bone tissue.
  - **Lacunae** ; small spaces between lamellae that contain mature bone cells called osteocytes.
  - **Canaliculi** : networks of minute canals that project from lacunae containing the processes of osteocytes. Canaliculi provide routes for nutrients to reach osteocytes and for wastes to leave them.
  - **A central (haversian) canal** contains blood vessels and nerves.

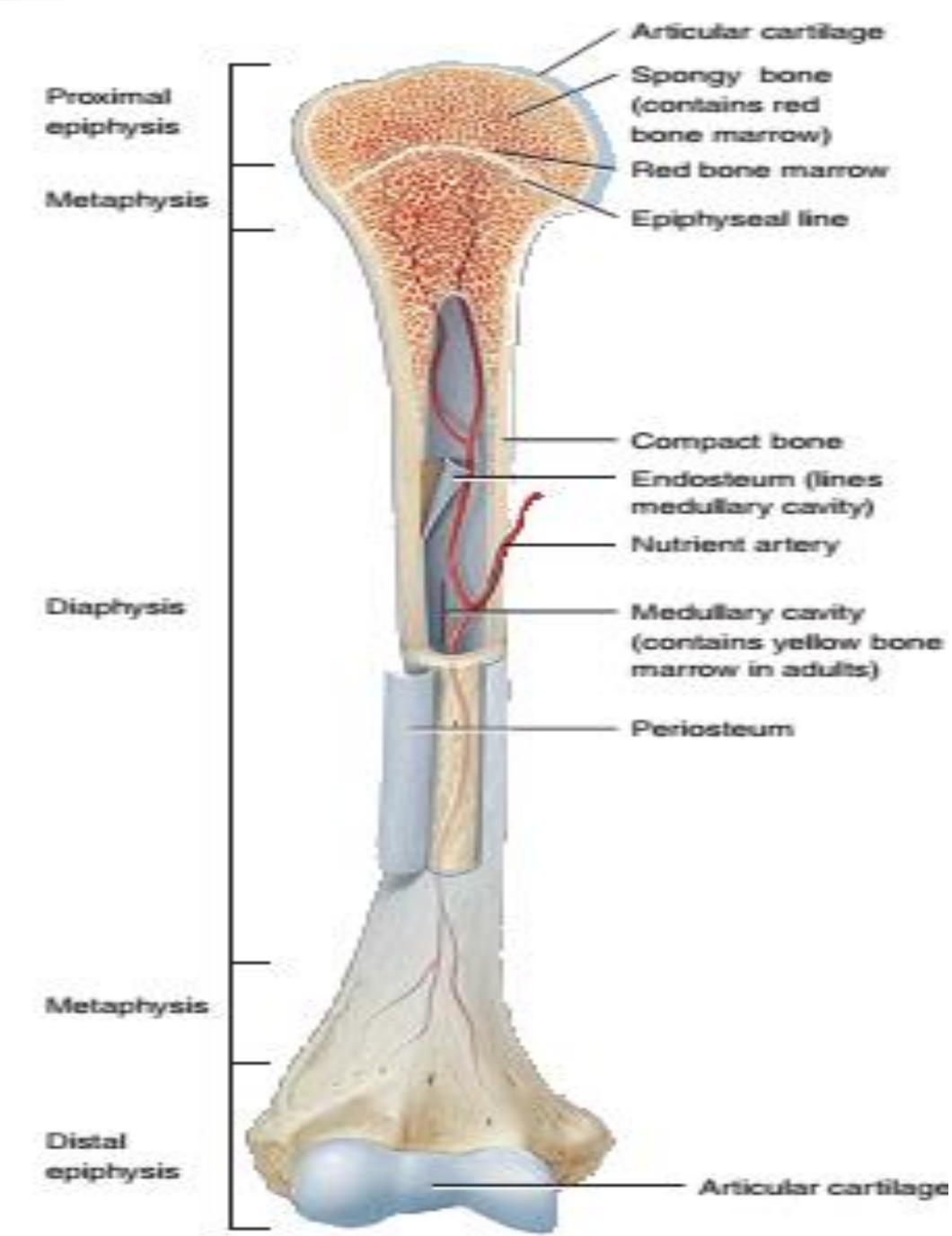
- The osteon runs parallel to the shaft of long bones


Compact bone
Spongy bone
Periosteum
Medullary cavity
Interstitial lamellae
Outer circumferential lamellae
Concentric lamellae
Canaliculi
Osteocyte
Lacuna
Blood vessels
See Figure 6.3b for details
Medullary cavity
Osteon
Trabeculae
Inner circumferential lamellae
Periosteal vein
Periosteal artery
Periosteum:
Outer fibrous layer
Inner osteogenic layer
Central canal
Perforating canal
Perforating (Sharpey's) fibers
Spongy bone
Compact bone

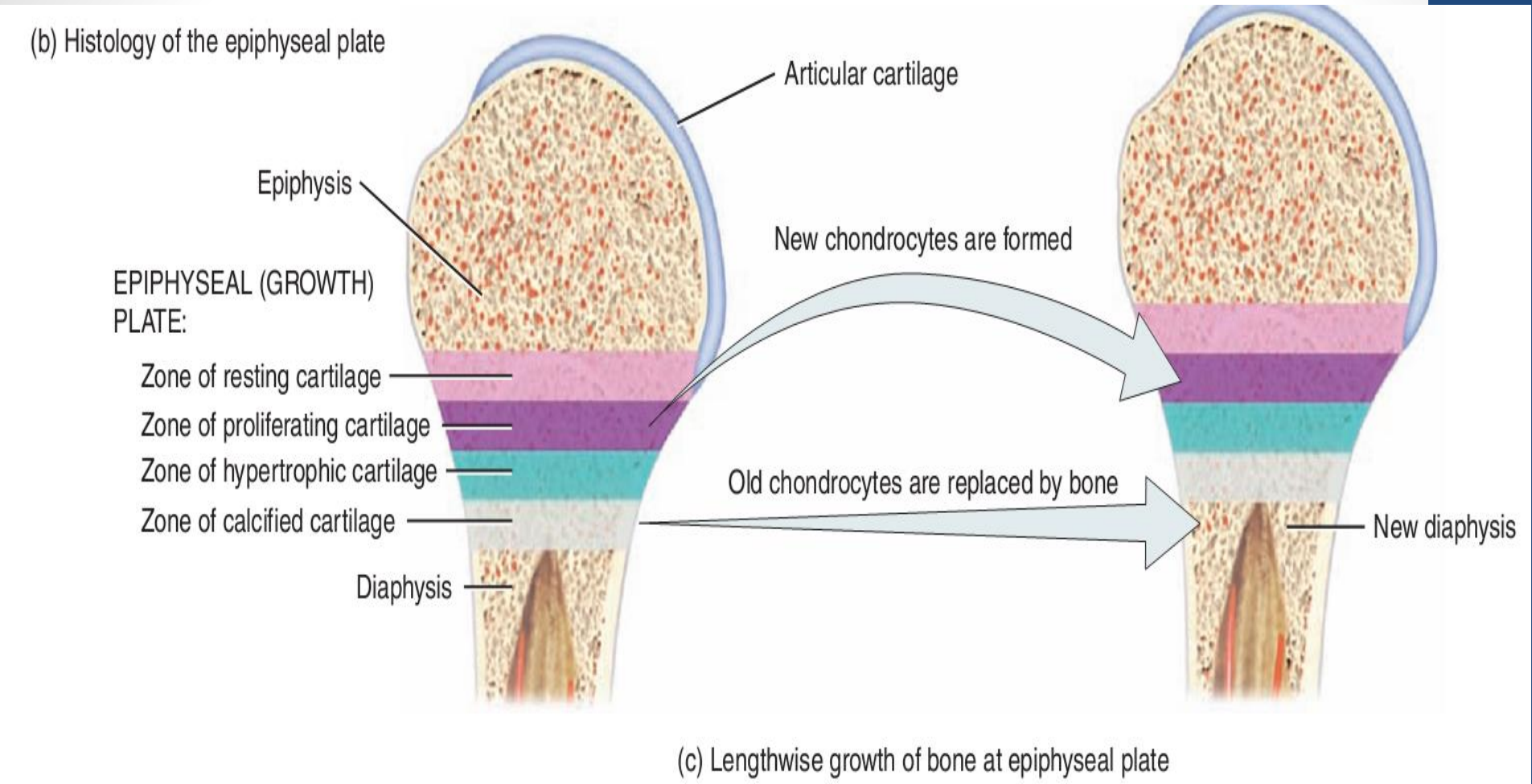
Spongy bone

- Located in the interior of the bone.
- Contain more space than matrix
- Instead of being completely solid, spongy bone contains spaces, and the bone connective tissue forms a latticework structure called trabeculae which contain lamellae, osteocytes, lacunae, and canaliculi.
- Spaces between trabeculae are filled with red bone marrow which is site for hemopoiesis
- Although lighter than compact bone, spongy bone is still designed for strength. Like braces used for support in buildings, the solid portions of spongy bone follow lines of stress


Lacuna
Lamellae
Canaliculi
Osteocyte
Osteoclast
Osteoblasts aligned along trabeculae of new bone
Space for red bone marrow
Trabeculae



(a) Partially sectioned humerus (arm bone)


(b) Histology of the epiphyseal plate
Articular cartilage
Epiphysis
EPIPHYSEAL (GROWTH) PLATE:
Zone of resting cartilage
Zone of proliferating cartilage
Zone of hypertrophic cartilage
Zone of calcified cartilage
Diaphysis
New chondrocytes are formed
Old chondrocytes are replaced by bone
New diaphysis
(c) Lengthwise growth of bone at epiphyseal plate

Classification of bones on basis of size

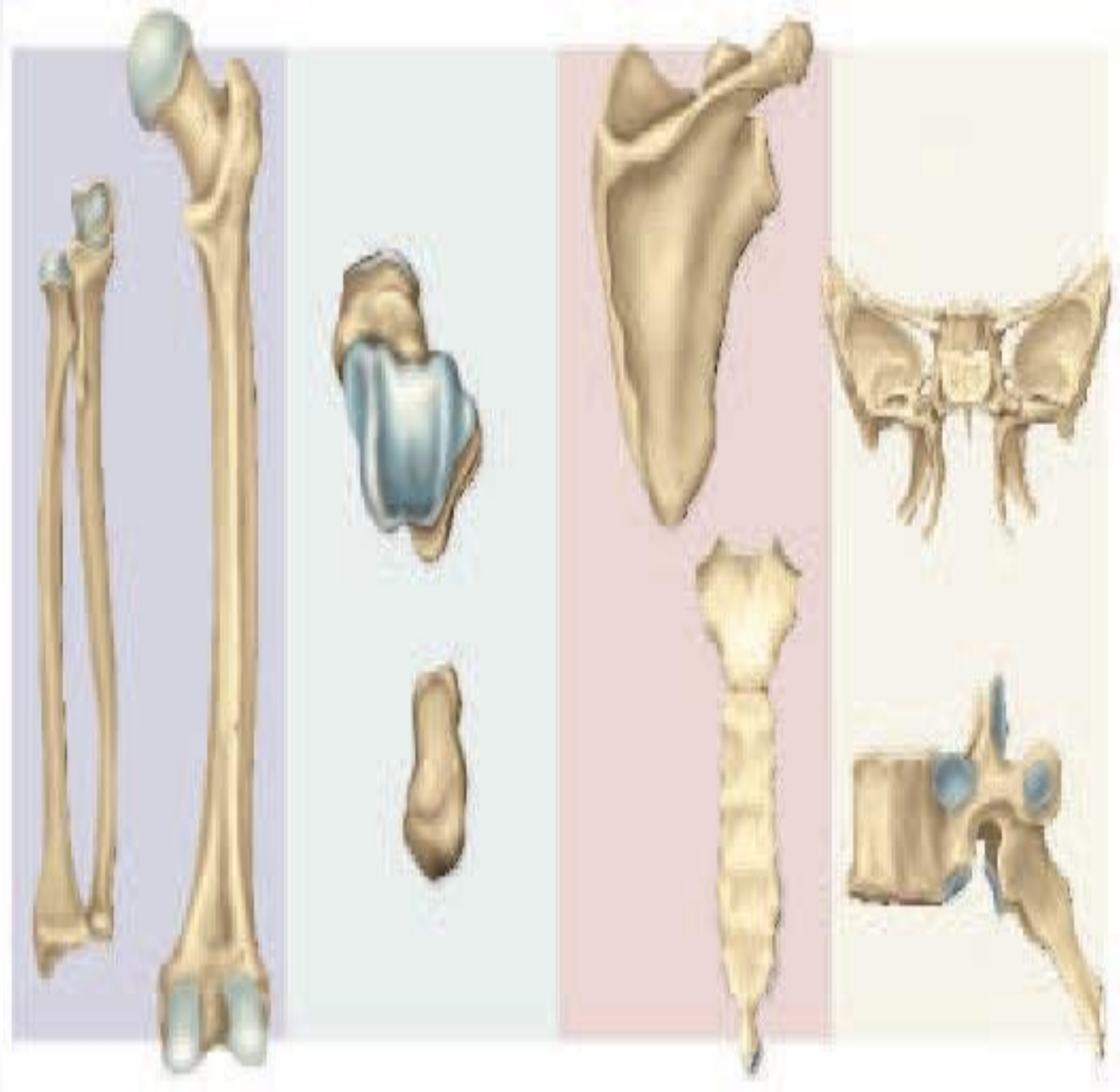
1: long bones,

2: Short bones,

3:Flat bones,

4: irregular bones.

- **Long bones are longer than wide.** Long bones include the humerus of the arm, the radius and ulna of the forearm,etc.
- **Short bones are more nearly equal in length and** width. They include the carpal (wrist) and tarsal (ankle) bones. They have limited motion and merely glide across one another.
- **Flat bones enclose and protect soft organs and** provide broad surfaces for muscle attachment. They include most cranial bones and the ribs, sternum.
- **Irregular bones have elaborate shapes that do not fit** into any of the preceding categories. They include the vertebrae.



Long Short Flat Irregular

Fluid connective tissue

Blood

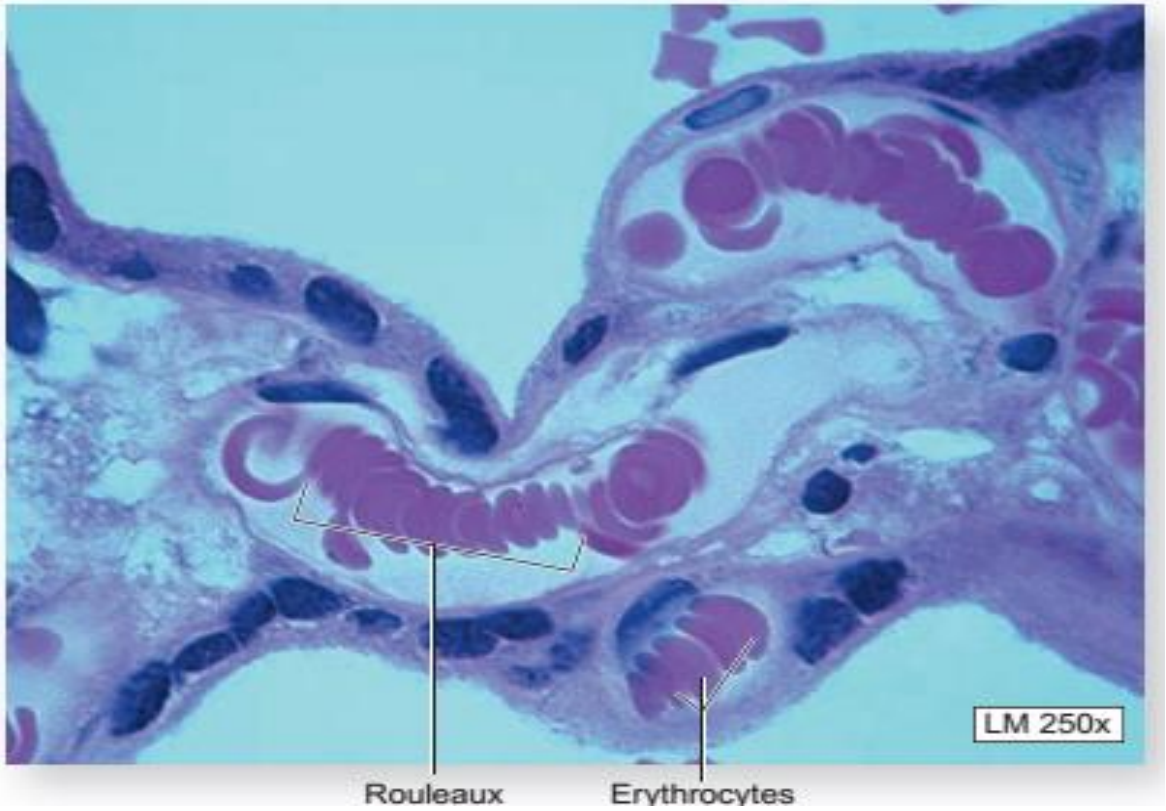
- Blood is a fluid connective tissue that travels through tubular vessels.
- Blood consists of cells and cell fragments collectively called formed elements. These formed elements are erythrocytes, leukocytes(white blood cells), and platelets.
- contains dissolved protein fibers in a watery ground substance. Together, the dissolved protein fibers and the watery ground substance form an extracellular matrix called plasma.
- The dissolved protein fibers are modified to become insoluble and form a clotting meshwork if a blood vessel or tissue becomes damaged.
- **Blood cells:** **RBC, WBC, PLATLETS.**
- **FIBERS** **e.g FIBRINOGENS.**
- **Ground substance.** **E.g Proteins.**

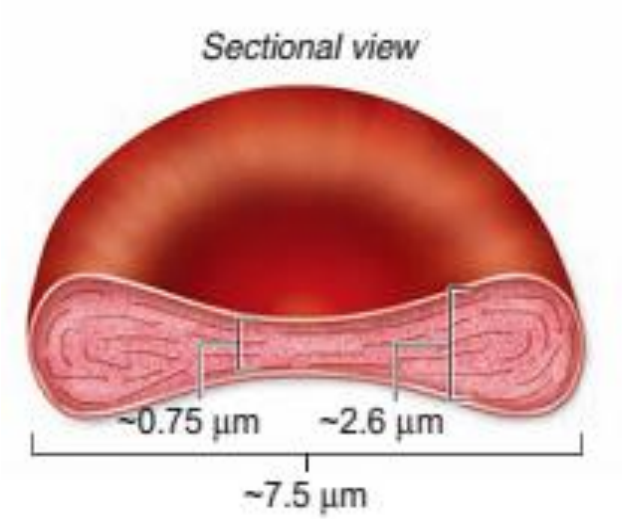
RBC

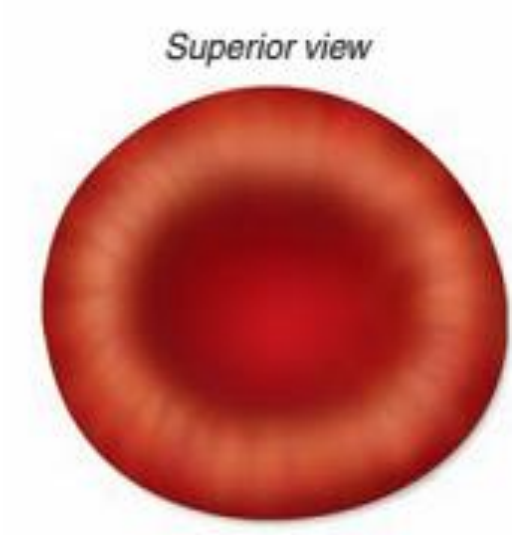
- **Erythrocytes** or red blood cells, are the most abundant formed elements.
- They have no nuclei.
- Produced in bone marrow.
- B.M Specialized reticular connective tissue
- RBCs are somewhat unusual as consist of plasma membrane but having no other organelles'.
- Largely composed of Hemoglobin. 4 globin chains, 2 alpha globin and 2 beta globin chains.
- **Shape:**

  Biconcave Discs.
- **Surface area:**

  5 L, 2000 times that of skin.


LM 250x
Rouleaux
Erythrocytes


Sectional view
~0.75 µm
~2.6 µm
~7.5 µm


Superior view

WBC (leukocytes)

- Leukocytes help initiate an immune response and defend the body against pathogens
- Leukocytes are larger than erythrocytes and have nuclei.
- Number ranges from 4500 to 11,000 per cubic millimeter of blood in adults
- Two types based on absence or presence of visible organelles called granules
- 1: Granulocytes.
- 2: Agranulocytes.

Granulocytes

- They named as granulocytes because their cytoplasm contains organelles (Granules) that appear as colored granules through the microscope. These are missing or relatively scanty in the agranulocytes.
- They are of three types

- Neutrophills
- Esinophills
- Basophills.

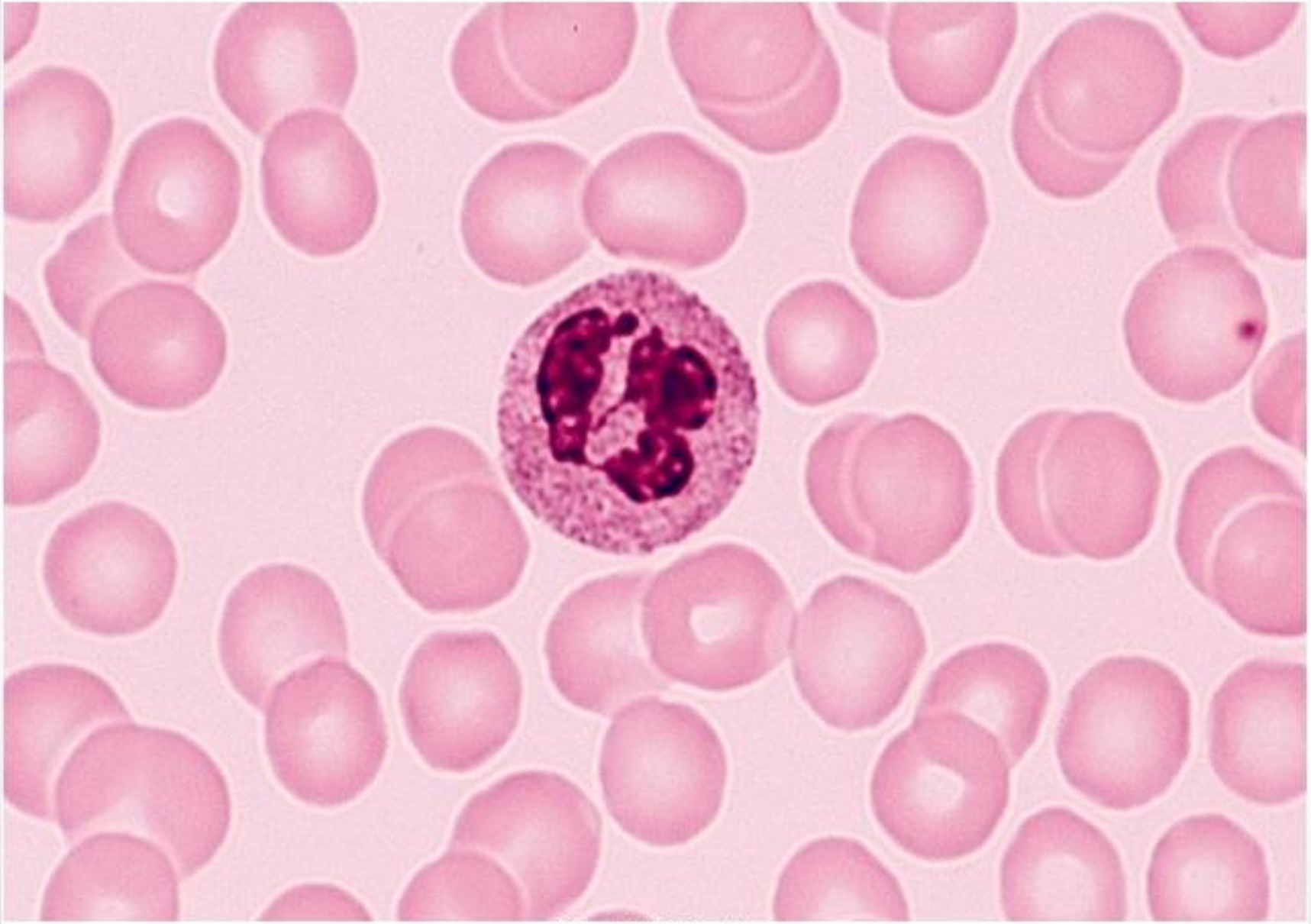
Neutrophills:

- Most numerous of all leukocytes
- Neutrophils are also called polymorphonuclear leukocytes (PMNs) because of their variety of nuclear shapes.
- Neutrophils have very fine cytoplasmic granules
- The nucleus is usually divided into three to five lobes, which are connected by strands of nucleoplasm so delicate that the cell may appear to have multiple nuclei.
- Neutrophils are 12-15 um in diameter.
- Cytoplasmic granules stain pink color.
- 54-62% of WBC.
- C or S shaped Nucleus.

Functions

- Phagocytosis of bacteria.
- Release of antimicrobial chemicals.

Neutrophil



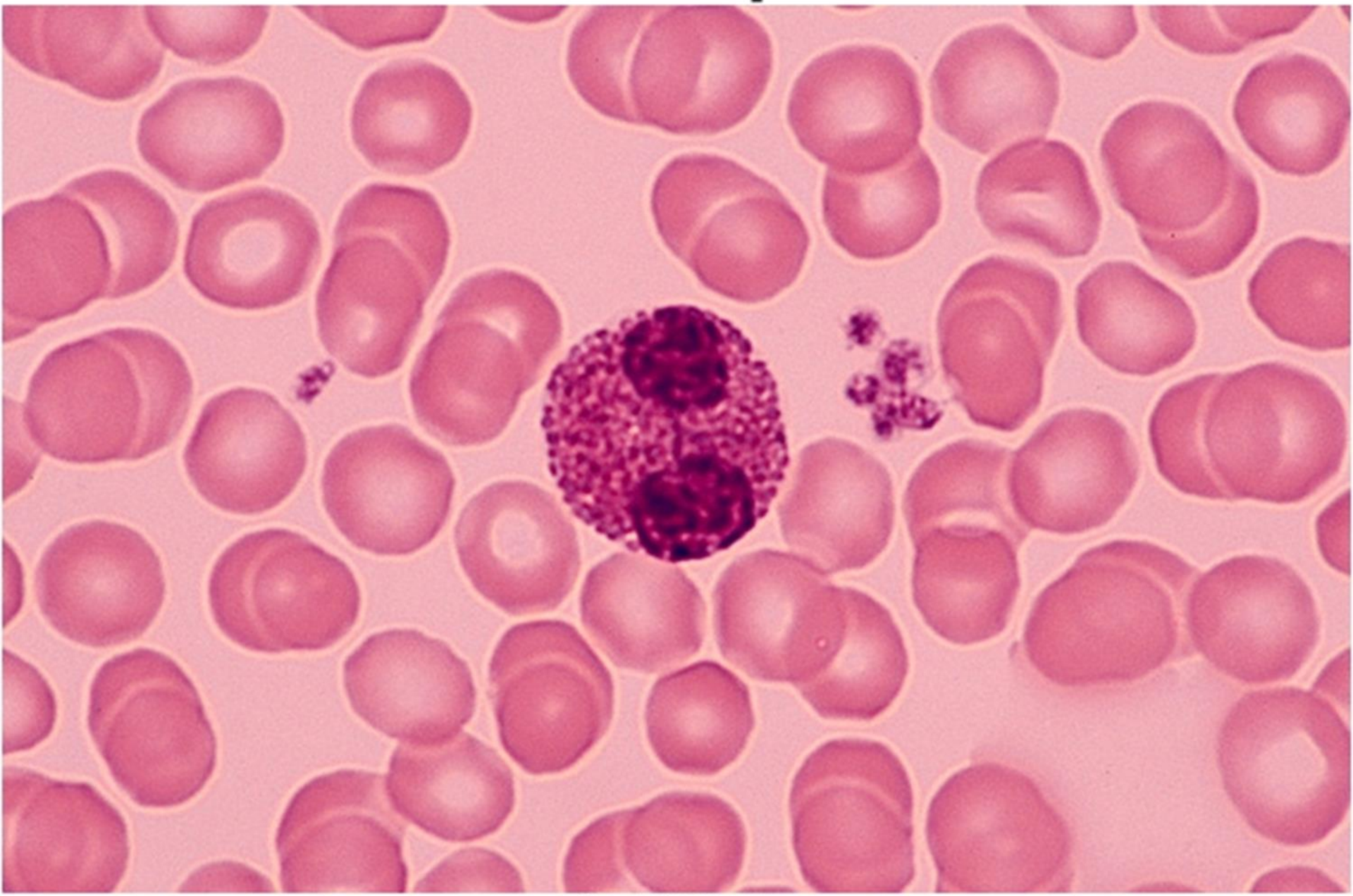
Eosinophil

- Eosinophils are easily distinguished by their large rosy to orange-colored granules and prominent, usually bilobed nucleus connected by thin strands.
- 1 – 4 % of total WBC.
- Diameter similar to that of Neutrophils.
- Stain red.

Functions

- Phagocytosis of antigen-antibody complexes, allergens, and inflammatory chemicals
- Release enzymes that weaken or destroy parasites such as worms.

Eosinophil



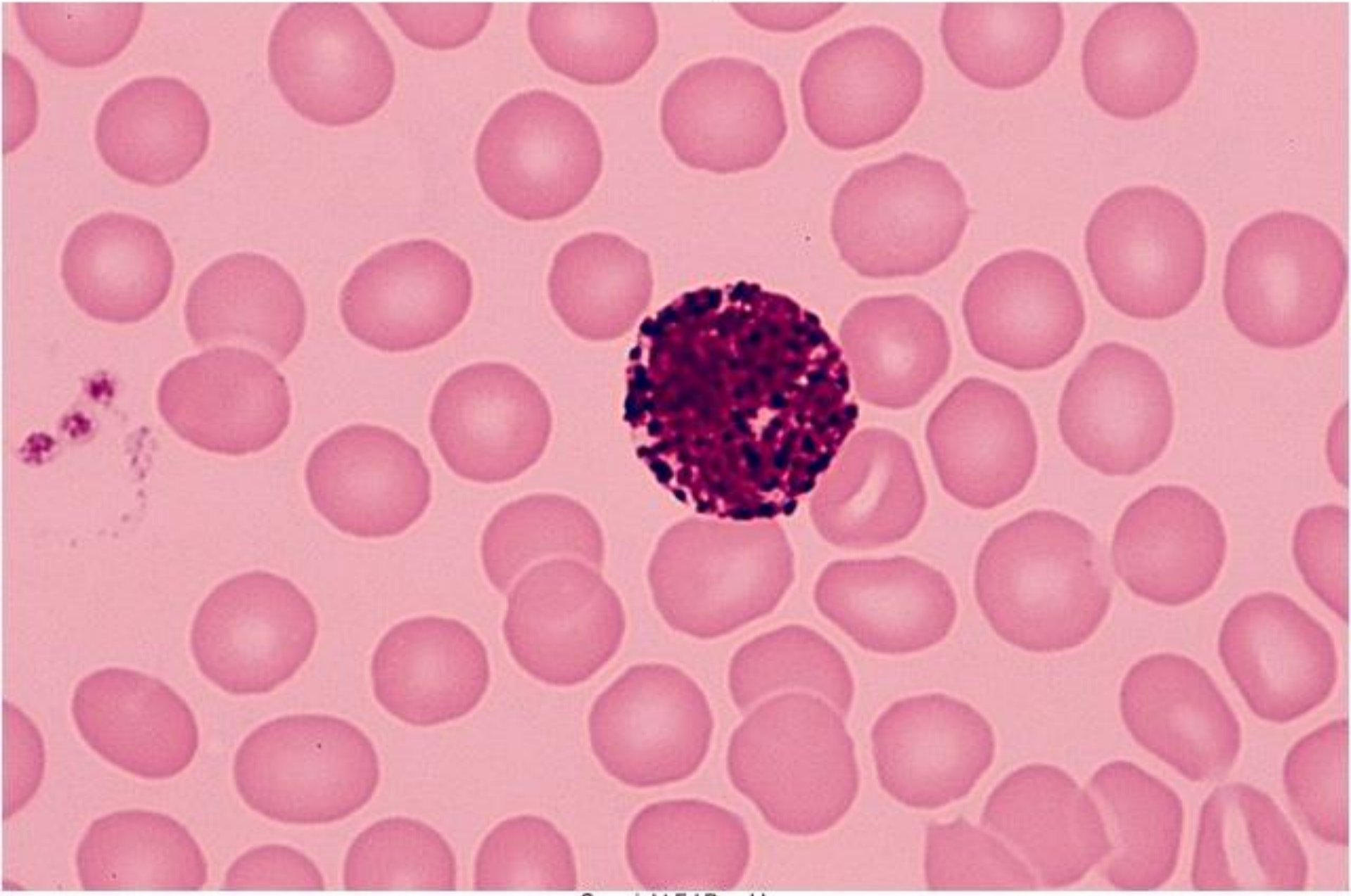
Basophils

- Have granules that stain blue with basic dyes.
- Size similar to that of neutrophils.
- 2-3 lobes.
- Nucleus U or S shaped.
- Less than1% of WBC.

Function:

- Secrete histamine (a vasodilator), which increases blood flow to a tissue
- Secrete heparin (an anticoagulant), which promotes mobility of other WBCs by preventing clotting

Basophil



Agranulocytes

- Lymphocytes
- Monocytes

Lymphocytes

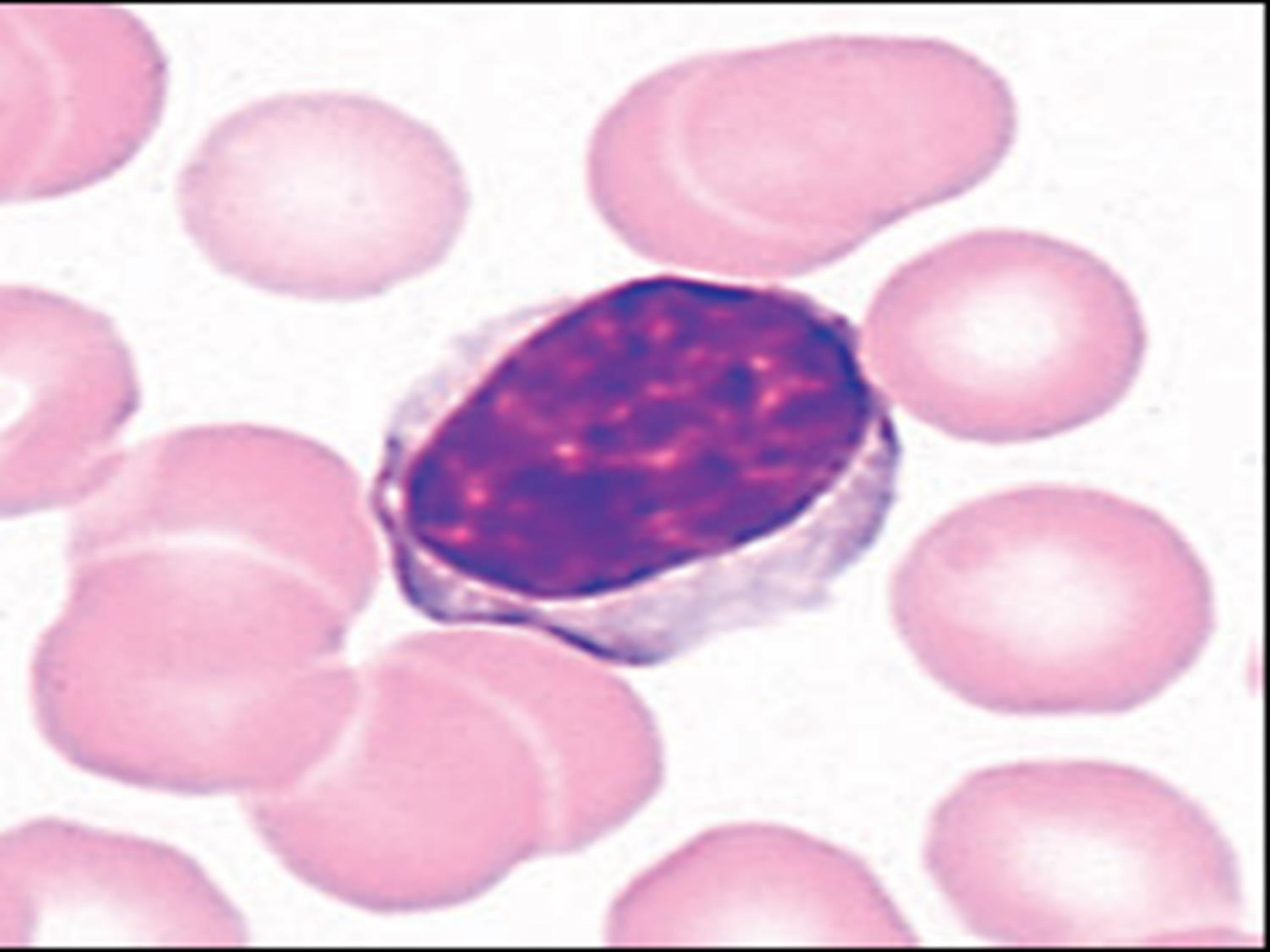
- As the name implies most lymphocytes reside in lymphatic organs and structures.
- Typically, lymphocytes constitute about 20–40% of the total number of leukocytes.
- Lymphocytes have large nuclei surrounded by a relatively thin layer of cytoplasm.
- Classed into three categories.
- Small, medium, and large.
- Medium and large lymphocytes are usually seen in fibrous connective tissues and only occasionally in the circulating blood.
- small lymphocytes, the nucleus often fills almost the entire cell and leaves only a narrow rim of clear, light blue cytoplasm.

Based on function they are of three types

- **T- lymphocytes** - attack foreign cells and virus-infected cells.
- **B-lymphocytes(B-cells)** are stimulated to become plasma cells and produce antibodies.
- **Natural killer cells(NK cells)** attack abnormal and infected tissue cells

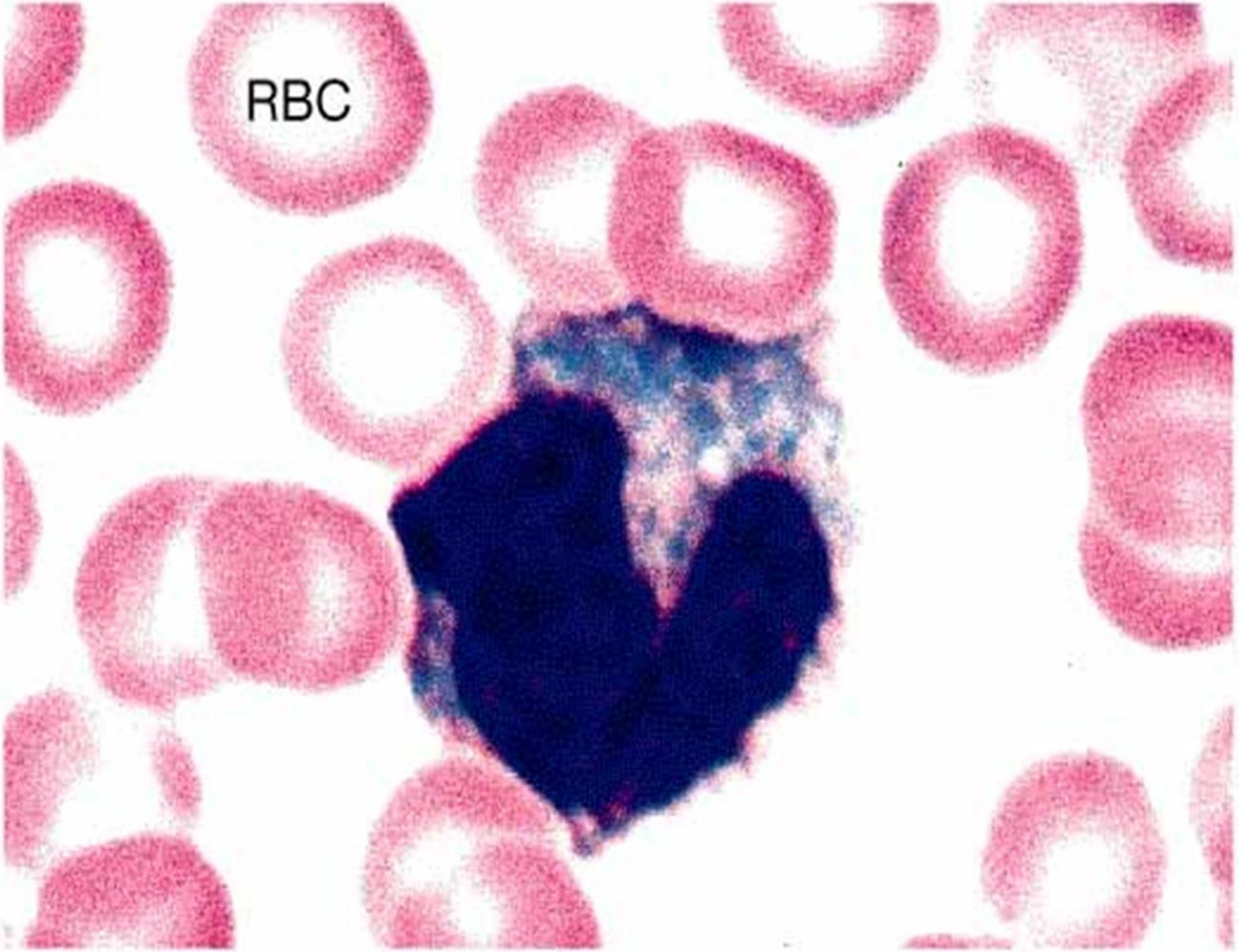
Function

- Destroy cancer cells, cells infected with viruses, and foreign cells
- “Present” antigens to activate other cells of immune system
- Coordinate actions of other immune cells
- Secrete antibodies
- Serve in immune memory



Monocytes

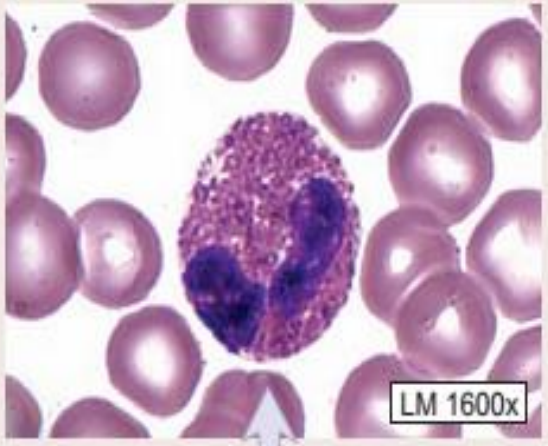
- **Monocytes are the largest of the formed elements,** typically about twice the diameter of an erythrocyte but sometimes approaching three times as large.
- The Monocytes nucleus tends to stain a lighter blue.
- Make up 2-8 % of all leukocytes
- They have round nucleus.
- Cytoplasm is abundant.
- ***Functions:***
- Differentiate into macrophages (large phagocytic cells of the tissues)
- Phagocytize pathogens, dead Neutrophils, and debris of dead cells
- "Present" antigens to activate other cells of immune system



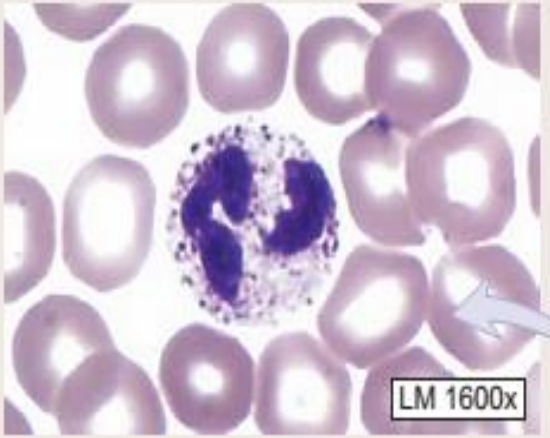
(d) Monocyte

Platelets

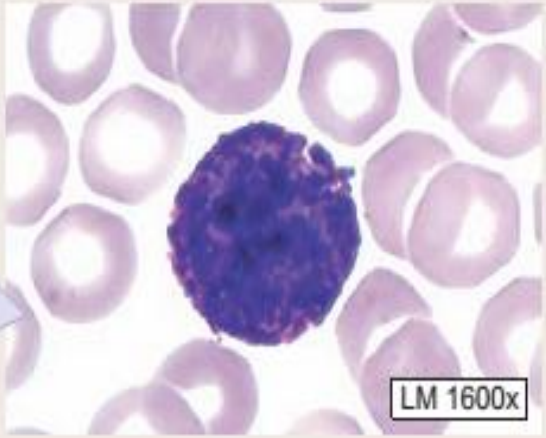
- Platelets are irregular, membrane-enclosed cellular fragments that are about 2 micrometers in diameter
- Sometimes also called as thrombocytes
- Platelets are the smallest of the formed elements and are actually fragments of large cells called megakaryocyte found in red bone marrow.
- The fragments that enter the circulation as platelets lack nuclei.
- They may be clustered in small or large masses.
- 2-4 um in diameter.
- **Function:**
- Clotting of blood



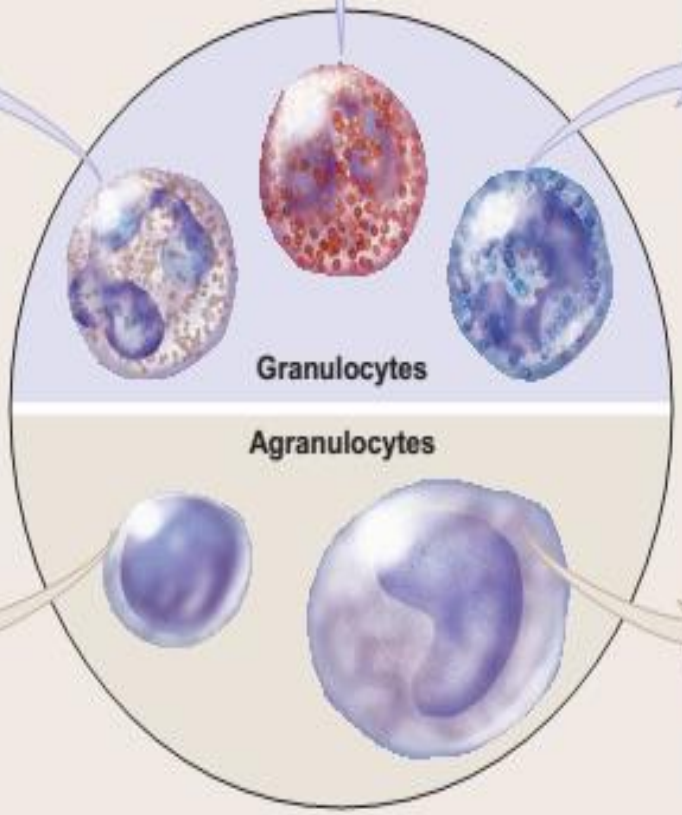
Eosinophil

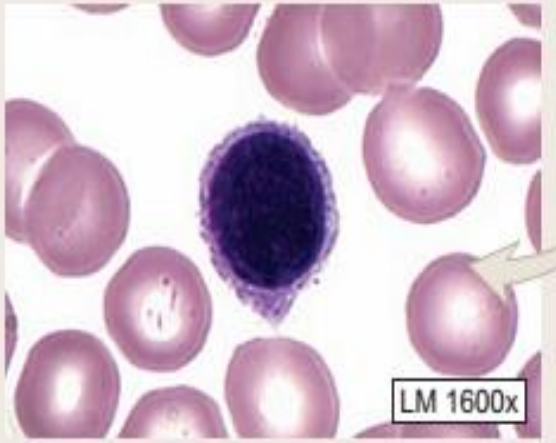


Neutrophil

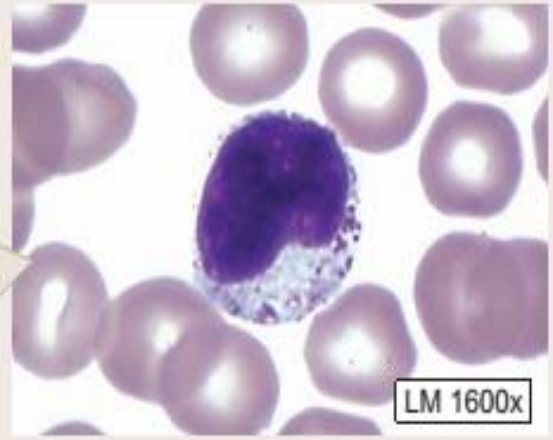


Basophil





Lymphocyte



Monocyte

Plasma

- Blood plasma is a complex mixture of water, proteins, and other solutes
- Water is the most abundant compound in plasma, making up about 92% of plasma's total volume
- The next most abundant compounds in plasma are the plasma proteins which makes 7% of the plasma
- The plasma proteins include

❑albumins

❑globulins

❑Fibrinogen

❑regulatory proteins

- **Albumins** are the smallest and most abundant of the plasma proteins, making up approximately 58% of total plasma proteins. They regulate water movement between the blood and interstitial fluid and also help in transport.

- **Globulins** are the second largest group of plasma proteins, forming about 37% of all plasma proteins. The smaller alpha-globulinsand the larger beta-globulins primarily bind, support, and protect certain water-insoluble or hydrophobic molecules, hormones, and ions. Gamma-globulins,also called immunoglobulins or antibodies, are soluble proteins produced by some of our defense cells to protect the body against pathogens that may cause disease.

- **Fibrinogen** makes up about 4% of all plasma proteins. Fibrinogen is responsible for blood clot formation. Following trauma to the walls of blood vessels, fibrinogen is converted into long, insoluble strands of fibrin, which helps form a blood clot.

- **Regulatory proteins** form a very minor class of plasma proteins (less than 1% of total plasma proteins) and include enzymes , proenzymes and hormones that are being transported to other parts of the body

Percentage by volume

Plasma 55%

Buffy coat

Formed elements 45%

Plasma (percentage by weight)

Proteins 7%

Water 91%

Other solutes 2%

Plasma proteins

Albumins 58%

Globulins 38%

Fibrinogen 4%

Ions

Nutrients

Waste products

Gases

Regulatory substances

Formed elements (number per cubic mm)

Platelets 250–400 thousand

White blood cells 5–10 thousand

Red blood cells 4.2–6.2 million

White blood cells

Neutrophils 60–70%

Lymphocytes 20–25%

Monocytes 3–8%

Eosinophils 2–4%

Basophils 0.5–1%

Fluid Connective Tissue, LYMPH

- Lymph is usually a clear, colorless fluid, similar to blood plasma but low in protein. Its composition varies substantially from place to place. After a meal, for example, lymph draining from the small intestine has a milky appearance because of its high lipid content.

- Lymph leaving the lymph nodes contains a large number of lymphocytes—indeed, this is the main supply of lymphocytes to the bloodstream

Muscular tissue

- Muscular tissue consists of elongated cells that are specialized to respond to stimulation by contracting.

- Muscle tissue is derived from mesoderm.

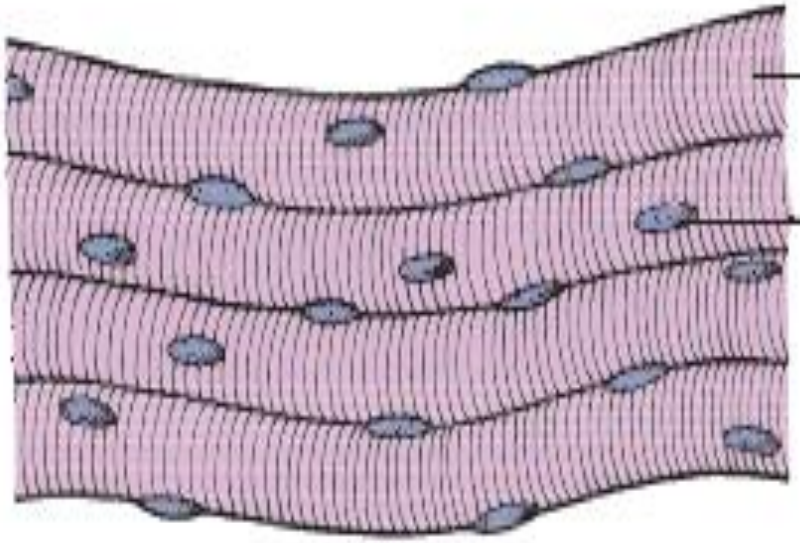
- Muscle fibers contain actin and myosin, which are protein filaments whose interaction accounts for movement

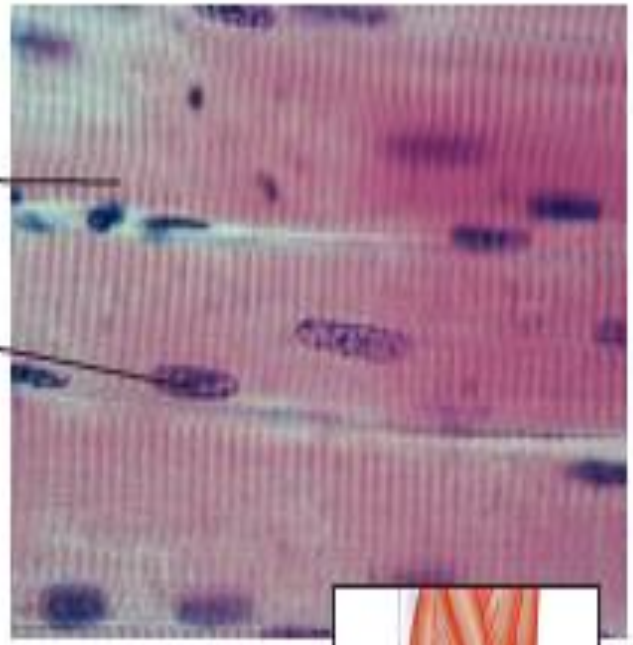
- There are three types of muscle tissue in the body:

- ***smooth,***
- ***cardiac***
- ***skeletal muscle*** .

Skeletal muscle

- tissue attaches to the skeleton and is responsible for voluntary body movements.
- Fibers are elongated, multinucleated and has transverse striations.
- Fibers of this muscle tissue are grouped into parallel bundles that can be seen.
- cannot replicate once tissue formation has been completed shortly after birth.
- Skeletal muscle fibers are cylindrical and quite long—sometimes they run the length of the muscle.
- They arise during development when several cells fuse, resulting in one fiber with multiple nuclei.
- The nuclei are located at the periphery of the cell, just inside the plasma membrane.
- The fibers have alternating light and dark bands that give them a striated (striped) appearance. These bands are due to the placement of actin filaments and myosin filaments in the fiber.



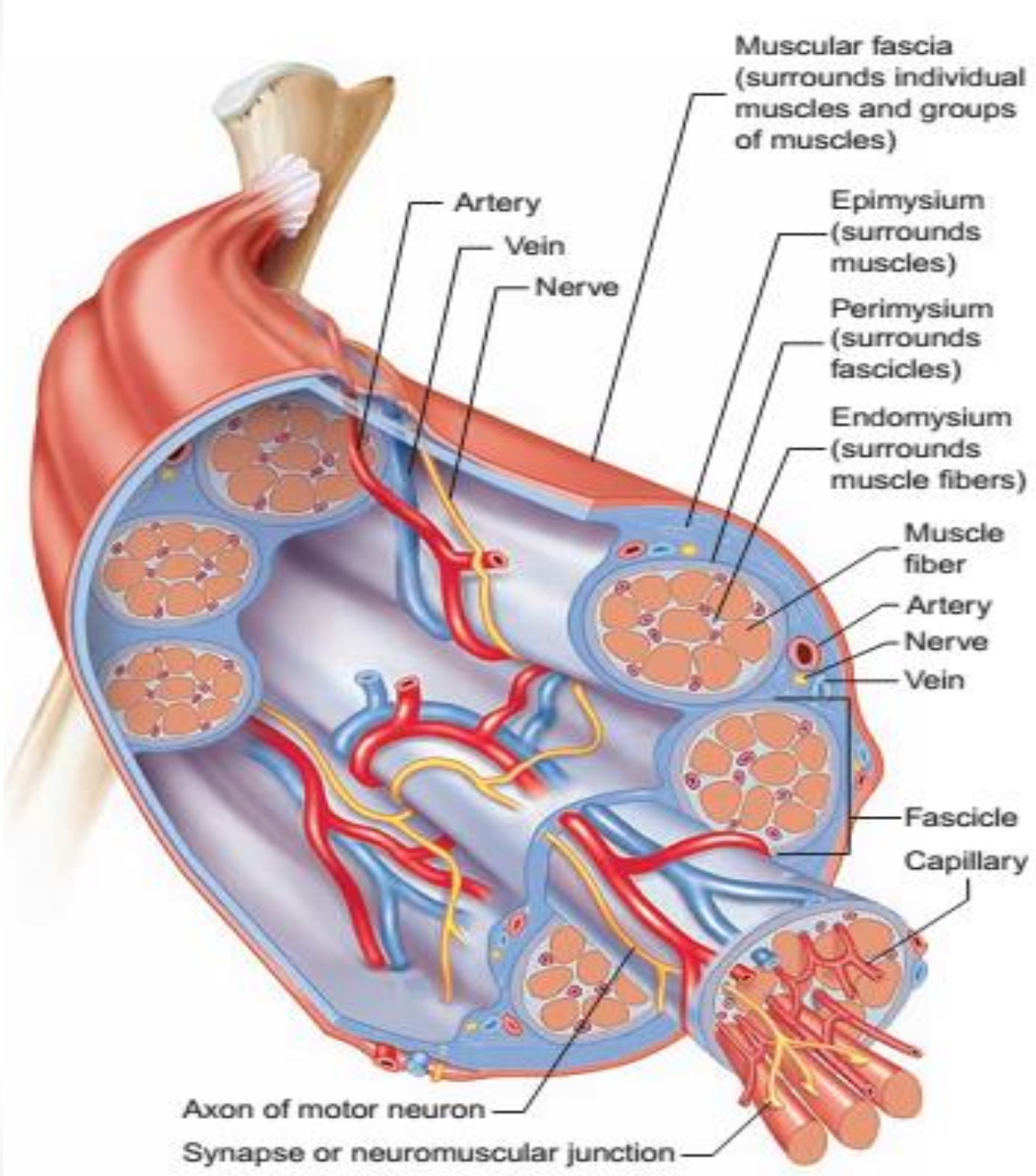


Skeletal Muscle

Fiber appearance: Striated

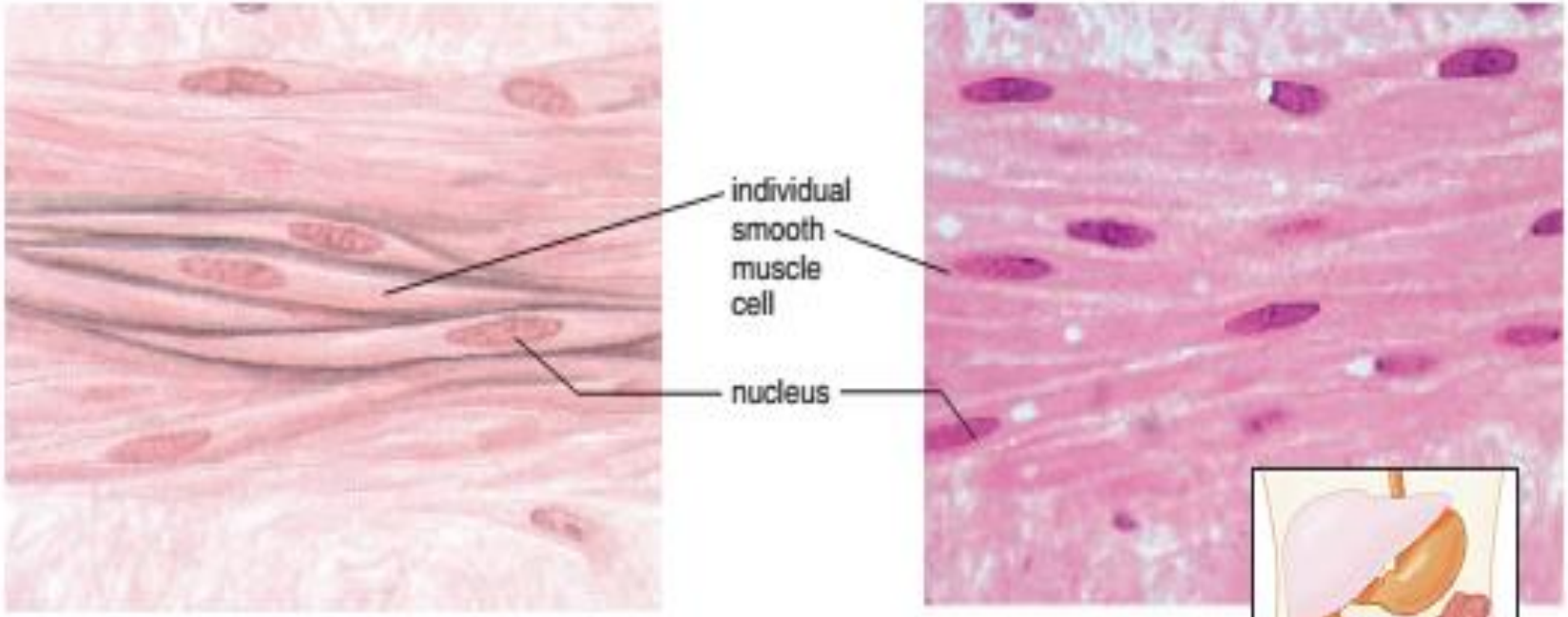
Location:
Usually attached to skeleton

Control: Voluntary


Muscular fascia (surrounds individual muscles and groups of muscles)
Artery
Vein
Nerve
Epimysium (surrounds muscles)
Perimysium (surrounds fascicles)
Endomysium (surrounds muscle fibers)
Muscle fiber
Artery
Nerve
Vein
Fascicle
Capillary
Axon of motor neuron
Synapse or neuromuscular junction

Smooth Muscle

- Smooth muscle tissue is common throughout the body. The contraction of smooth muscle is under autonomic (involuntary) nervous control.
- Smooth muscles are so named because the arrangement of actin and myosin does not give the appearance of cross-striations
- Smooth muscle fibers are long, spindle-shaped cells. They contain a single nucleus. These cells are usually grouped together in flattened sheets.
- The spindle-shaped cells form layers in which the thick middle portion of one cell is opposite the thin ends of adjacent cells. Consequently, the nuclei form an irregular pattern in the tissue
- Smooth muscles contract slowly but stay contracted for longer period and also has rhythmicity in contractions
- **Location**
- *Mainly present in hollow viscera like GIT, walls blood vessels,* the walls of respiratory passages, and in the urinary and reproductive ducts.
- **Function**
- Swallowing ,feces, respiration etc

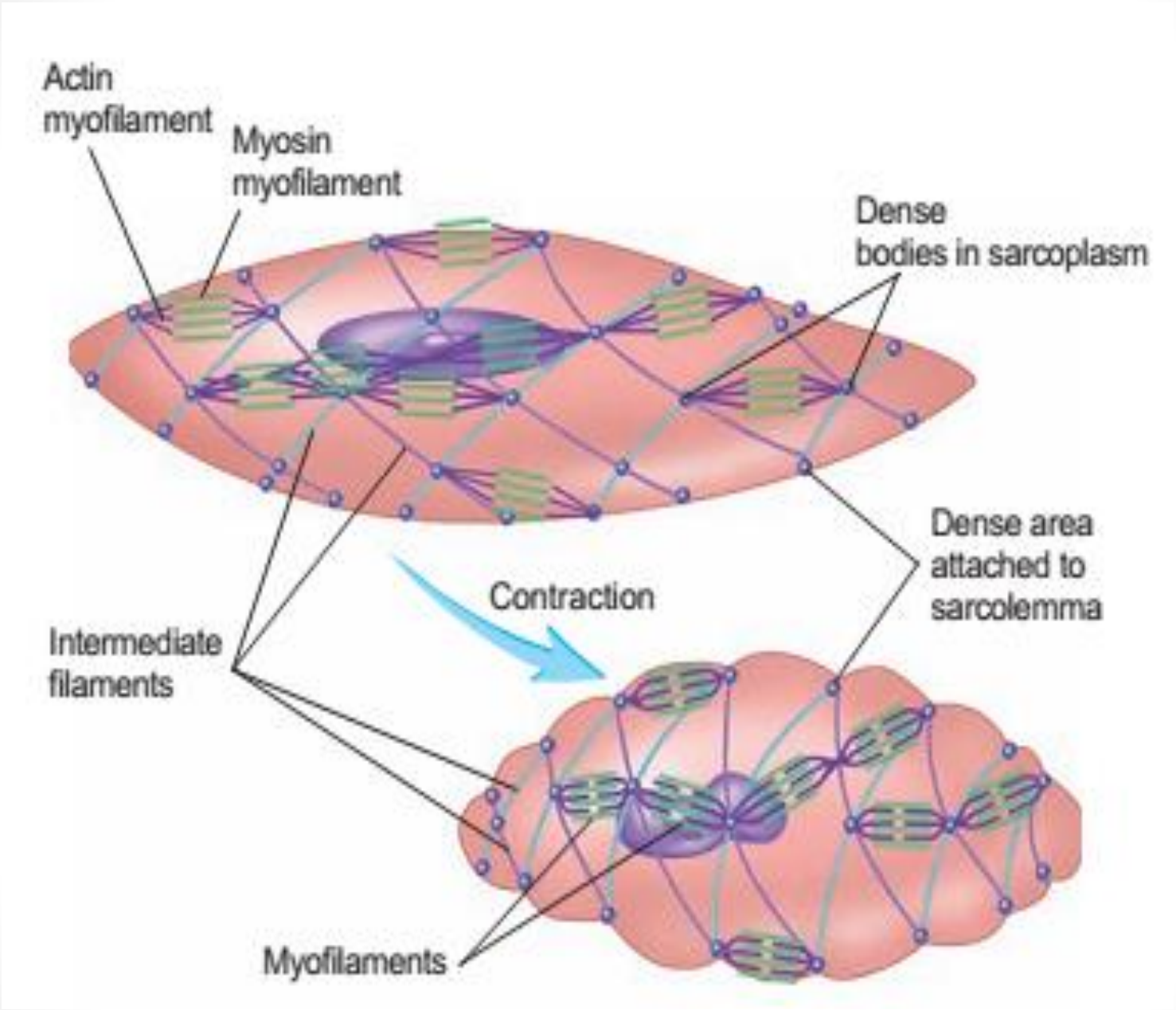


Smooth Muscle

Fiber appearance: Spindle-shaped

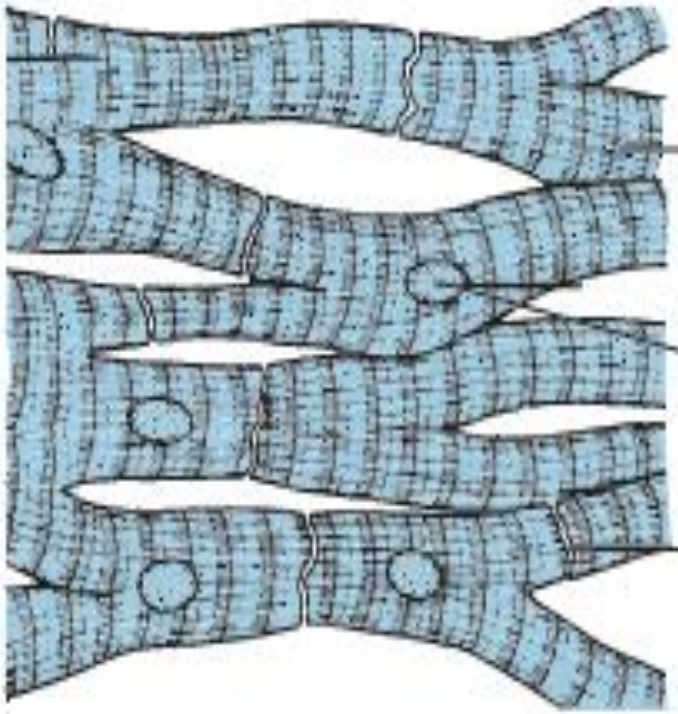
Location: Walls of hollow organs (e.g., stomach, intestines, urinary bladder, uterus, blood vessels)

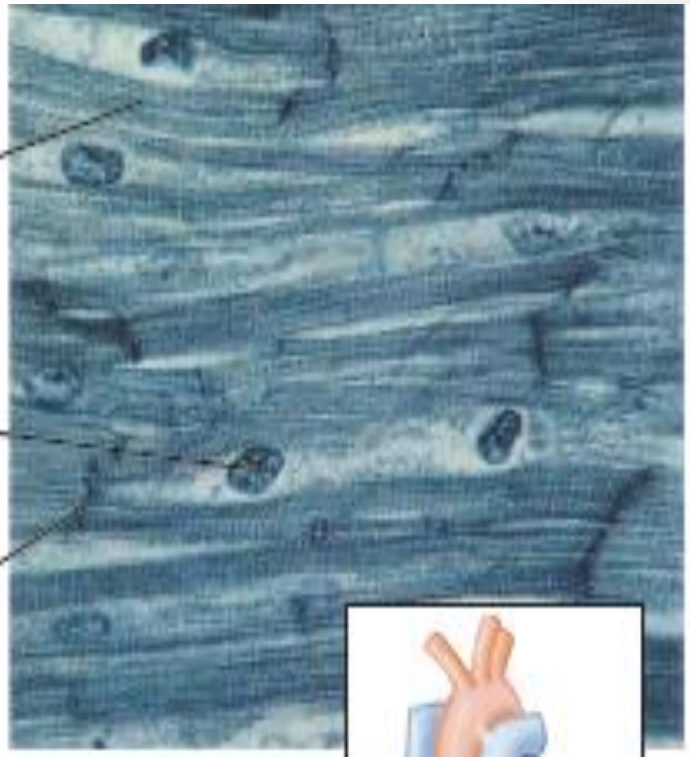
Control: Involuntary


Actin myofilament
Myosin myofilament
Dense bodies in sarcoplasm
Dense area attached to sarcolemma
Contraction
Intermediate filaments
Myofilaments

Cardiac Muscle

- Cardiac muscle tissue make up wall of the heart.
- This tissue is characterized by branching fibers, with a single, central nucleus, and by transversely positioned intercalated *discs, which helps in muscle contraction.*
- Cardiac muscle combines features of both smooth muscle and skeletal muscle. Like skeletal muscle, it has striations, but the contraction of the heart is involuntary for the most part
- Cardiac muscle is striated, experiences rhythmic involuntary contractions.
- Also like skeletal muscle, its contractions are strong, but like smooth muscle, the contraction of the heart is inherent and rhythmical. Also, its contraction can be modified by the nervous system
- Have a single, centrally placed nucleus. The cells are branched and seemingly fused one with the other, and the heart appears to be composed of one large, interconnecting mass of muscle cells.
- Actually, cardiac muscle cells are separate and individual, but they are bound end-to-end at intercalated disks, areas where folded plasma membranes between two cells contain adhesion junctions and gap junctions. These permit extremely rapid spread of contractile stimuli so that the fibers contract almost simultaneously.





Cardiac Muscle

Fiber appearance: Striated and branched

Location: Heart

Control: Involuntary

Nervous tissue

- Nervous tissue is composed of neurons and neuroglia.
- Neurons respond to stimuli and conduct impulses to and from all body organs
- Neuroglia functionally support and physically bind neurons.
- There are several kinds of neurons in nervous tissue, they all have three principal components:
- (1) a cell body, or perikaryon; (2) dendrites; and (3) an axon
- Dendrites are branched processes that receive stimuli and conduct nerve impulses toward the cell body. The cell body, contains nucleus and specialized organelles.
- The axon is a cytoplasmic extension that conducts nerve impulses away from the cell body. The term nerve fiber refers to any process extending from the cell body of a neuron.
- Outside the brain and spinal cord, fibers are bound together by connective tissue to form nerves
- The myelin sheath that surrounds the neuron.

- **Neuroglia**
- Also called as glial cells.
- Are five times more abundant than neurons and make up about half of the volume of nervous system
- Primary function is support and nourishment of neurons