

CARTILAGE:

1-Cartilage is characterized by an extracellular matrix (ECM) enriched with glycosaminoglycans and proteoglycans, macromolecules that interact with collagen and elastic fibers.

2-Variations in the composition of these matrix components produce three types of cartilage adapted to local biomechanical needs.

3-Cartilage is a specialized form of connective tissue in which the firm consistency of the ECM allows the tissue to bear mechanical stresses without permanent distortion.

4- In the respiratory system cartilage forms a framework supporting soft tissues. Because it is smooth-surfaced and resilient, cartilage provides a shock-absorbing and sliding area for joints and facilitates bone movements. Cartilage is also essential for the development and growth of long bones, both before and after birth.

5-Cartilage consists of cells called chondrocytes and an extensive extracellular matrix composed of fibers and ground substance. Chondrocytes synthesize and secrete the ECM and the cells themselves are located in matrix cavities called lacunae.

6-Collagen, hyaluronic acid, proteoglycans, and small amounts of several glycoproteins are the principal macromolecules present in all types of cartilage matrix.

7-As a consequence of different functional requirements, three forms of cartilage have evolved, each exhibiting variation in **matrix composition**.

i)In the matrix of **hyaline cartilage**, the most common form, type **II collagen** is the principal collagen type.

ii)The more pliable and distensible **elastic cartilage** possesses, in addition to **collagen type II**, an abundance of **elastic fibers** within its matrix.

iii)**Fibrocartilage**, present in regions of the body subjected to pulling forces, is characterized by a matrix containing **a dense network of coarse type I collagen fibers**.

Chondrocytes:

A) At the periphery of **hyaline cartilage**, **young chondrocytes** have an **elliptic shape**, with the long axis parallel to the surface. Farther in, they are round and may appear in groups of up to eight cells originating from mitotic divisions of **a single chondrocyte**.

B) These groups are called **isogenous aggregates**. Chondrocytes synthesize **collagens** and the other matrix molecules. As matrix is produced, cells in the aggregates are moved apart and occupy **separate lacunae**.

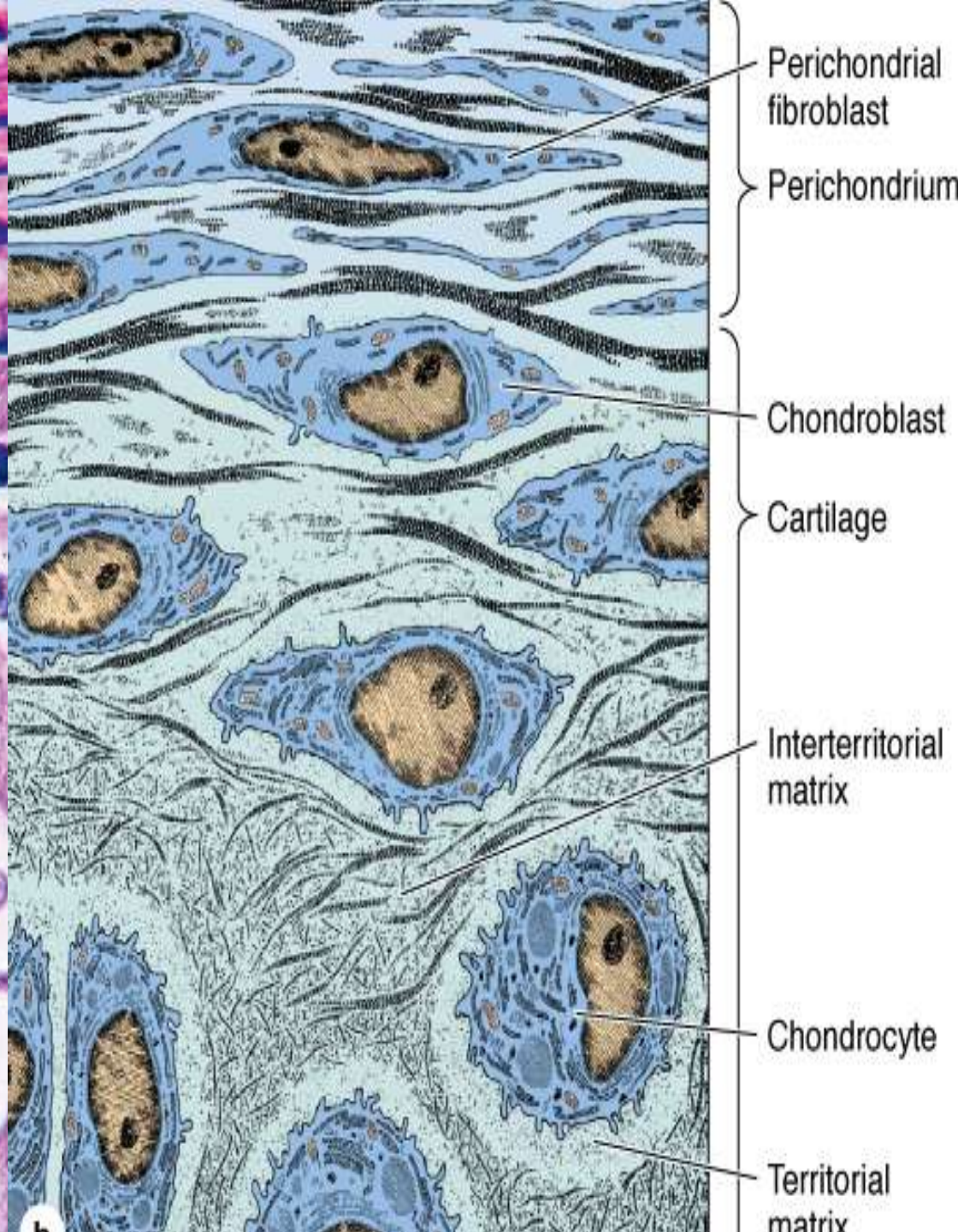
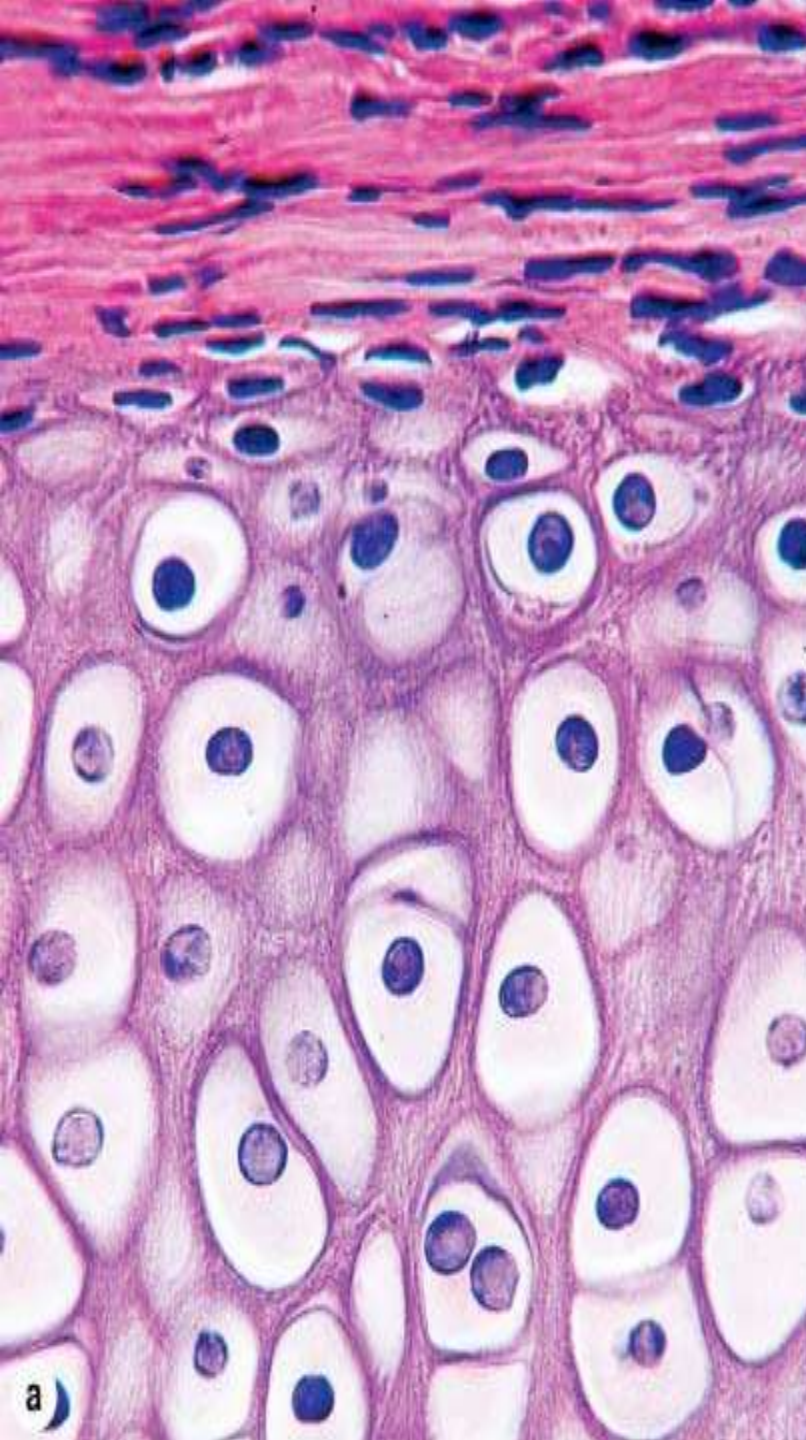
Perichondrium:

A-The perichondrium is a sheath of dense connective tissue that surrounds cartilage in most places, forming an interface between the **cartilage and the tissue supported by the cartilage.**

B-The perichondrium harbors the vascular supply for the **avascular cartilage** and also contains nerves and lymphatic vessels.

C- Articular cartilage, which covers the surfaces of the bones in **movable joints**, is devoid of perichondrium and is sustained by the diffusion of oxygen and nutrients from the **synovial fluid.**

1-Hyaline cartilage is the most common and best studied of the three forms. Fresh hyaline cartilage is bluish-white and translucent. **2-In the embryo**, it serves as a temporary skeleton until it is gradually replaced by bone. **3-In adult mammals**, hyaline cartilage is located in the articular surfaces of the movable joints, in the walls of larger respiratory passages in the ventral ends of ribs, where they articulate with the sternum, and in the **epiphyseal plate**, where it is responsible for the longitudinal growth of bone. **4-Except in the articular cartilage of joints**, all hyaline cartilage is covered by a layer of dense connective tissue, the **perichondrium**, which is essential for the growth and maintenance of cartilage. It consists largely of collagen type I fibers and numerous fibroblasts. cells in the inner layer of the perichondrium resemble fibroblasts, they are precursors for **chondroblasts** which divide and **differentiate into chondrocytes**.



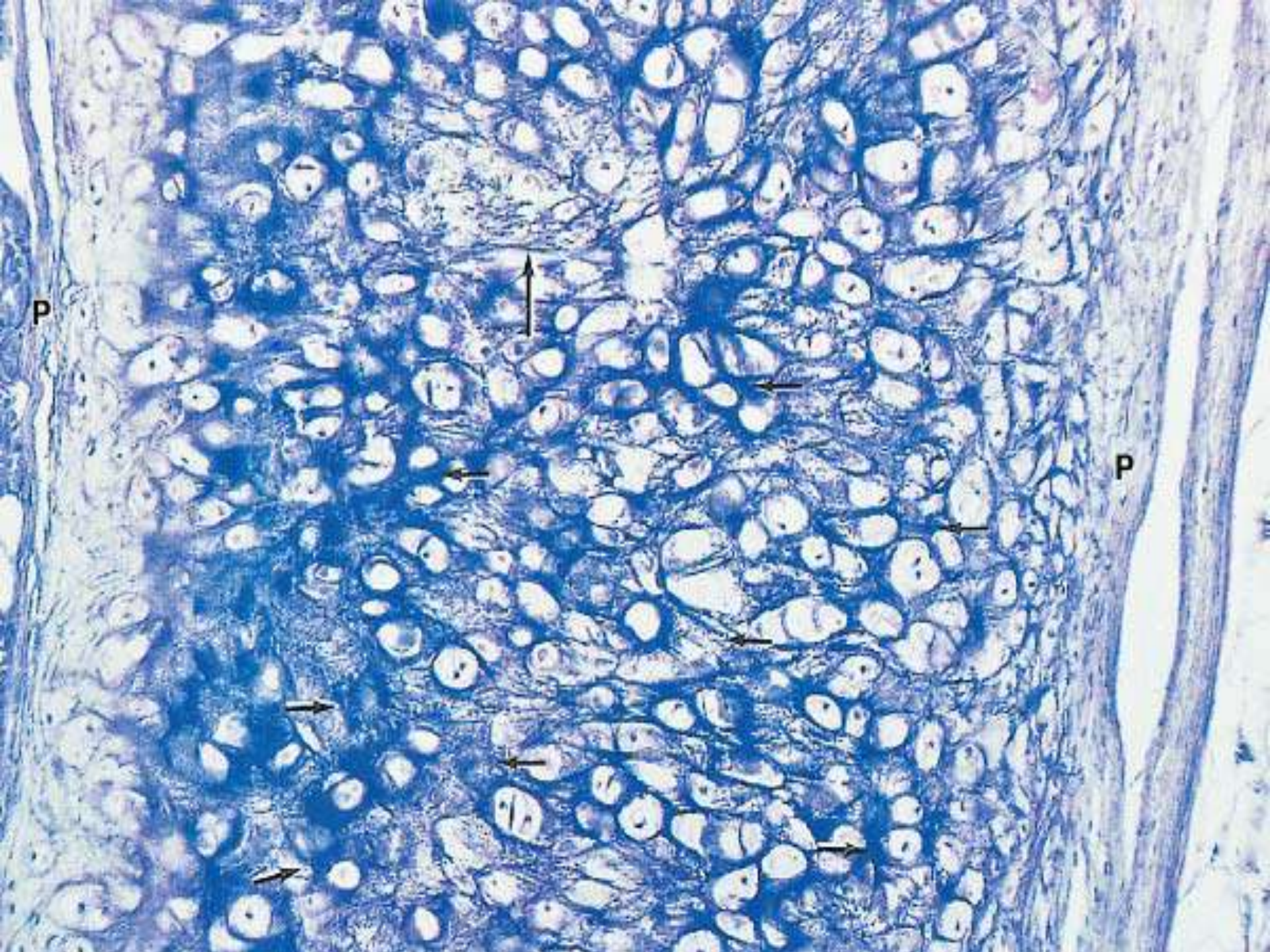
ELASTIC CARTILAGE:

1-Elastic cartilage is essentially very similar to hyaline cartilage except that it contains an abundant network of fine elastic fibers in addition to collagen type II fibrils .

2- Fresh elastic cartilage has a yellowish color owing to the presence of elastin in the elastic fibers.

3- Elastic cartilage is frequently found to be gradually continuous with hyaline cartilage. Like hyaline cartilage, elastic cartilage possesses a perichondrium.

4-Elastic cartilage is found in the auricle of the ear, the walls of the external auditory canals, the auditory (eustachian) tubes, the epiglottis, and the cuneiform cartilage in the larynx.

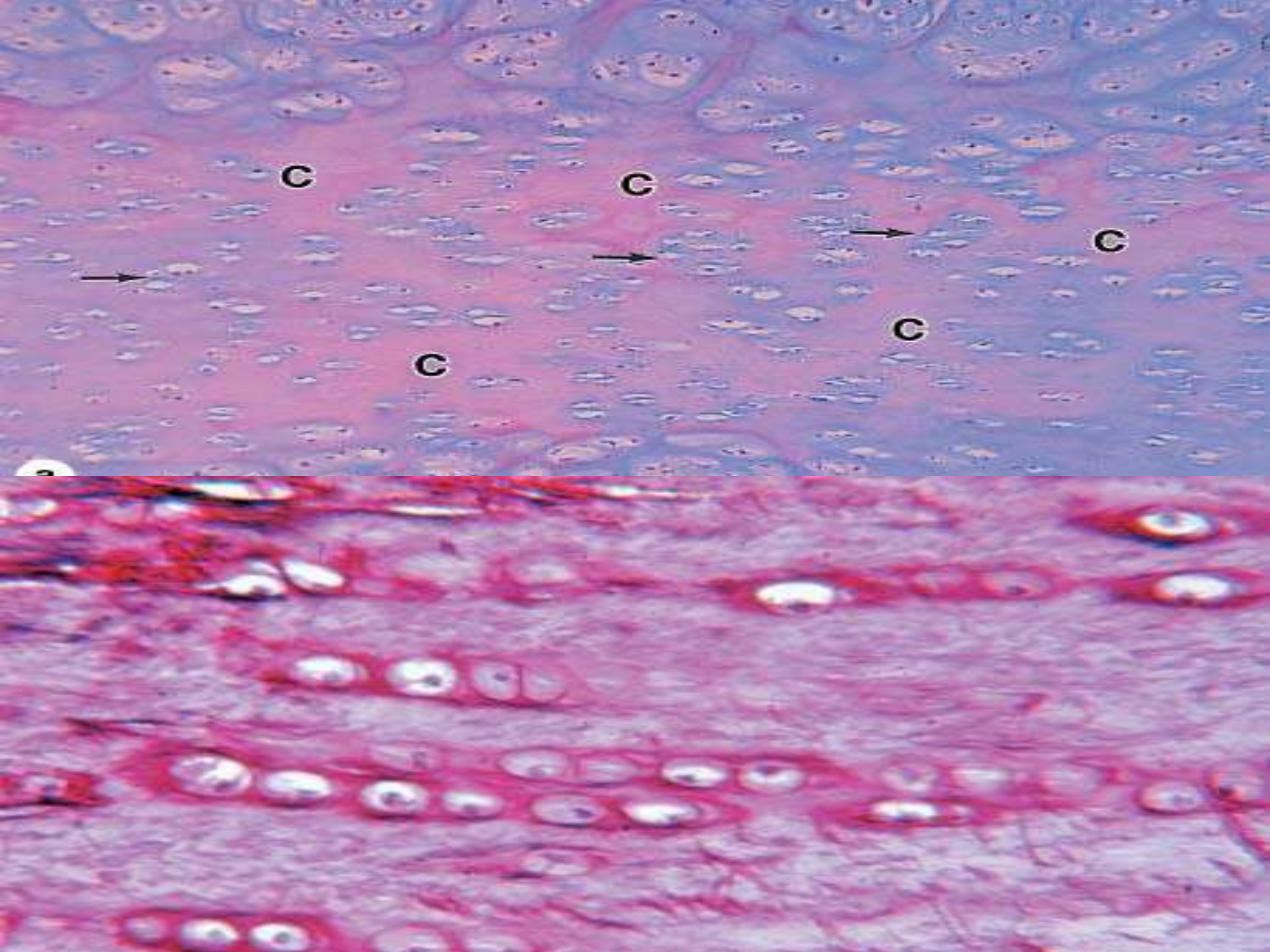


FIBROCARILAGE:

1-Fibrocartilage is a tissue intermediate between dense connective tissue and hyaline cartilage. It is found in intervertebral disks, in attachments of certain ligaments, and in the **pubic symphysis**.

2-Fibrocartilage is always associated with dense connective tissue and the border between these two tissues is not clear-cut, showing a gradual transition.

3-Fibrocartilage contains **chondrocytes**, either singly or in isogenous aggregates, usually arranged axially, in long rows separated by **coarse collagen type I** fibers and less proteoglycans than other forms of cartilage .**4- Because** it is richer in collagen type I, the **fibrocartilage** matrix is more **acidophilic**.



BONE:

1-Bone is a **specialized connective** tissue composed of calcified intercellular material, the **bone matrix**, and three cell types:

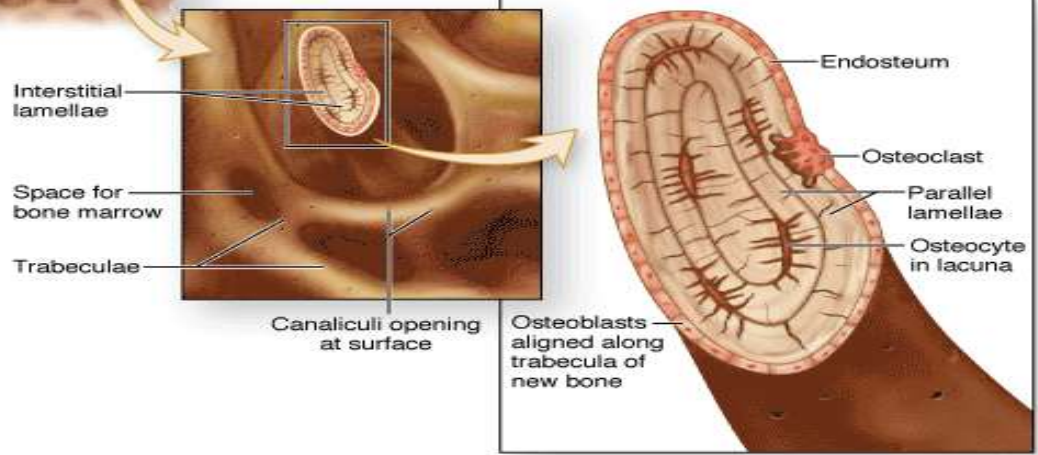
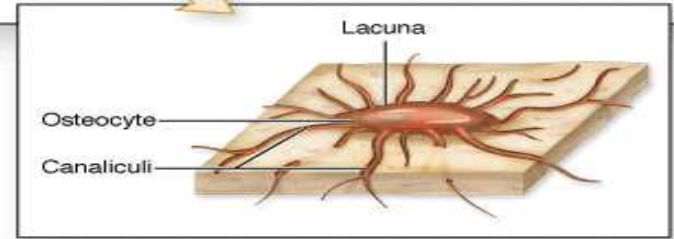
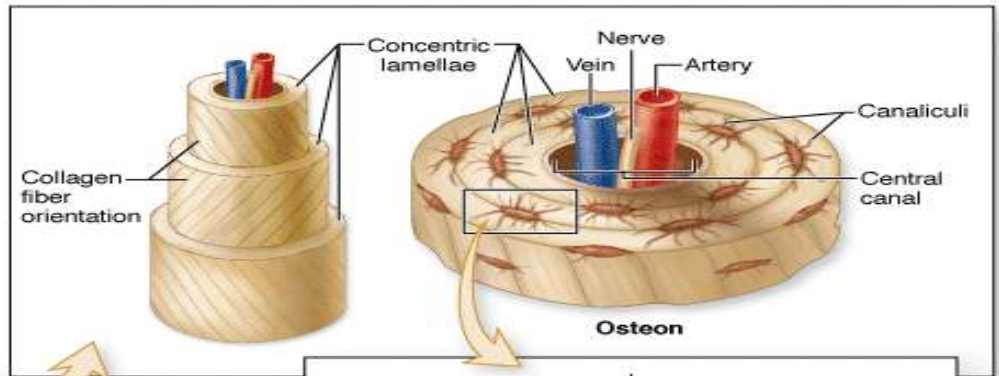
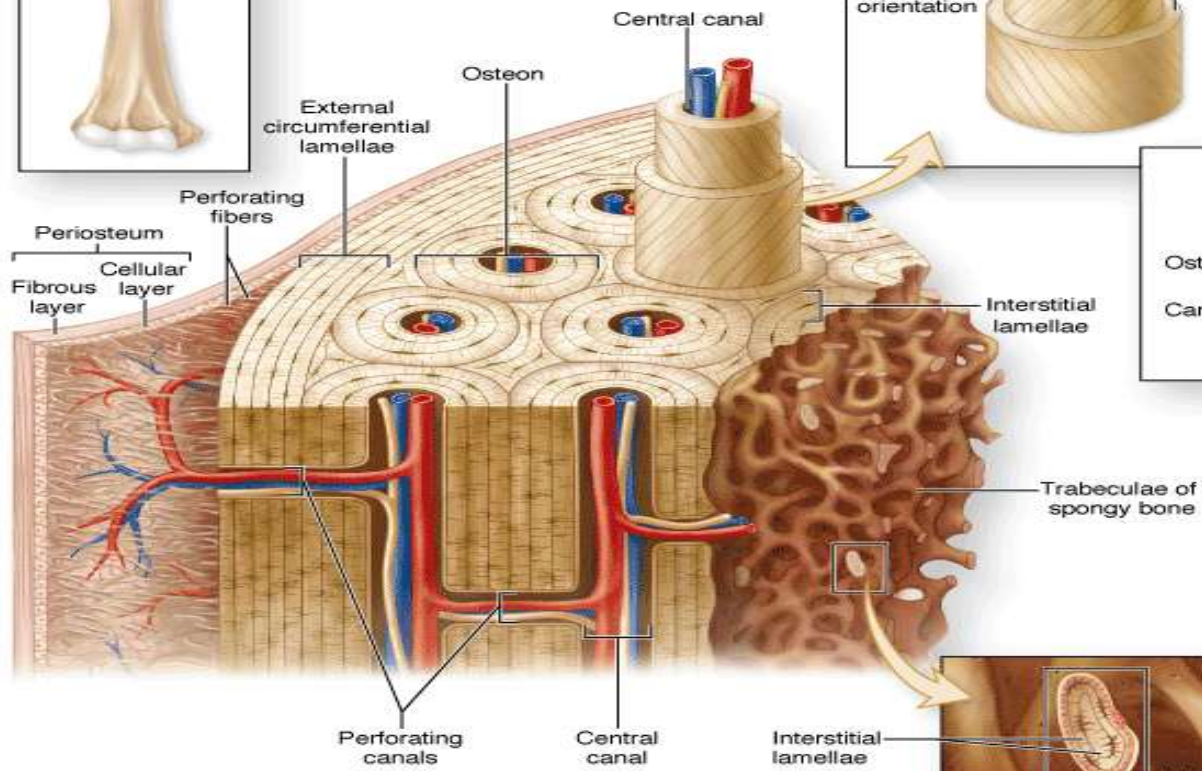
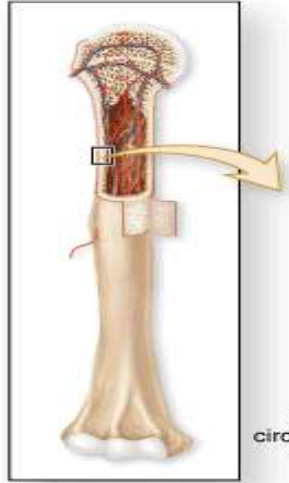
i)Osteocytes , which are found in cavities (**lacunae**) between layers (lamellae) of bone matrix .

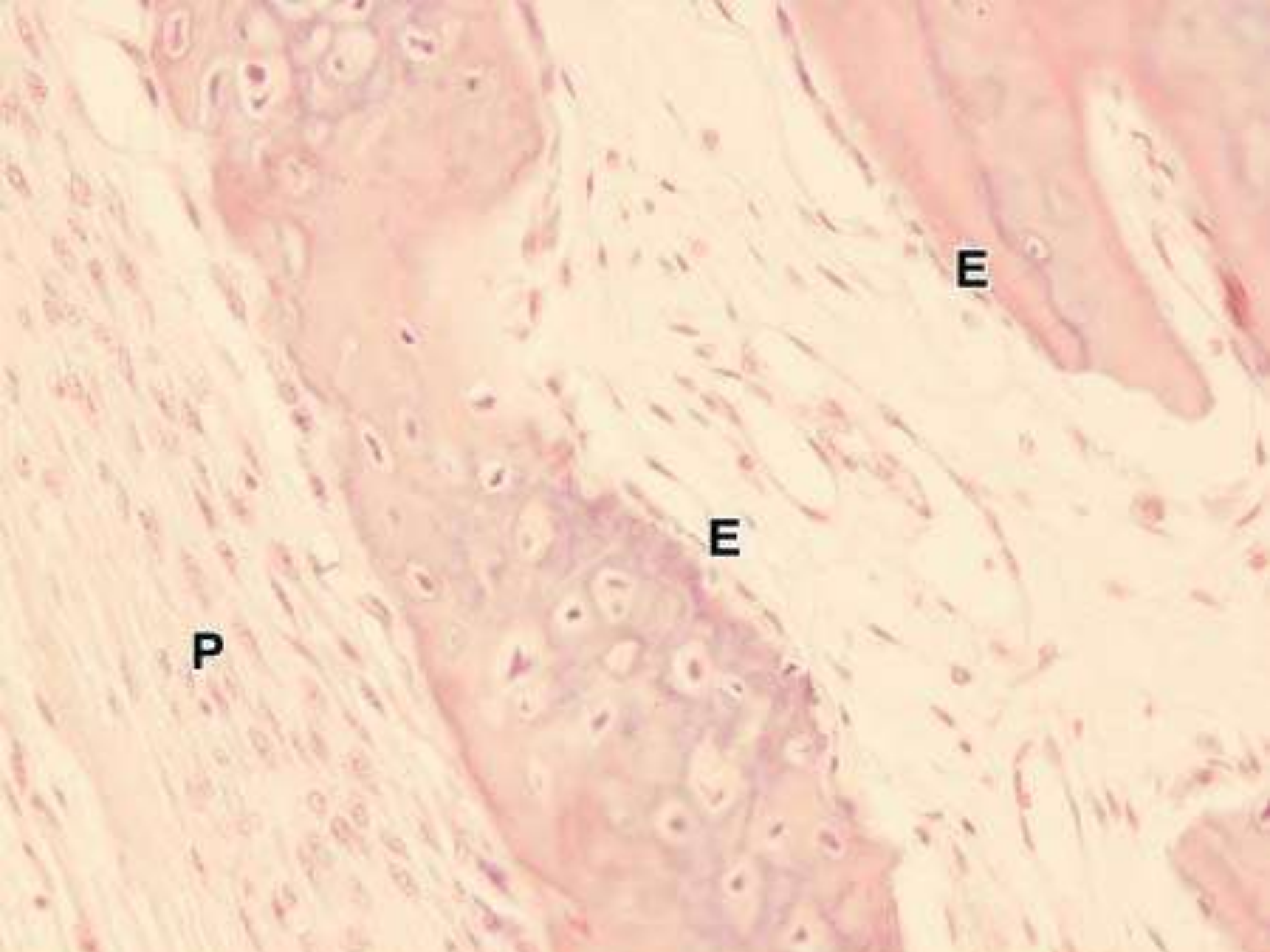
ii)Osteoblasts , which synthesize the organic components of the matrix.

iii)Osteoclasts , which are multi-nucleated giant cells involved in the resorption and remodeling of bone tissue.

2-All bones are lined on both **internal and external** surfaces by layers of connective tissue containing osteogenic cells—**endosteum** on the internal surface and **periosteum** on the external surface.

3-The **periosteum** consists of a dense fibrous outer layer of collagen bundles and fibroblasts . Bundles of periosteal collagen fibers, called **perforating(or Sharpey's) fibers**, **penetrate** the bone matrix, binding the periosteum to bone. The innermost cellular layer of the periosteum contains stem cells called **osteoprogenitor cells**, with the potential to divide by mitosis and differentiate into osteoblasts. Osteoprogenitor cells play **a prominent role** in bone growth and repair. 4-The large internal marrow cavities of bone are lined by **endosteum** . **Endosteum** is a single very thin layer of connective tissue, containing flattened osteoprogenitor cells and osteoblasts, which covers the small spicules or trabeculae of bone that project into these cavities. **The endosteum** is therefore considerably thinner than the periosteum. The functions of **periosteum and endosteum** are nutrition of osseous tissue and new osteoblasts for repair or **growth of bone**.





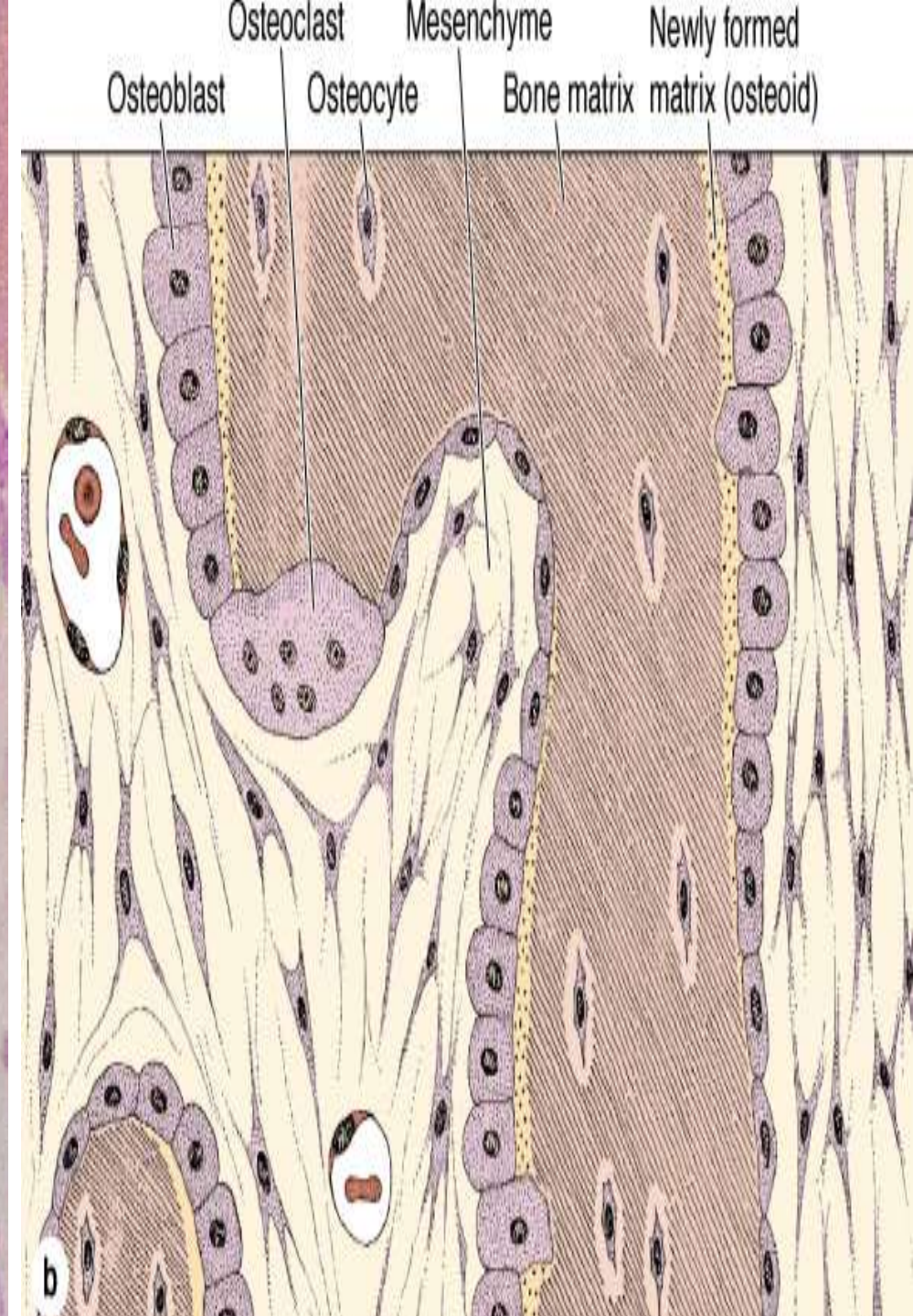
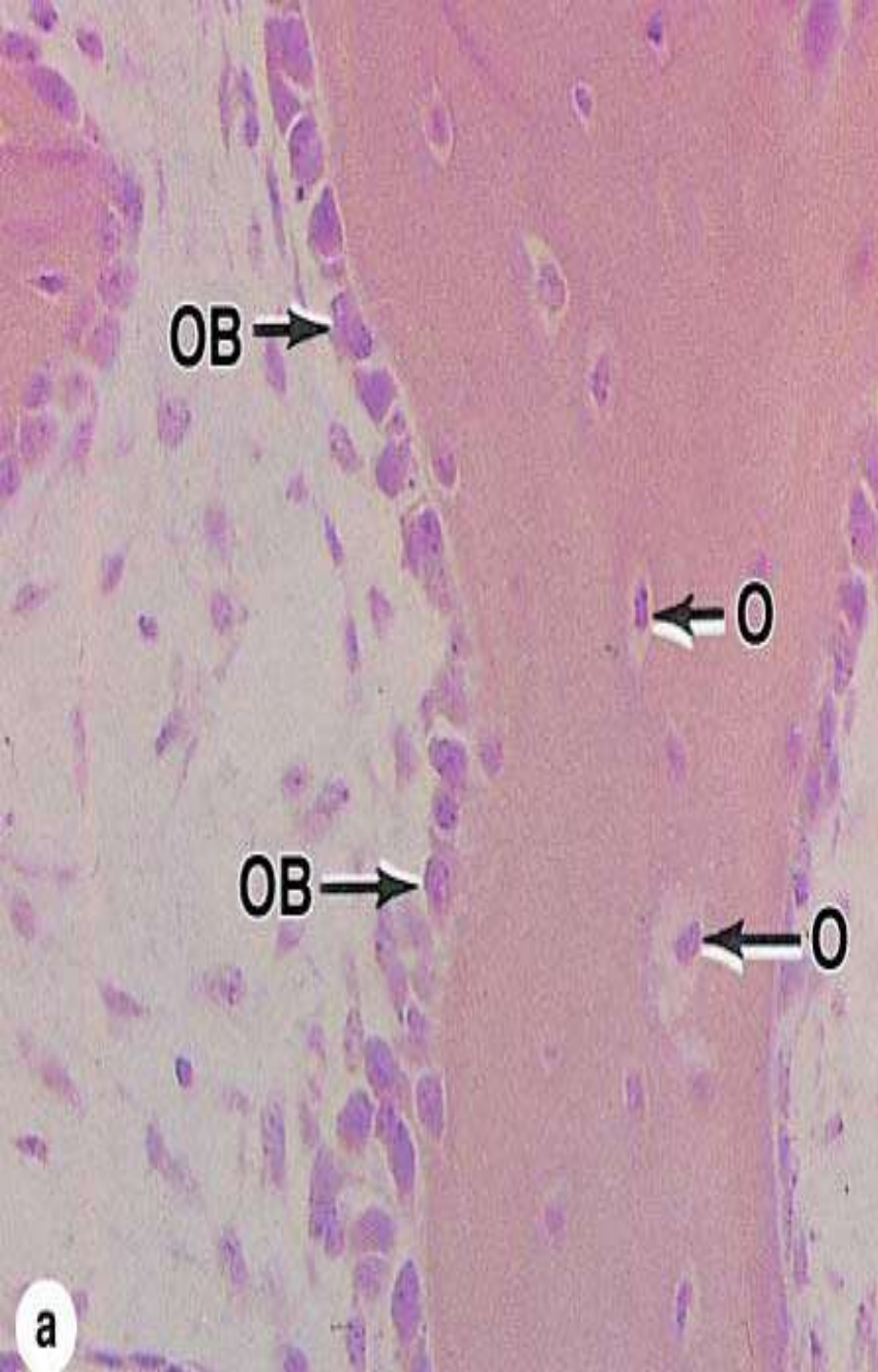
I-Osteoblasts:

i)Osteoblasts are responsible for the synthesis of the organic components of bone matrix, consisting of **type I collagen** fibers, **proteoglycans**, and several **glycoproteins** including osteonectin.

ii) Deposition of the inorganic components of bone also depends on viable osteoblasts. **Osteoblasts** are located exclusively at the surfaces of bone matrix, usually side by side in a layer somewhat resembling a **simple epithelium** .

iii)When they are actively engaged in matrix synthesis, osteoblasts have a **cuboidal to columnar shape** and basophilic cytoplasm. When their synthesizing activity declines, they flatten and cytoplasmic basophilia is reduced. **Osteoblast** activity is stimulated by **parathyroid hormone (PTH)**.

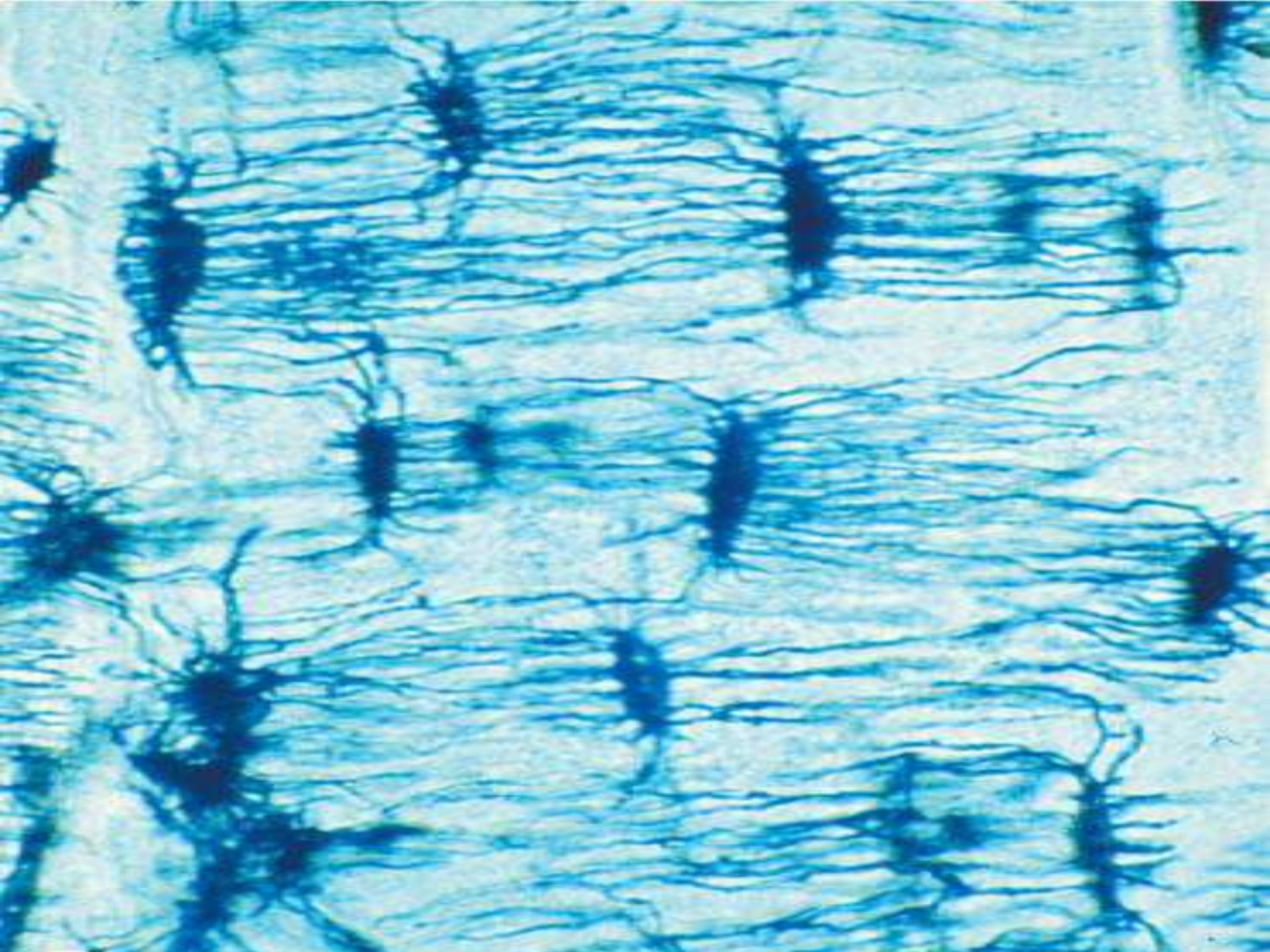
iv) **Osteoblasts** are polarized cells: matrix components are secreted at the cell surface in contact with **older bone matrix**, producing a layer of new (but not yet calcified) material called **osteoid** between the **osteoblast layer** and the bone formed earlier . This process of bone appositional growth is completed by subsequent **deposition of calcium salts** into the newly formed matrix.



II-Osteocytes:

i) Individual osteoblasts are gradually surrounded by their own secretion and become osteocytes enclosed singly within spaces called lacunae. *ii*) In the transition from osteoblasts to osteocytes the cells extend many long cytoplasmic processes, which also become surrounded by calcifying matrix.

iii) An osteocyte and its processes occupy each lacuna and the canaliculi radiating from it. *iv*) Some molecular exchange between osteocytes and blood vessels also takes place through the small amount of extracellular fluid located between osteocytes and the bone matrix. *v*) When compared with osteoblasts, the flat, almond-shaped osteocytes exhibit a significantly reduced RER and Golgi apparatus and more condensed nuclear chromatin. These cells are involved in maintaining the bony matrix and their death is followed by resorption of this matrix.



III-Osteoclasts:

i) **Osteoclasts** are very large, motile cells with multiple nuclei. The large size and multinucleated condition of osteoclasts is due to their origin from the fusion of bone marrow-derived cells.

ii) In areas of bone undergoing resorption, osteoclasts lie within enzymatically etched depressions or crypts in the matrix known as **resorption bays** (formerly called **Howship lacunae**).

iii) In active osteoclasts, the surface against the bone matrix is folded into irregular projections, which form a **ruffled border**. Formation of the ruffled borders is related to the activity of osteoclasts. Surrounding the ruffled border is a clear cytoplasmic zone rich in actin filaments which is the site of adhesion to the bone matrix.

iv) This circumferential adhesion zone creates a microenvironment between the osteoclast and the matrix in which bone resorption occurs .

Into this subcellular pocket the osteoclast secretes collagenase and other enzymes and pumps protons, forming an acidic environment locally for dissolving hydroxyapatite and promoting the localized digestion of collagen.

v) Osteoclast activity is controlled by local signaling factors and hormones. Osteoclasts have receptors for calcitonin, a thyroid hormone, but not for parathyroid hormone.

vi) Osteoblasts activated by PTH produce a cytokine called osteoclast stimulating factor. Thus, activity of these two cells is coordinated and both are essential in bone remodeling.



Bone

Bone

Osteoclast

Bone matrix



c

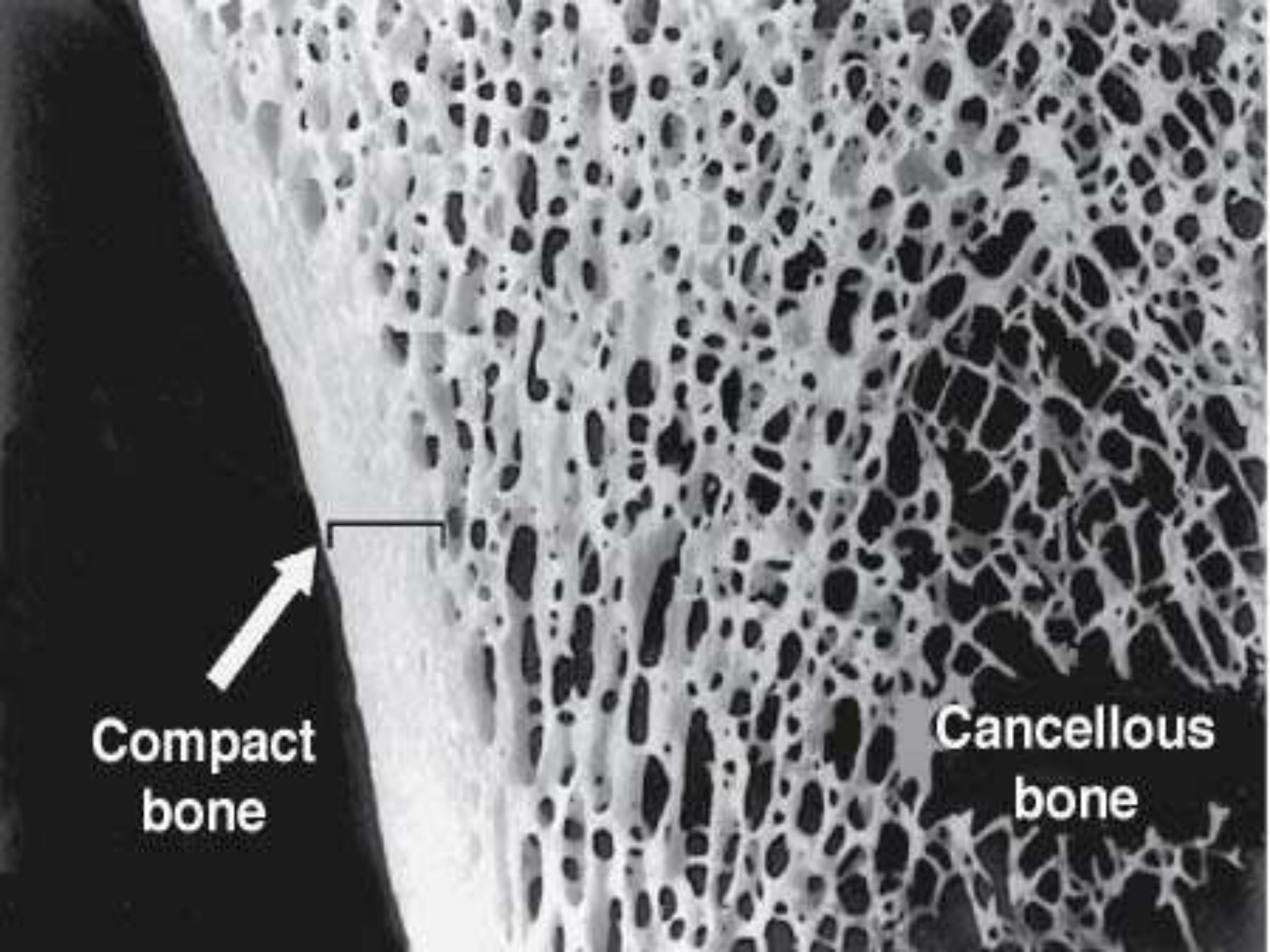
TYPES OF BONE:

I-Gross observation :

1- bone in cross section shows dense areas generally without cavities, corresponding to **compact bone**.

2- areas with numerous interconnecting cavities, corresponding to **cancellous (spongy) bone**. Under the microscope, however, both compact bone and the trabeculae separating the cavities of cancellous bone have the same basic histologic structure.

3- **In long bones**, the bulbous ends, called **epiphyses**, are composed of spongy bone covered by a thin layer of compact bone. The cylindrical part, the **diaphysis**, is almost totally composed of compact bone, with a thin component of spongy bone on its inner surface around the **bone marrow cavity**.



A black and white micrograph of bone tissue. On the left, a thick, dark, and relatively uniform band represents compact bone. To its right is a large area of cancellous bone, characterized by a highly porous, honeycomb-like structure with many irregular, dark, oval-shaped spaces (trabeculae) separated by a network of thin, light-colored bone tissue. A white arrow points from the text 'Compact bone' to the dark band. A bracket is positioned between the compact and cancellous bone, and the text 'Cancellous bone' is located in the lower right area of the porous structure.

**Compact
bone**

**Cancellous
bone**

4-Short bones usually have a core of spongy bone surrounded completely by compact bone. The flat bones that form the calvaria (skullcap) have two layers of compact bone called **plates** (tables), separated by a thicker layer of spongy bone called **the diploë**.

5- A plate of epiphyseal cartilage is divided into five zones , starting from the **epiphyseal side of cartilage**:

A-The resting zone consists of hyaline cartilage with typical chondrocytes.

B. In the proliferative zone, chondrocytes begin to divide rapidly and form columns of stacked cells parallel to the long axis of the bone.

C-The hypertrophic cartilage zone contains swollen chondrocytes whose cytoplasm has accumulated glycogen.

Hypertrophy compresses the matrix into thin septa between the chondrocytes.

D-In the calcified cartilage zone, loss of the chondrocytes by apoptosis is accompanied by calcification of the septa of cartilage matrix by the formation of **hydroxyapatite** crystals.

E-In the ossification zone, bone tissue first appears. Capillaries and **osteoprogenitor cells** originating from the **periosteum** invade the cavities left by the **chondrocytes**. Many of these cavities will be merged and become the marrow cavity. **The osteoprogenitor cells** form osteoblasts, which **settle** in a discontinuous layer over the septa of calcified cartilage matrix. **The osteoblasts** deposit osteoid over the spicules of calcified cartilage matrix, forming woven bone.

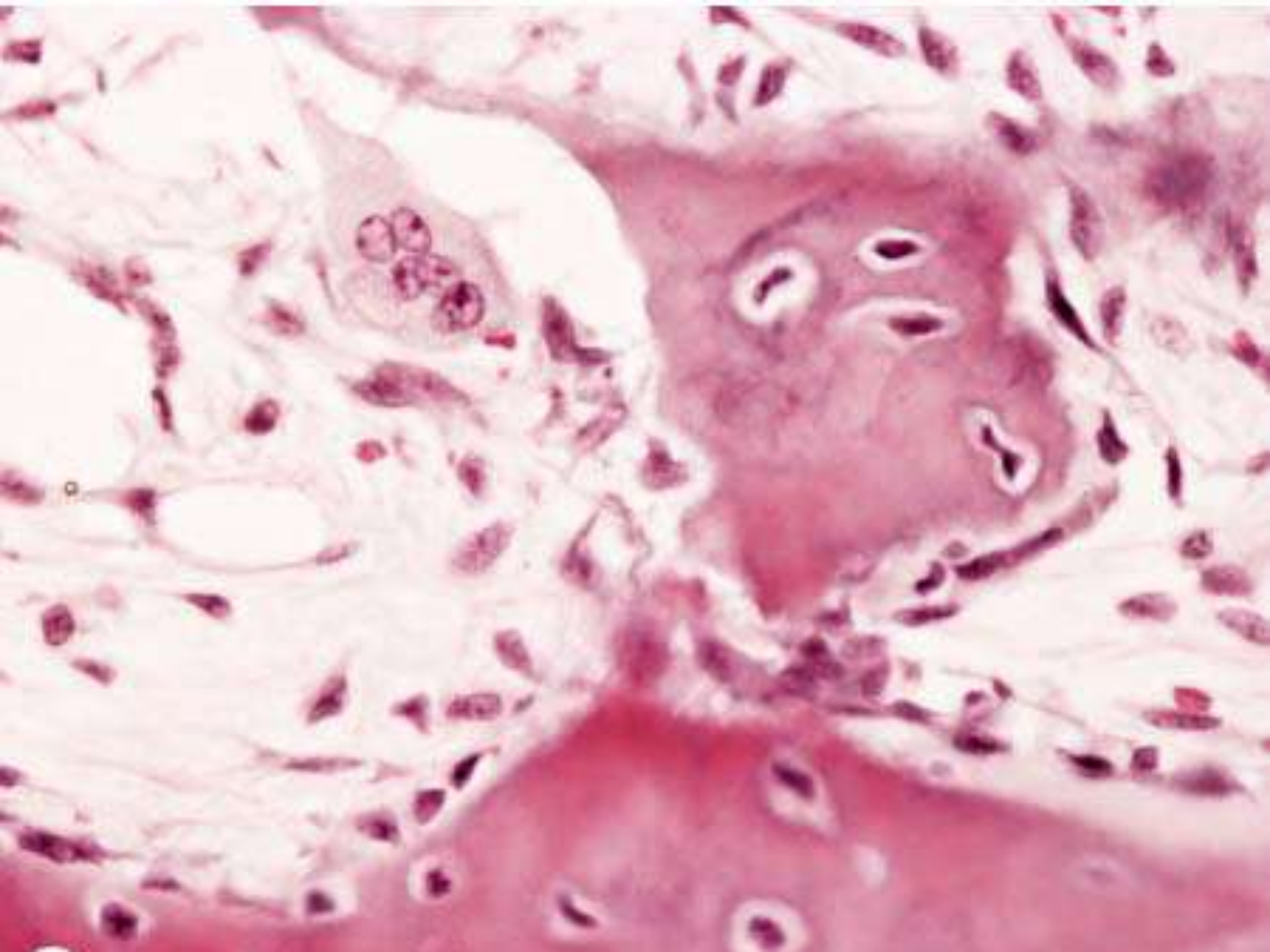
II-Microscopic examination of bone shows two types: immature **primary bone** and mature **secondary bone**.

1-Primary Bone Tissue.

*i)*Primary bone is the first bone tissue to appear in **embryonic development and in fracture repair**. It is characterized by random disposition of **fine collagen fibers** and is therefore often called **woven bone** .

*ii)*Primary bone tissue is usually **temporary** and is replaced in adults by **secondary bone tissue** except in a very few places in the body, eg, near the sutures of the calvaria, in tooth sockets, and in the insertions of some **tendons**.

*iii)*In addition to the irregular array of collagen fibers, other characteristics of **primary bone tissue** are a **lower mineral content** (it is more easily penetrated by x-rays) and a higher proportion of **osteocytes** than that in **secondary bones**.



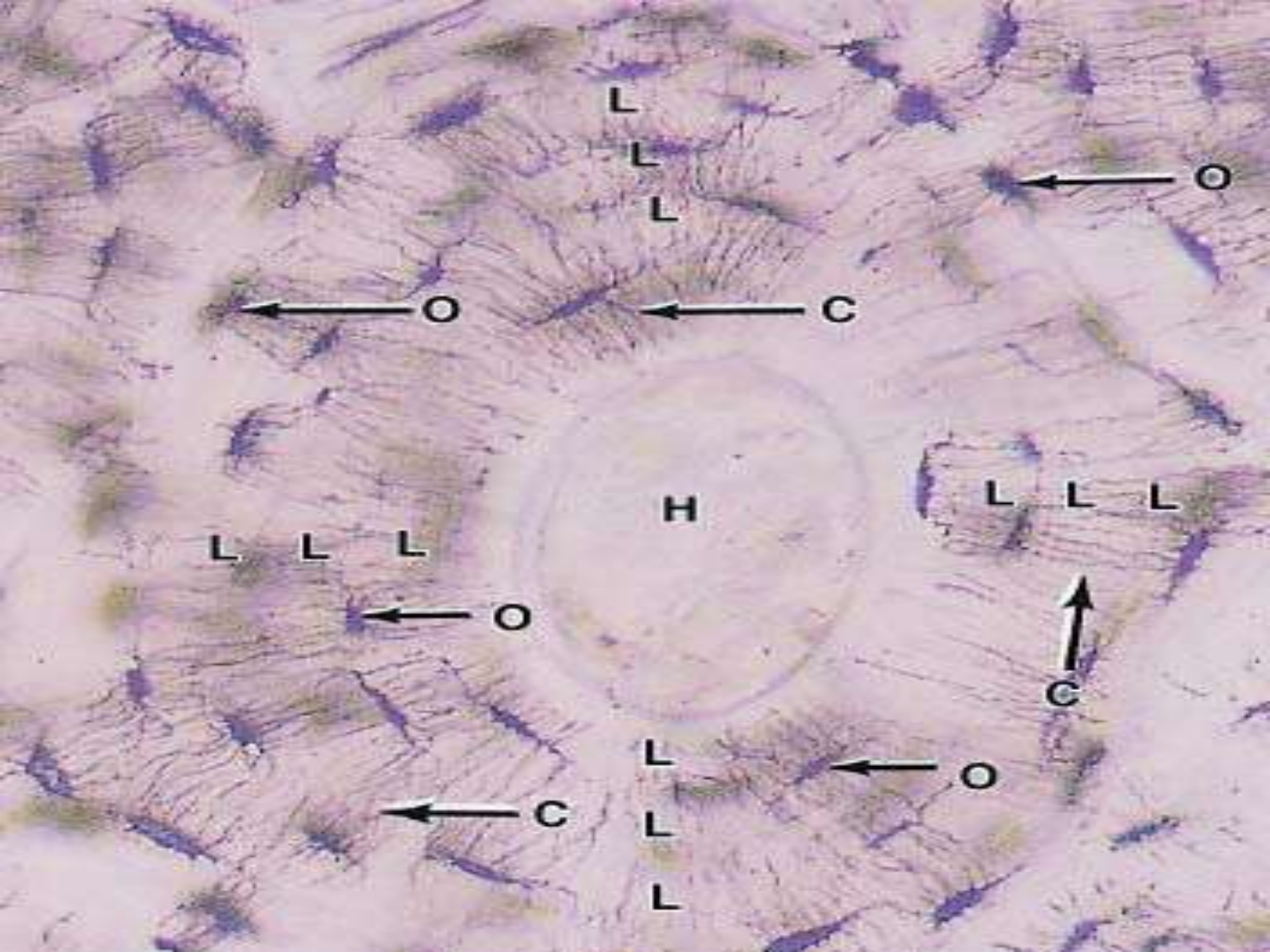
2-Secondary Bone Tissue.

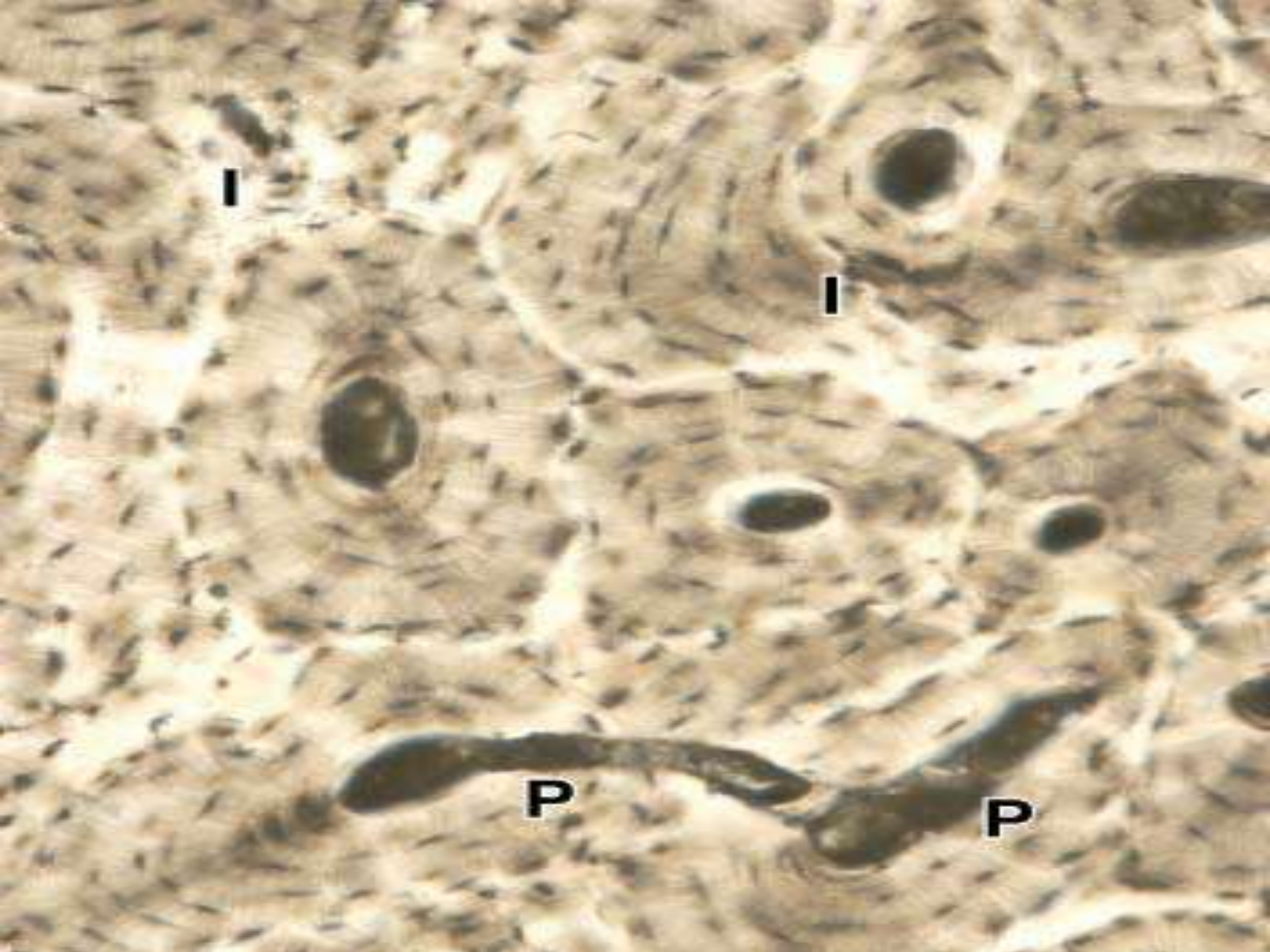
i) Secondary bone tissue is the type usually found in adults. It characteristically shows multiple layers of calcified matrix and is often referred to as **lamellar bone**. The lamellae are quite organized, either parallel to each other or concentrically around a vascular canal.

ii) Each complex of concentric bony lamellae surrounding a small canal containing blood vessels, nerves, and loose connective tissue is called an **osteon** (formerly known as an **haversian system**) .

iii) **Lacunae** with osteocytes are found between the lamellae, interconnected by **canaliculi** which allow all cells to be in contact with the source of nutrients and oxygen in the **osteonic canal**. The outer boundary of each osteon is a more collagen-rich layer called the **cement line**.







JOINTS:

1-Joints are regions where bones are capped and surrounded by connective tissues that firmly hold the bones together and determine the type and degree of movement between them.

2- Joints may be classified as **diarthroses**, which permit free bone movement, and **synarthroses** , in which very limited or no movement occurs.

Synarthroses Joints :

There are three types of synarthroses, based on the type of tissue uniting the bone surfaces:

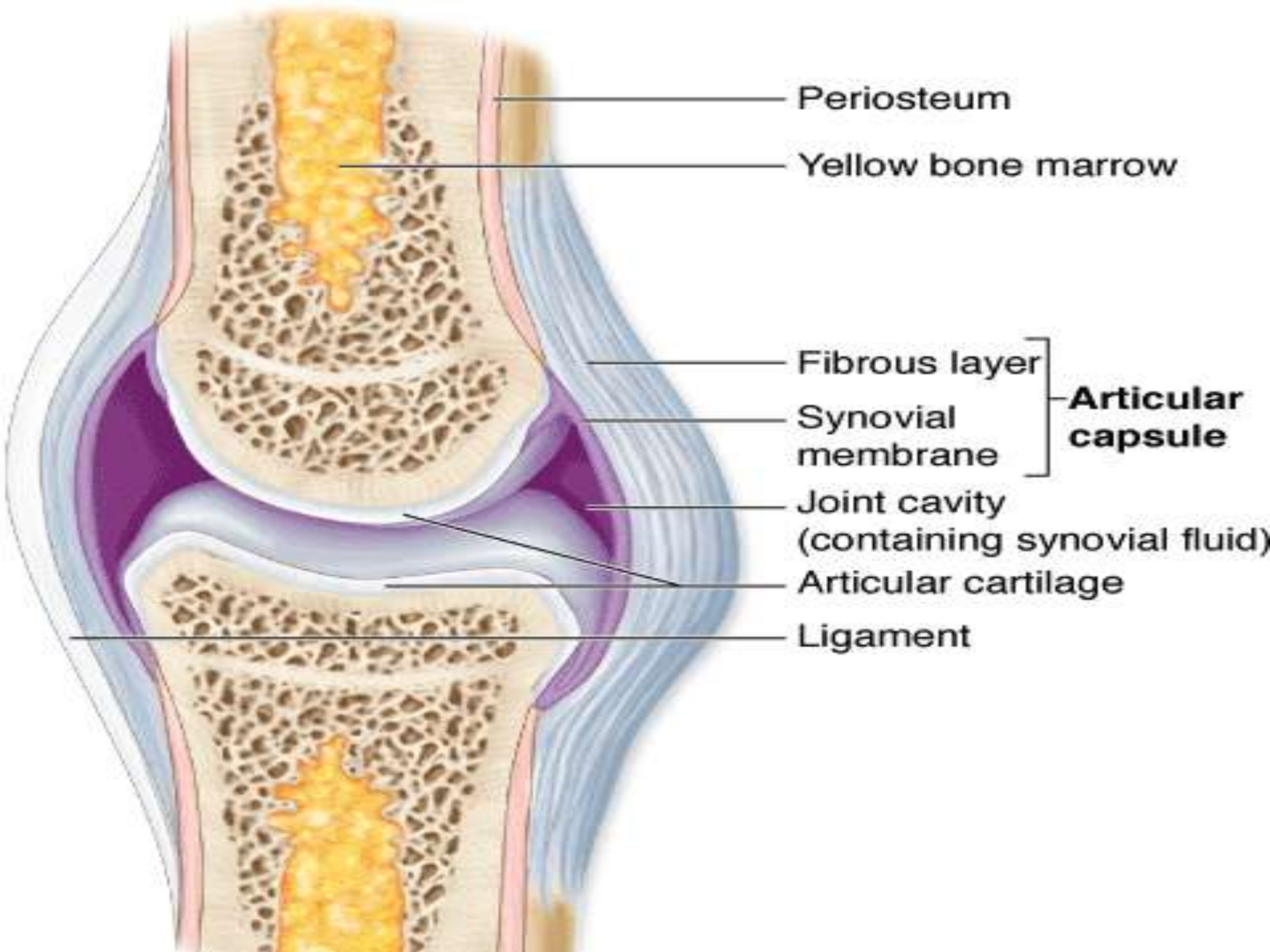
i) Synostoses, in which bones are united by bone tissue and no movement takes place. In older adults, synostoses unite the skull bones, which, in children and young adults, are united only by dense connective tissue.

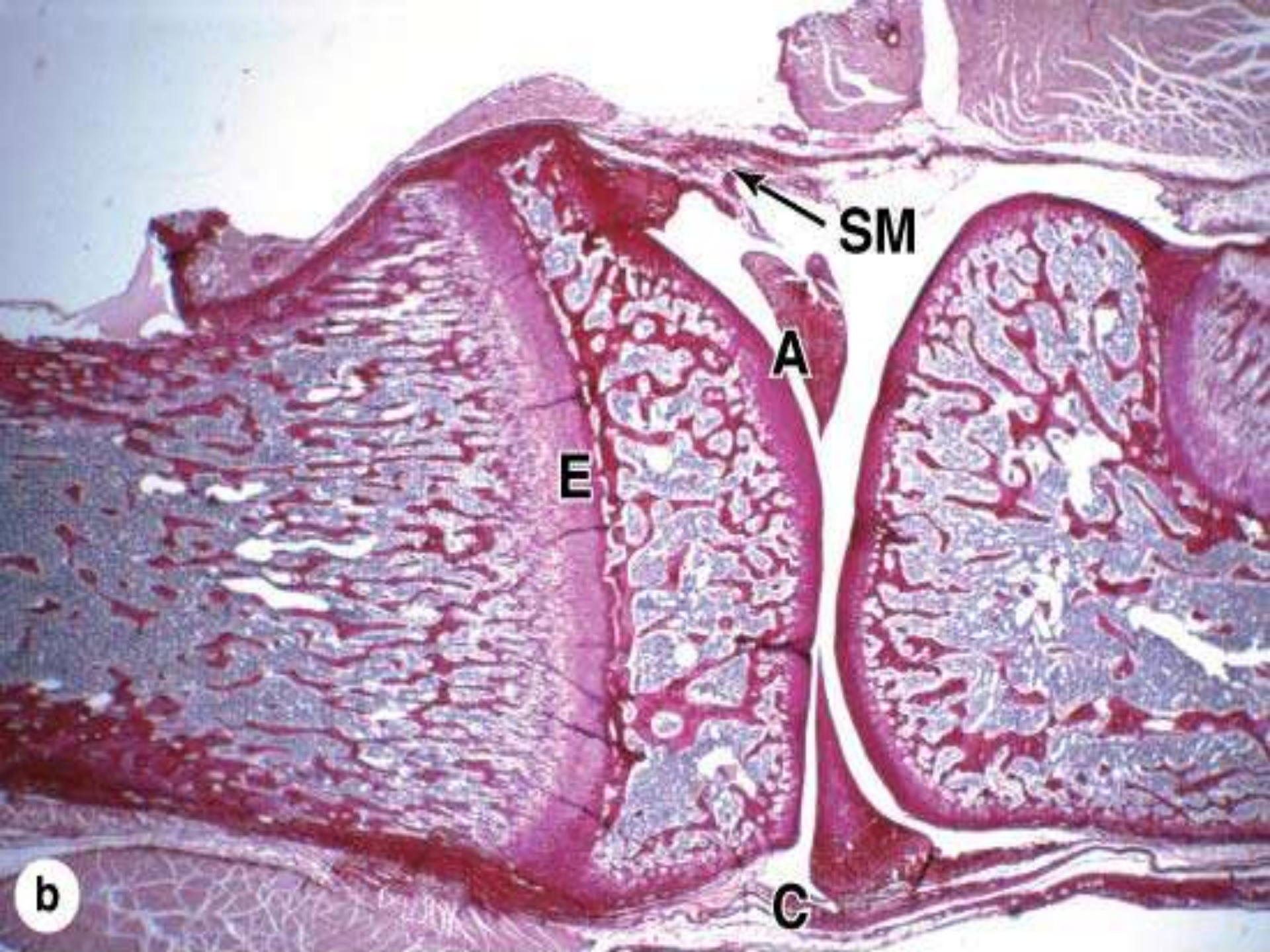
ii) Synchrondroses, in which the bones are joined by hyaline cartilage. The epiphyseal plates of growing bones are one example and in adults a synchrondrosis unites the first rib to the sternum, with little movement.

iii) Syndesmoses, in which bones are joined by an interosseous ligament of dense connective tissue or fibrocartilage (eg, the pubic symphysis,) again with very limited movement.

Diarthroses Joints:

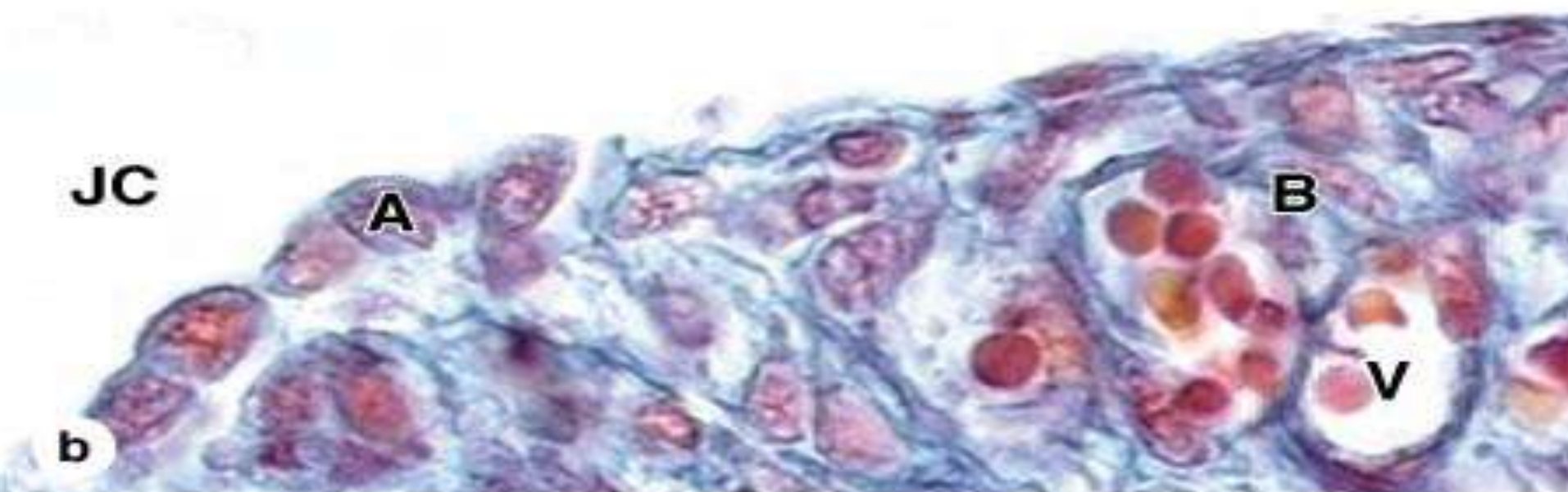
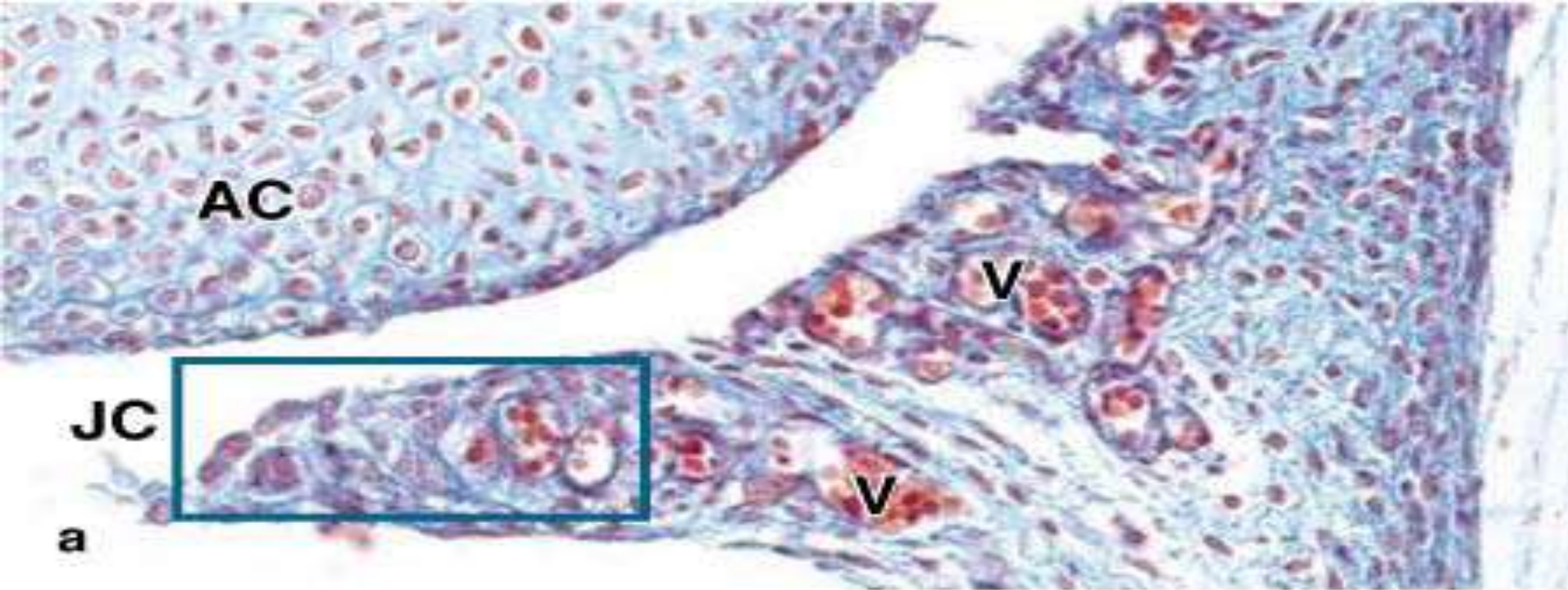
- i)* Diarthroses are joints that generally unite long bones and have great mobility, such as the elbow and knee joints.
- ii)* In a diarthrosis, ligaments and a capsule of dense connective tissue maintain proper alignment of the bones.
- iii)* The capsule encloses a sealed **joint cavity** that contains **synovial fluid**, a colorless, transparent, viscous fluid.
- iv)* The joint cavity is not lined by epithelium, but by a specialized connective tissue called the **synovial membrane** which extends folds and villi into the cavity and secretes the lubricant synovial fluid.
- v)* Synovial fluid is derived from blood plasma, but with a high concentration of hyaluronic acid produced by cells of the synovial membrane.





Synovial membrane:

- 1-The synovial membrane or layer may have prominent regions with various types of connective tissue (areolar, fibrous, or adipose) in different diarthrotic joints.
- 2- At the surface contacting the synovial fluid the tissue is usually well-vascularized, with many porous (fenestrated) capillaries, and contains two specialized cells(synoviocytes) with distinctly different functions and origins .
- 3-Rounded synoviocytes in contact with the synovial cavity are phagocytic and remove wear-and-tear debris from the synovial fluid.



4- Among the capillaries are many more fibroblastic synoviocytes specialized to produce the long, non sulfated glycosaminoglycan (GAG) hyaluronic acid and secrete other components of ground substance.

5-These GAGs along with plasma from the capillaries leave the synovial membrane, oozing into the synovial fluid. This viscous, gel-like fluid lubricates the joint, reducing friction on all internal surfaces, and supplies nutrients and oxygen to the articular cartilage.

Macrophagelike
cell

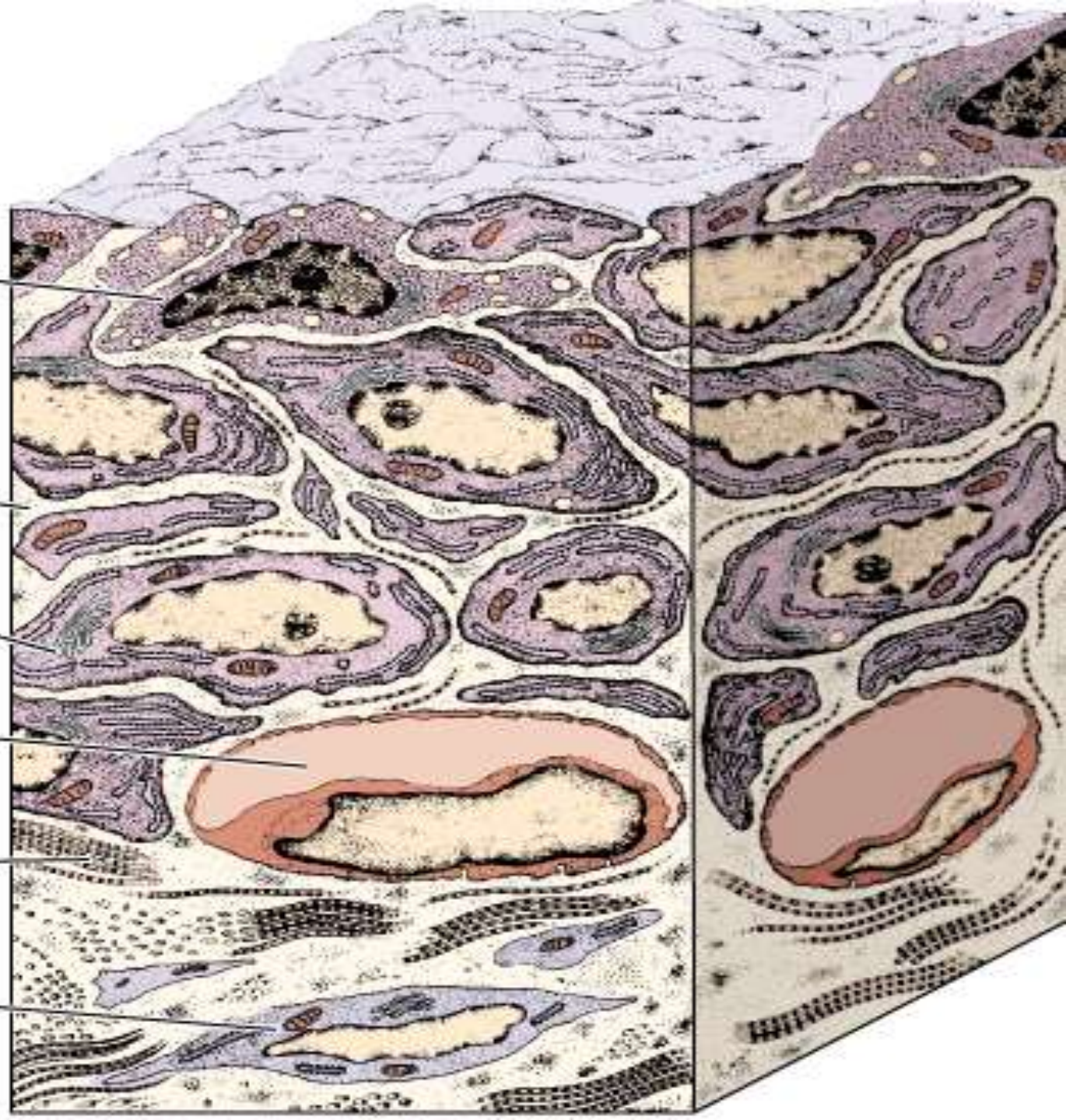
Ground
substance

Fibroblast-like
cell

Fenestrated
blood capillary

Collagen
fibrils

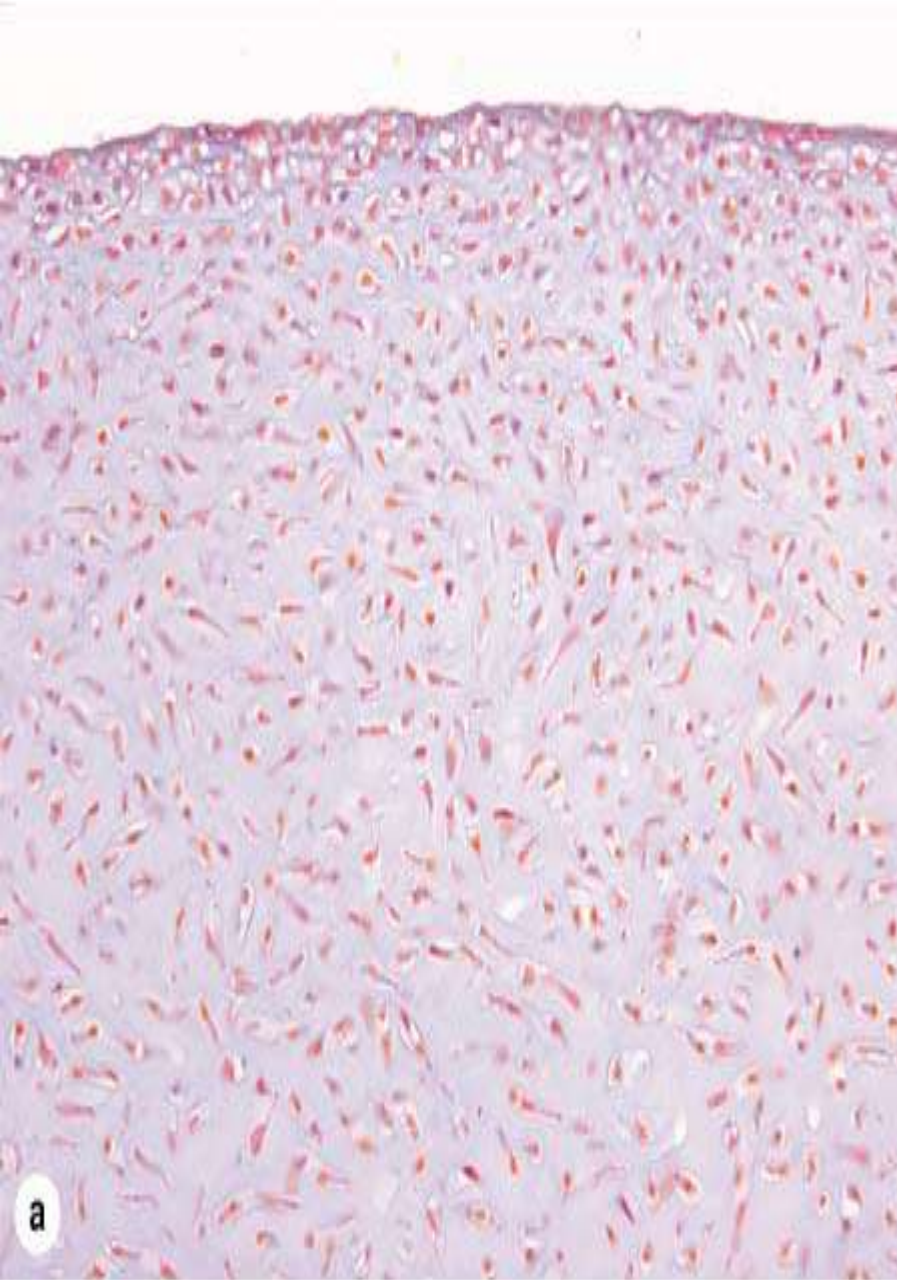
Fibroblast



6-The collagen fibers of the hyaline articular cartilage are disposed as arches with their tops at the exposed surface, which unlike most cartilage is not covered by perichondrium .

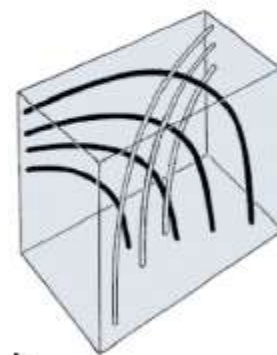
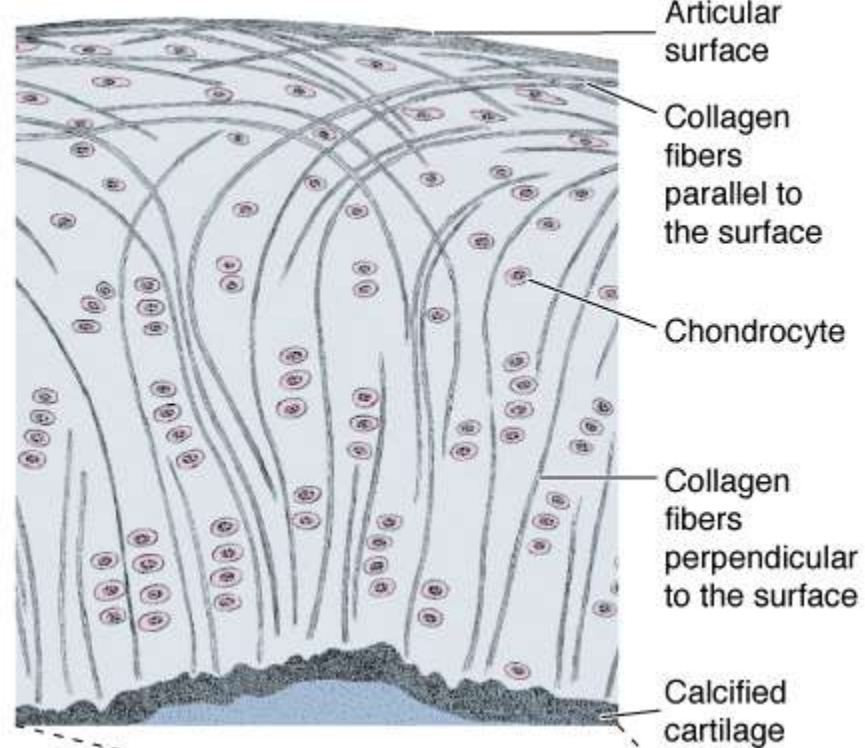
i) This arrangement of collagen helps to distribute more evenly the forces generated by pressure on joints.

ii) The resilient articular cartilage is also an efficient absorber of the intermittent mechanical pressures to which many joints are subjected.

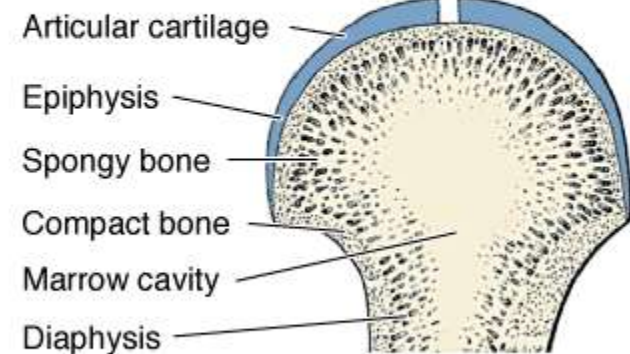


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Intervertebral disks:

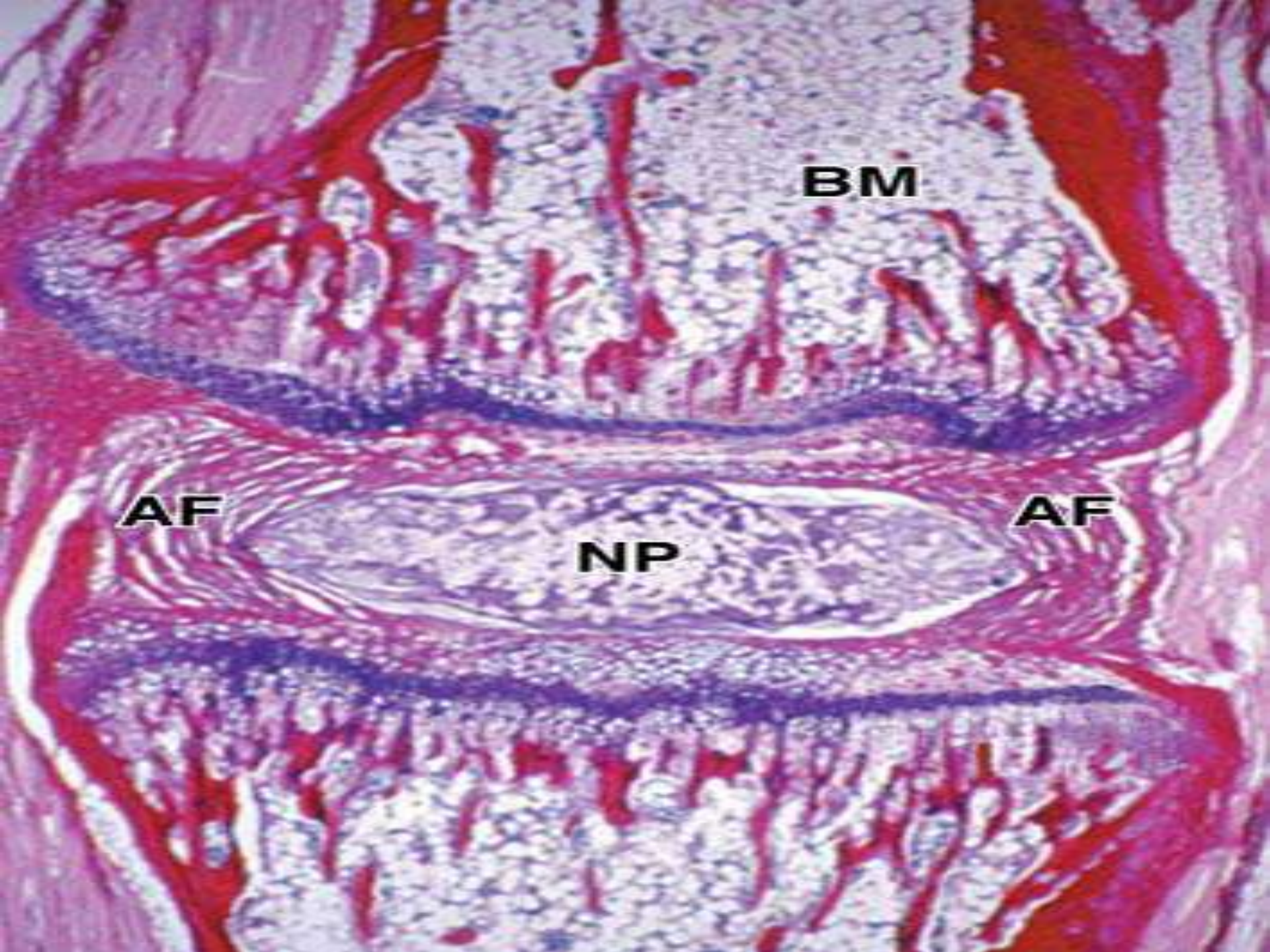
1-A similar mechanism is seen in **intervertebral disks** which are thick disks of fibrocartilage between the articular surfaces of successive bony vertebrae.

2-The **annulus fibrosus** of each disk has an external layer of dense connective tissue, but is mainly composed of overlapping laminae of fibrocartilage in which collagen bundles are orthogonally arranged in adjacent layers.

3-The multiple lamellae, with the 90-degree registration of type I collagen fibers in adjacent layers, provide the disk with unusual resilience that enables it to withstand the pressures generated by the impinging vertebrae.

4-The nucleus pulposus is situated in the center of the annulus fibrosus. It may contain a few scattered cells derived from the embryonic notochord, but is largely composed of viscous, gel-like matrix rich in hyaluronic acid and fibers of type II collagen.

5-The nucleus pulposus is large in children, but gradually becomes smaller with age and is partially replaced by fibrocartilage. The nucleus pulposus allows each intervertebral disk to function as a shock absorber within the spinal column.



BM

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MUSCLE TISSUE:

Three types of muscle tissue .

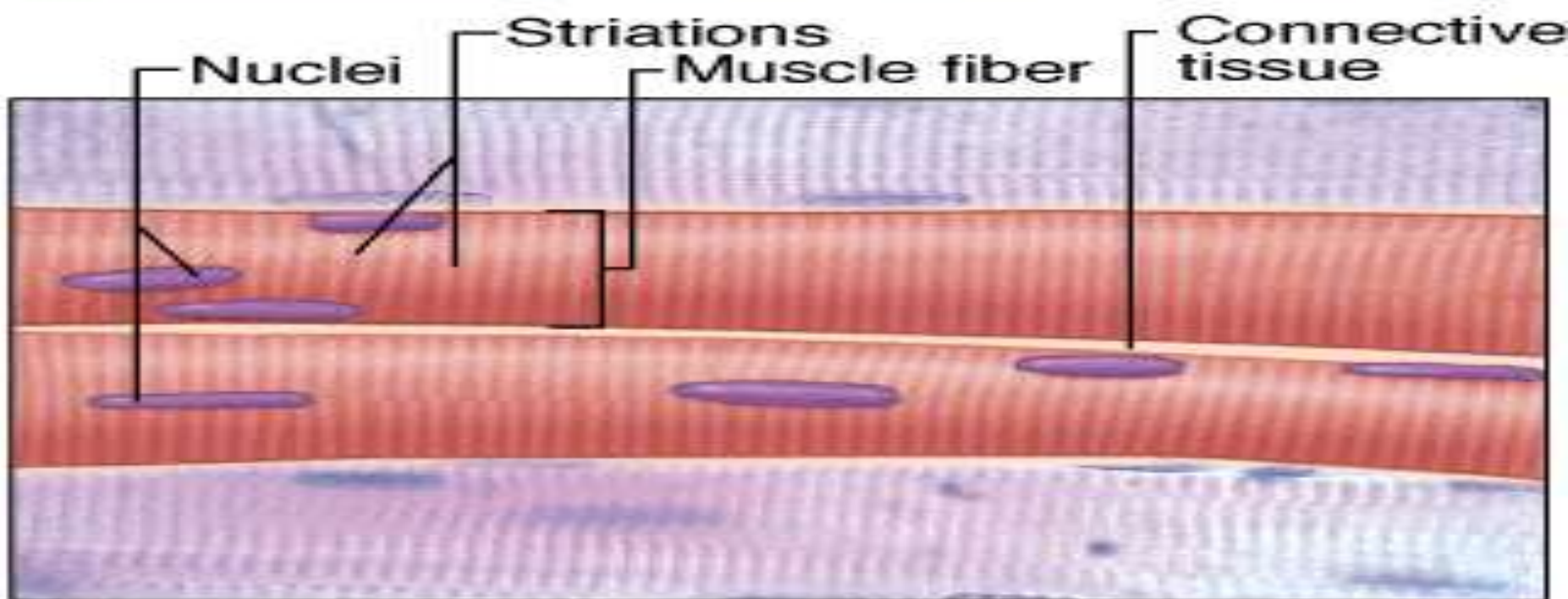
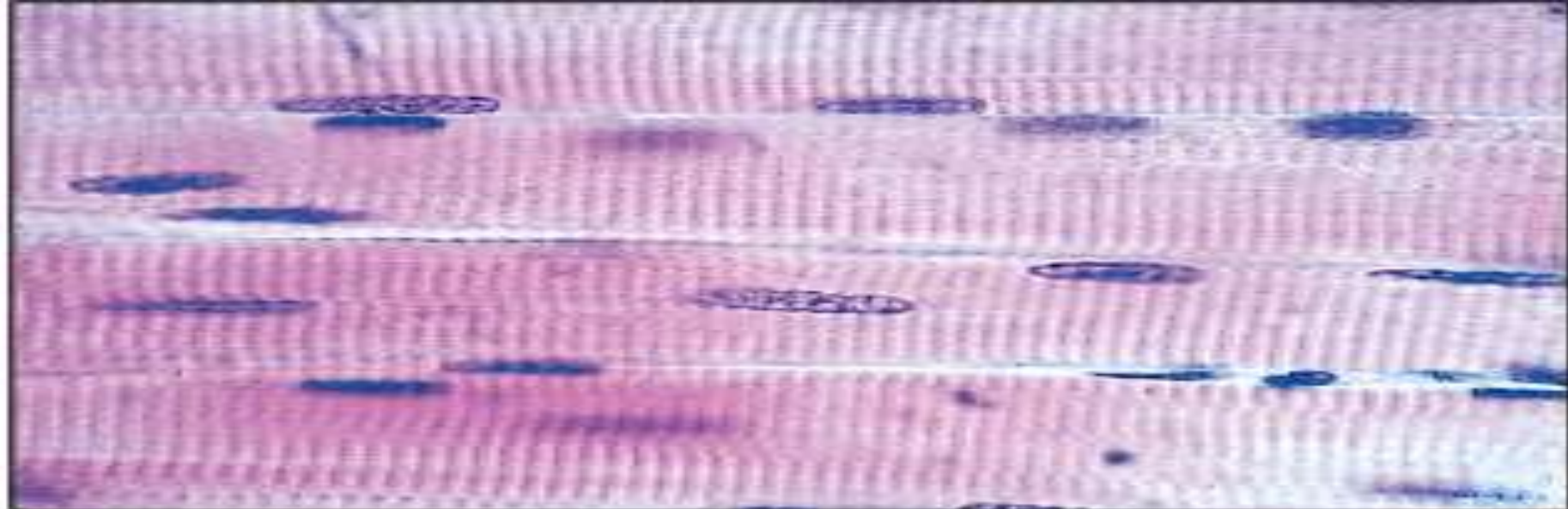
I-Skeletal muscle :

1-Its composed of bundles of very long, cylindrical,multinucleated cells that show cross-striations. Their contraction is quick,forceful, and usually under voluntary control.

2-It is 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.

3-Skeletal muscle consists of **muscle fibers**, Multinucleation 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.

4-This characteristic nuclear location is helpful in discriminating skeletal muscle from cardiac and smooth muscle, both of which have centrally located nuclei.



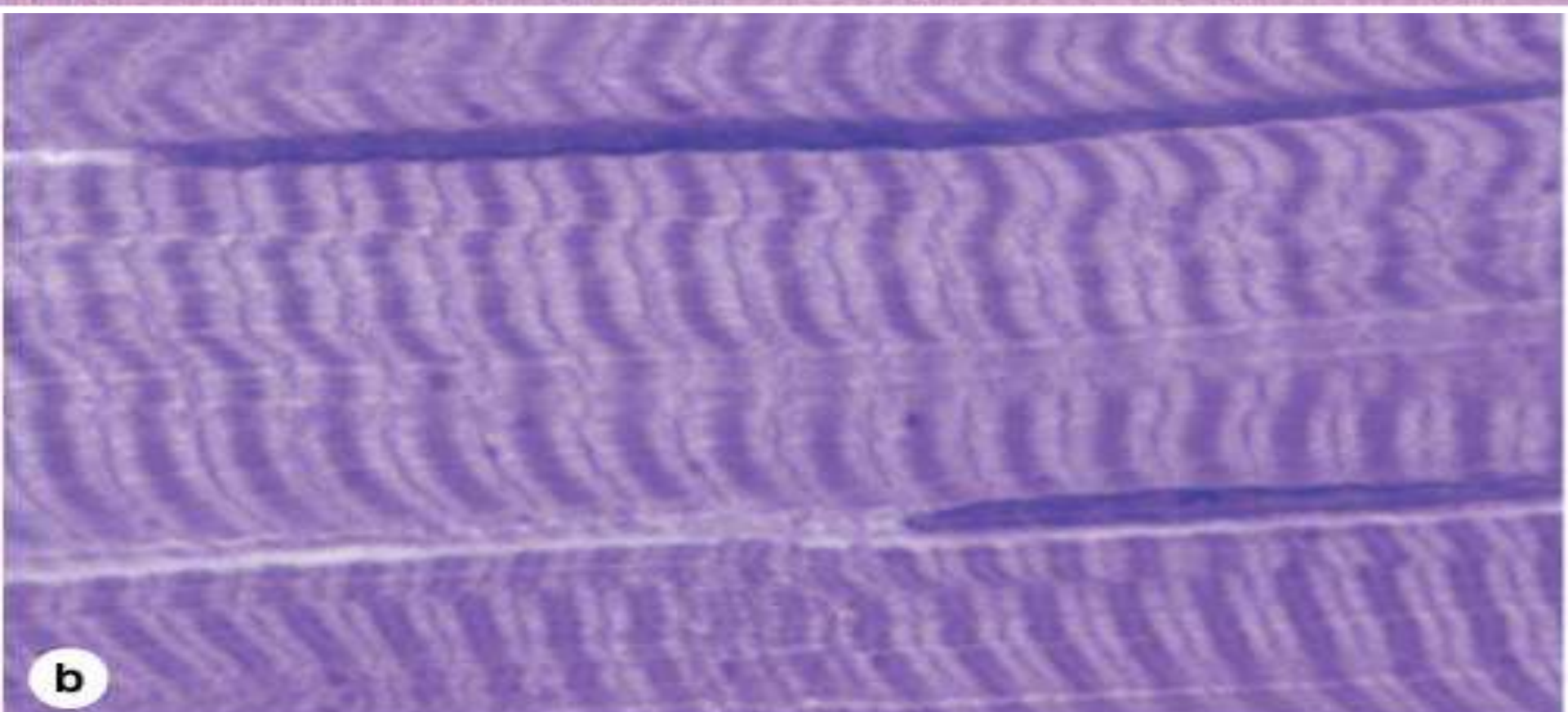
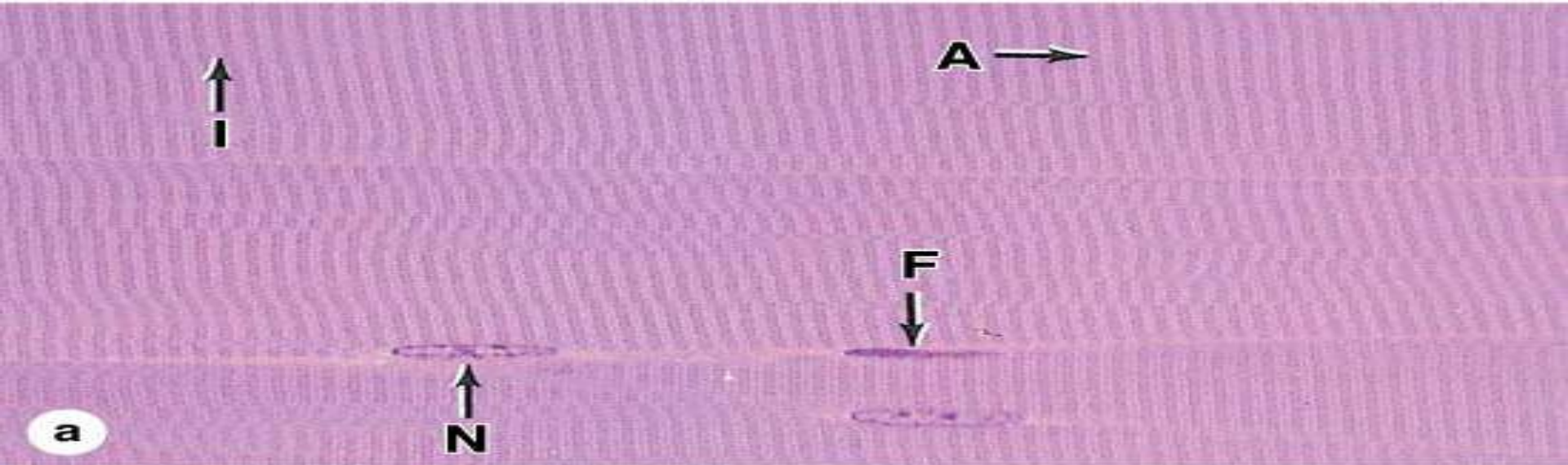
a Skeletal muscle

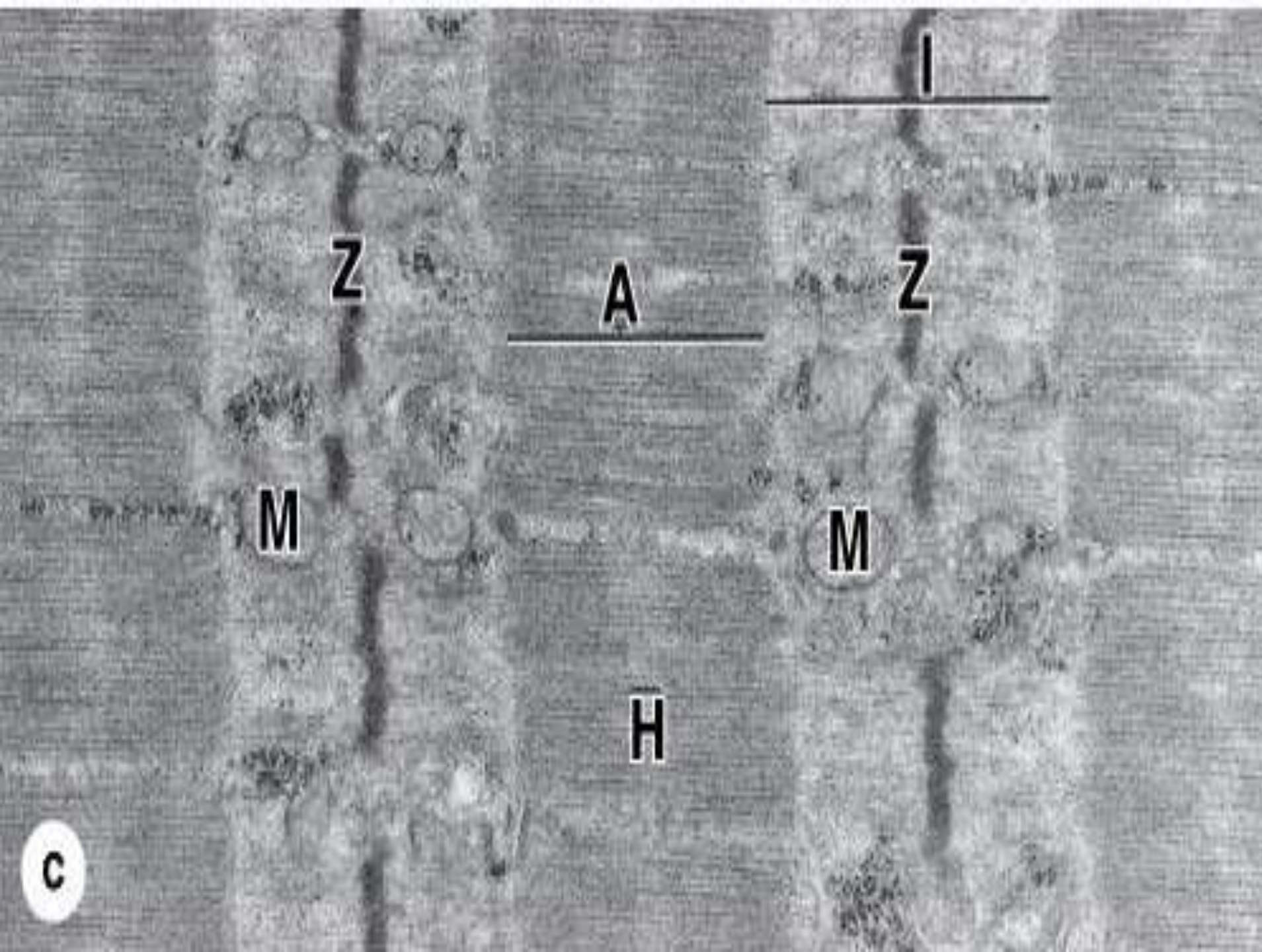
Skeletal Muscle Fibers:

1-As observed with the light microscope, longitudinally sectioned skeletal muscle fibers show cross-striations of alternating light and dark bands .

2-The darker bands are called **A bands** (*anisotropic* or birefringent in polarized light); the lighter bands are called **I bands** (*isotropic*, do not alter polarized light).

3-In the EM each I band is seen to be bisected by a dark transverse line, the **Z line** . The repetitive functional subunit of the contractile apparatus, the **sarcomere**, extends from Z line to Z line .



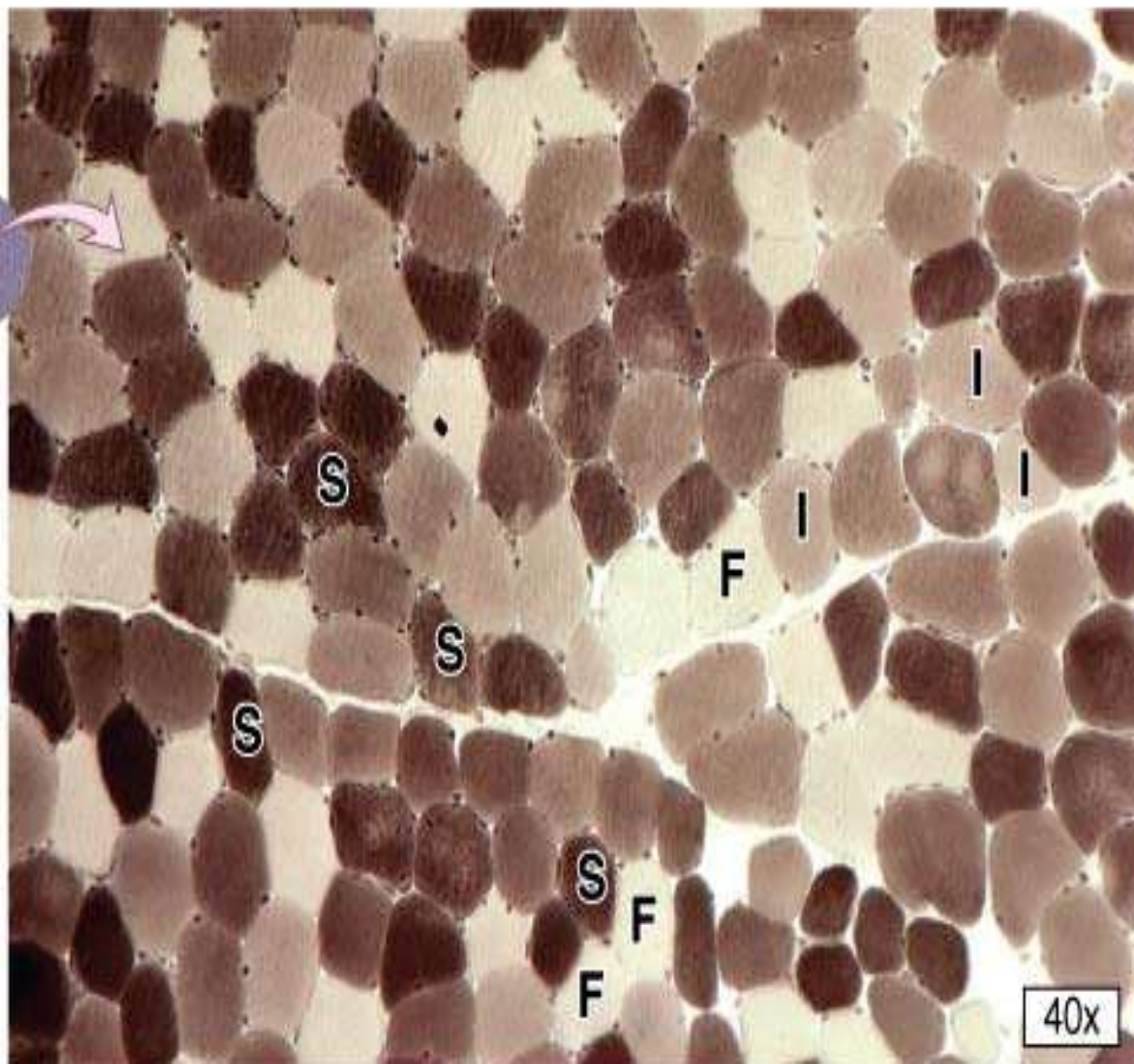
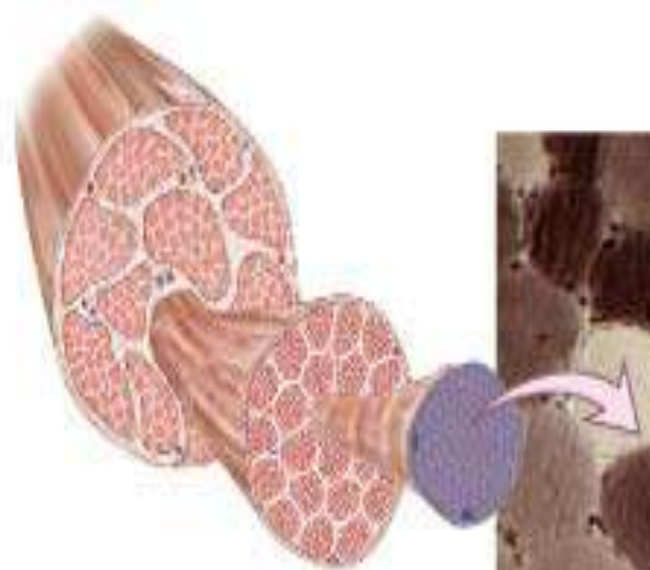


4-Skeletal muscle fibers of humans are classified into three types based on their physiological, biochemical, and histochemical characteristics. All three fiber types are normally found throughout most muscles.

i) **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.

ii) Type IIa 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.

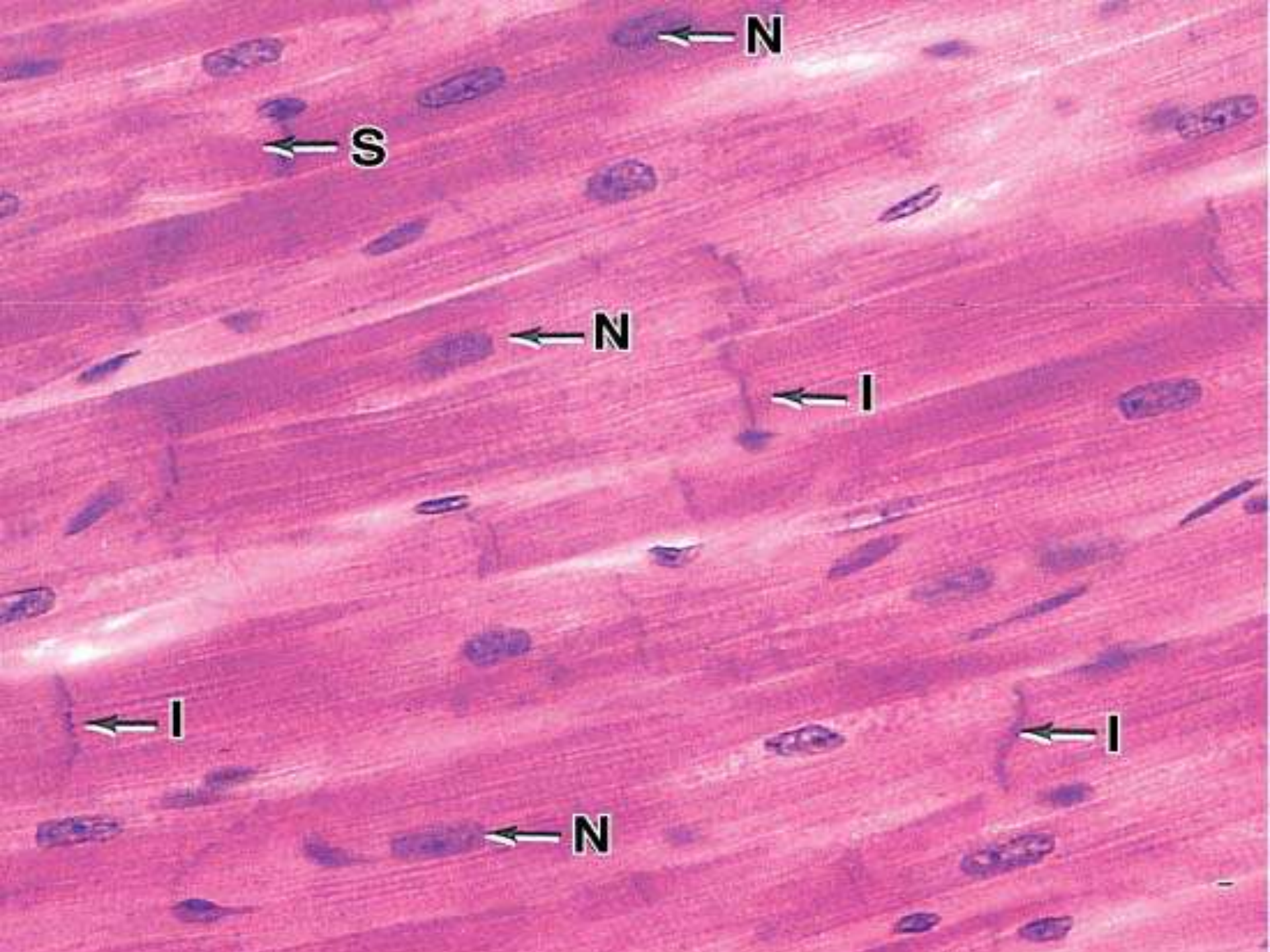
iii) Type IIb or fast, white glycolytic fibers have fewer mitochondria and less myoglobin, but abundant glycogen, making them very pale in color. They depend largely on glycolysis for energy and are adapted for rapid contractions, but fatigue quickly. They are typically small muscles with a relatively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



II-Cardiac muscle:

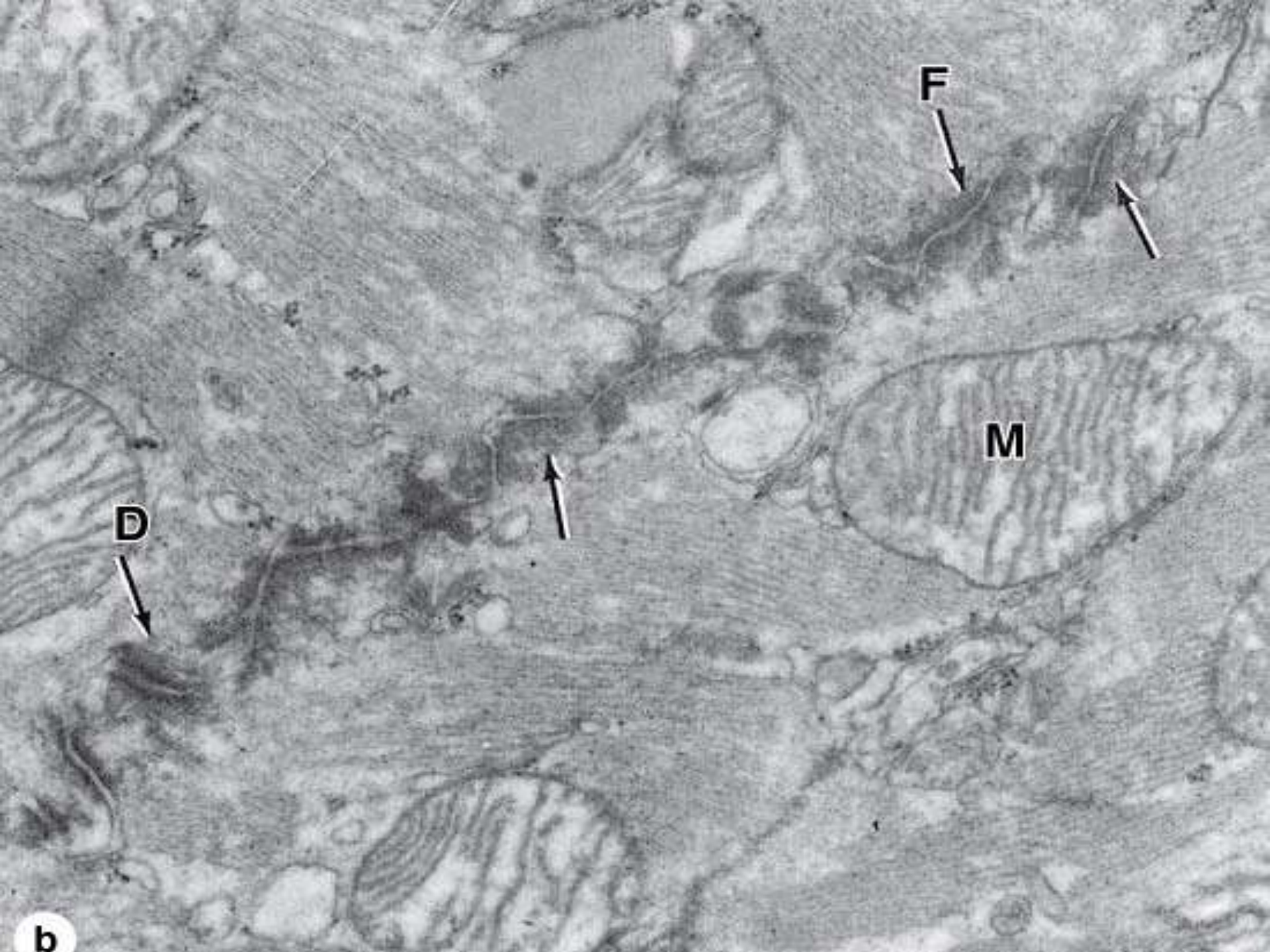
1-They exhibit a cross-striated banding pattern comparable to that of skeletal muscle. Unlike multinucleated skeletal muscle, however, each cardiac muscle cell possesses only one or two centrally located pale-staining nuclei. Surrounding the muscle cells is a delicate sheath of endomysium containing a rich capillary network.

2-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 .



3-Transverse regions of these steplike discs have many **desmosomes** and **fascia adherentes** (which resemble the zonula adherentes between epithelial cells) and together these serve to bind cardiac cells firmly together to prevent their pulling apart under constant contractile activity.

4-The more longitudinal portions of each disc have multiple **gap junctions**, which provide ionic continuity between adjacent cells. These act as "electrical synapses" and allow cells of cardiac muscle to act as in a multinucleated syncytium, with contraction signals passing in a wave from cell to cell.



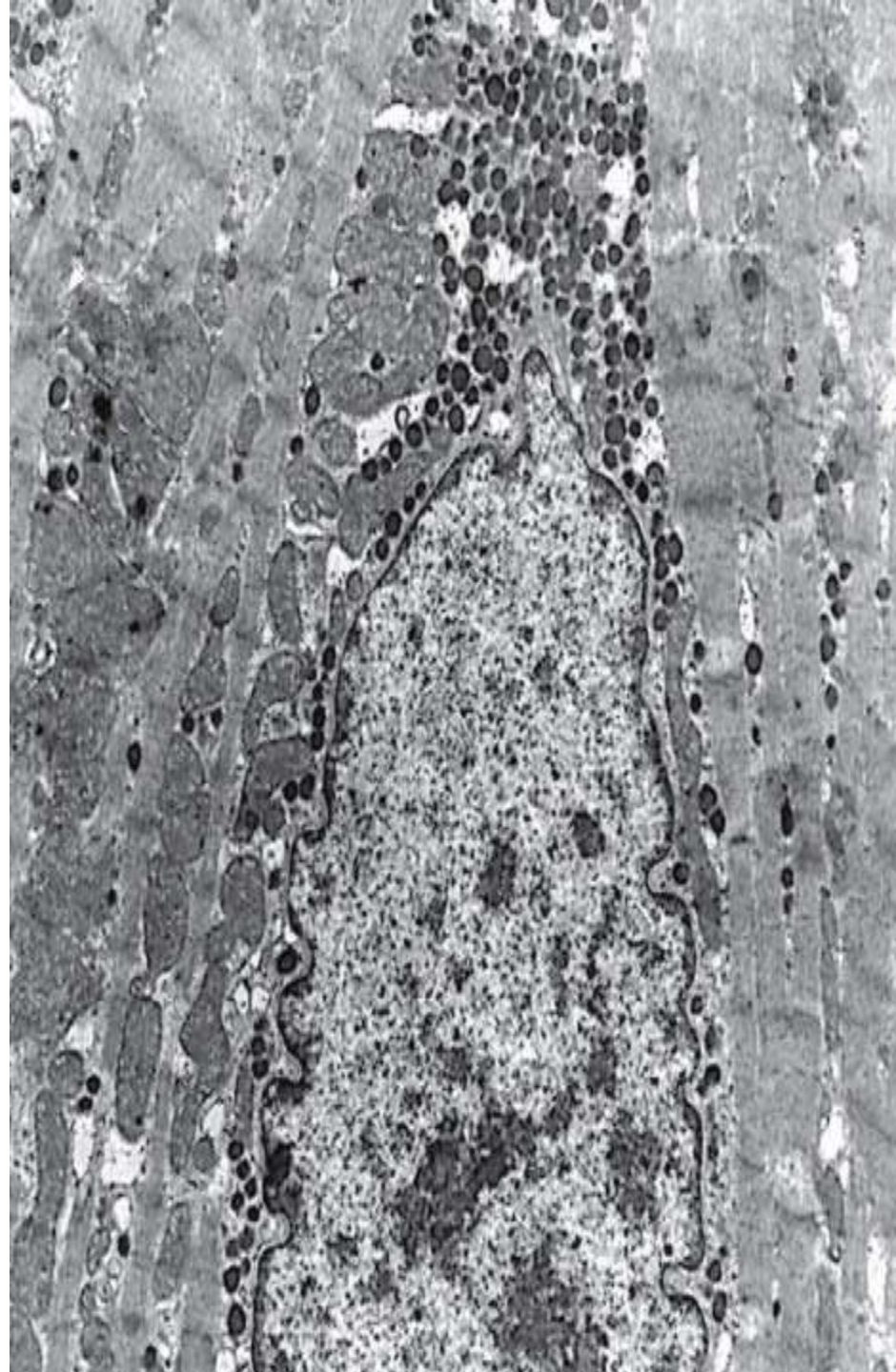
5-A few differences in structure exist between atrial and ventricular muscle.

a) The arrangement of myofilaments is the same in both, but atrial muscle has markedly fewer T tubules, and the cells are somewhat smaller.

b) Membrane-limited granules, are found at the poles of atrial muscle nuclei and are associated with Golgi complexes in this region

c) These granules release the peptide hormone atrial natriuretic factor (ANF) which acts on target cells in the kidney to affect Na^+ excretion and water balance.

d) The contractile cells of the heart's atria thus also serve an endocrine function.



III-Smooth muscle :

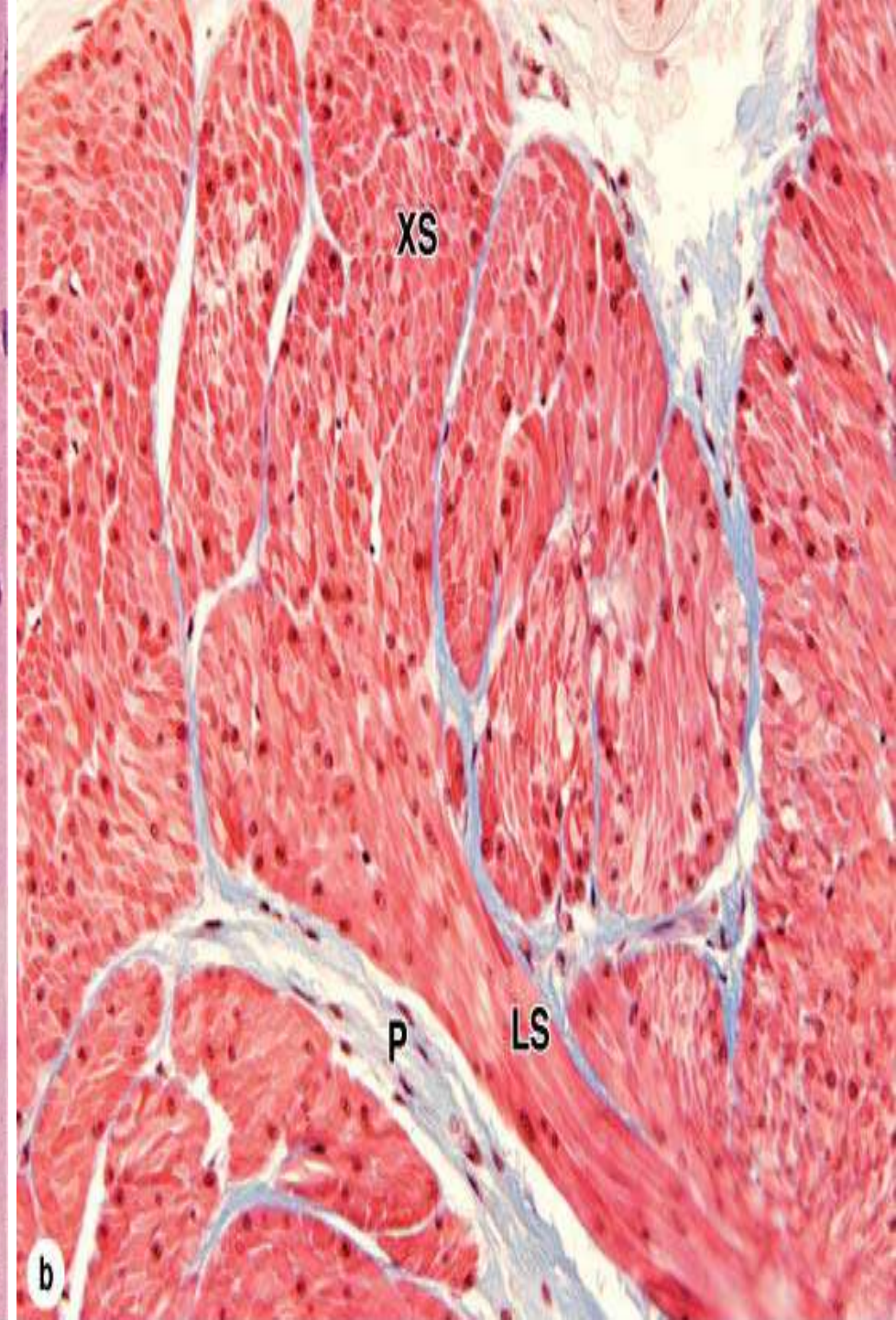
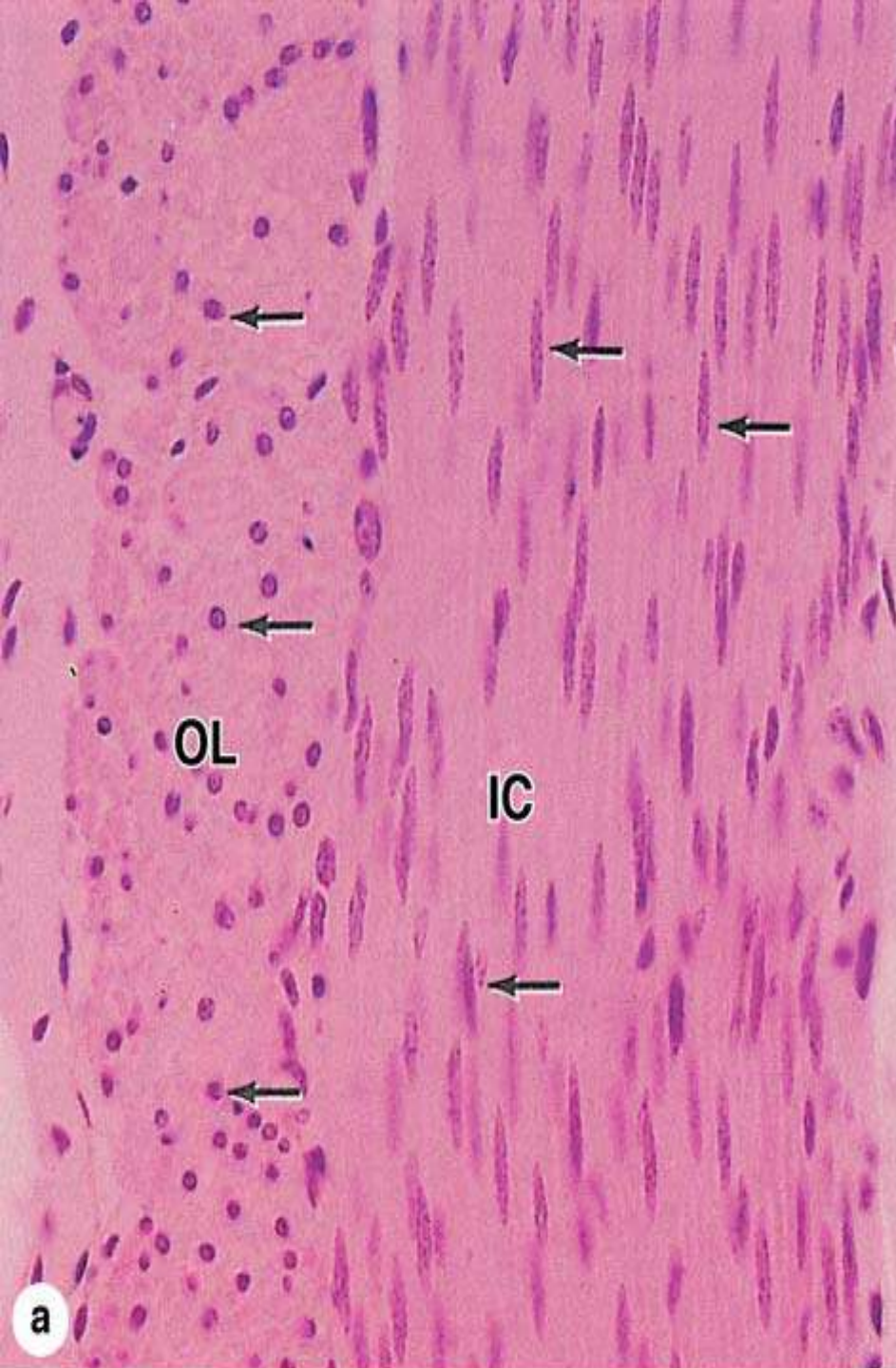
1-It is consists of collections of fusiform cells that do not show striations. Their contraction process is slow and not subject to voluntary control.

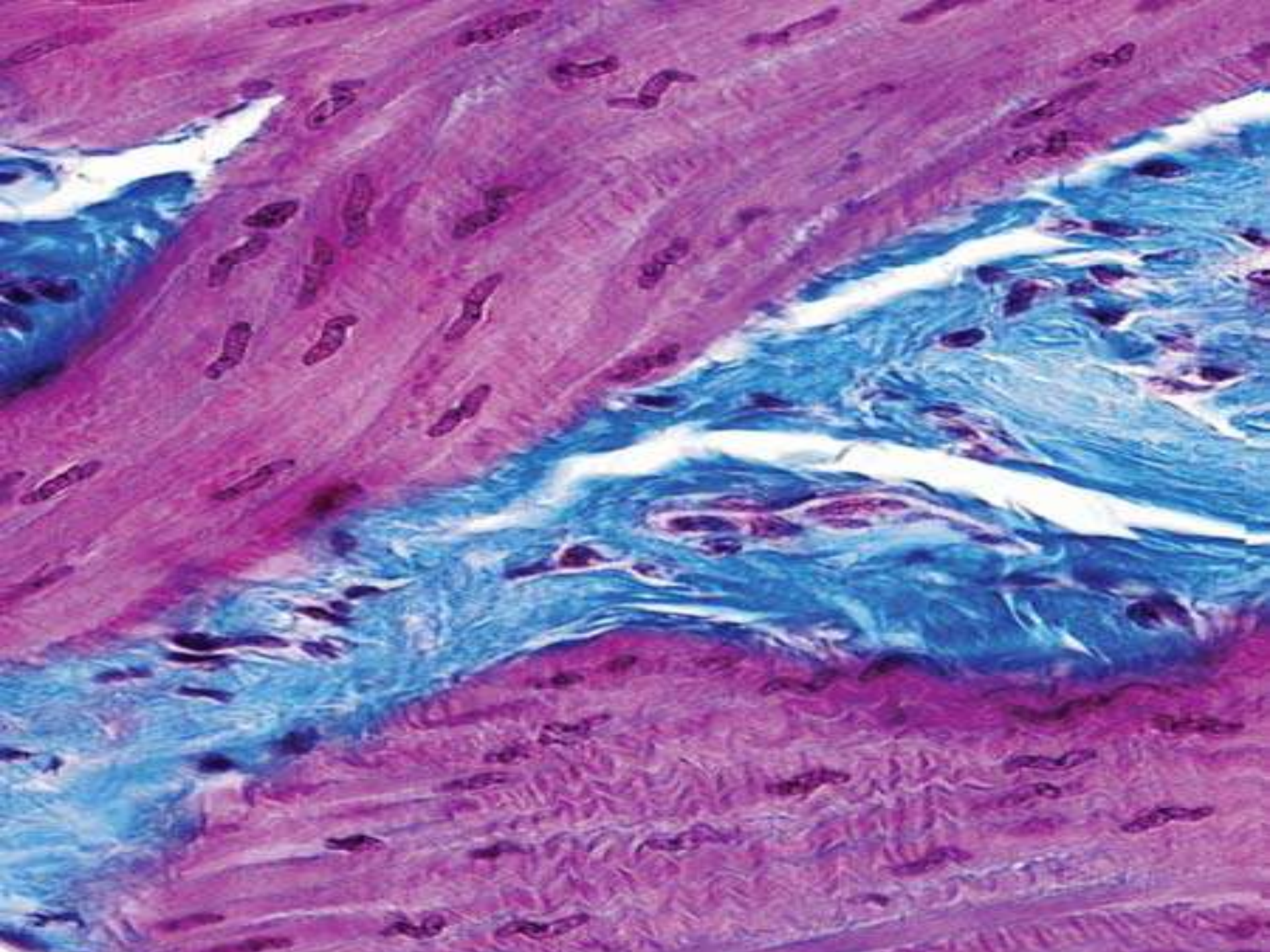
2-Smooth muscle fibers are elongated, tapering, and nonstriated cells, each of which is enclosed by a thin basal lamina and a fine network of reticular fibers. The connective tissues serve to combine the forces generated by each smooth muscle fiber into a concerted action, eg, peristalsis in the intestine.

3-Smooth muscle cells has a single nucleus located in the center of the cell's broadest part. To achieve the tightest packing, the narrow part of one cell lies adjacent to the broad parts of neighboring cells.

4- Such an arrangement viewed in cross section shows a range of diameters, with only the largest profiles containing a nucleus .

5-The borders of the cell become scalloped when smooth muscle contracts and the nucleus becomes distorted.





ADIPOSE TISSUE:

1-Adipose tissue is a specialized type of connective tissue in which **adipocytes** or fat cells predominate. These cells can be found isolated or in groups within loose or irregular connective tissue, often in large aggregates where they are the major component of adipose tissue.

2-Located in many areas throughout the body, adipose tissue represents 15–20% of the body weight in men of normal weight; in women of normal weight, 20–25% of body weight.

3-Long considered little more than inert masses of energy stored as fat, adipocytes are now recognized as key regulators of the body's energy metabolism. Because of a growing worldwide epidemic of obesity and its associated problems, including diabetes and heart disease, adipocytes are now the most widely studied cell of connective tissue.

4-Adipose tissue is the largest repository of energy (in the form of triglycerides, the neutral fats) in the body.

Adipose tissue also fills up spaces between other tissues and helps to keep some organs in place. Subcutaneous layers of adipose tissue help to shape the surface of the body.

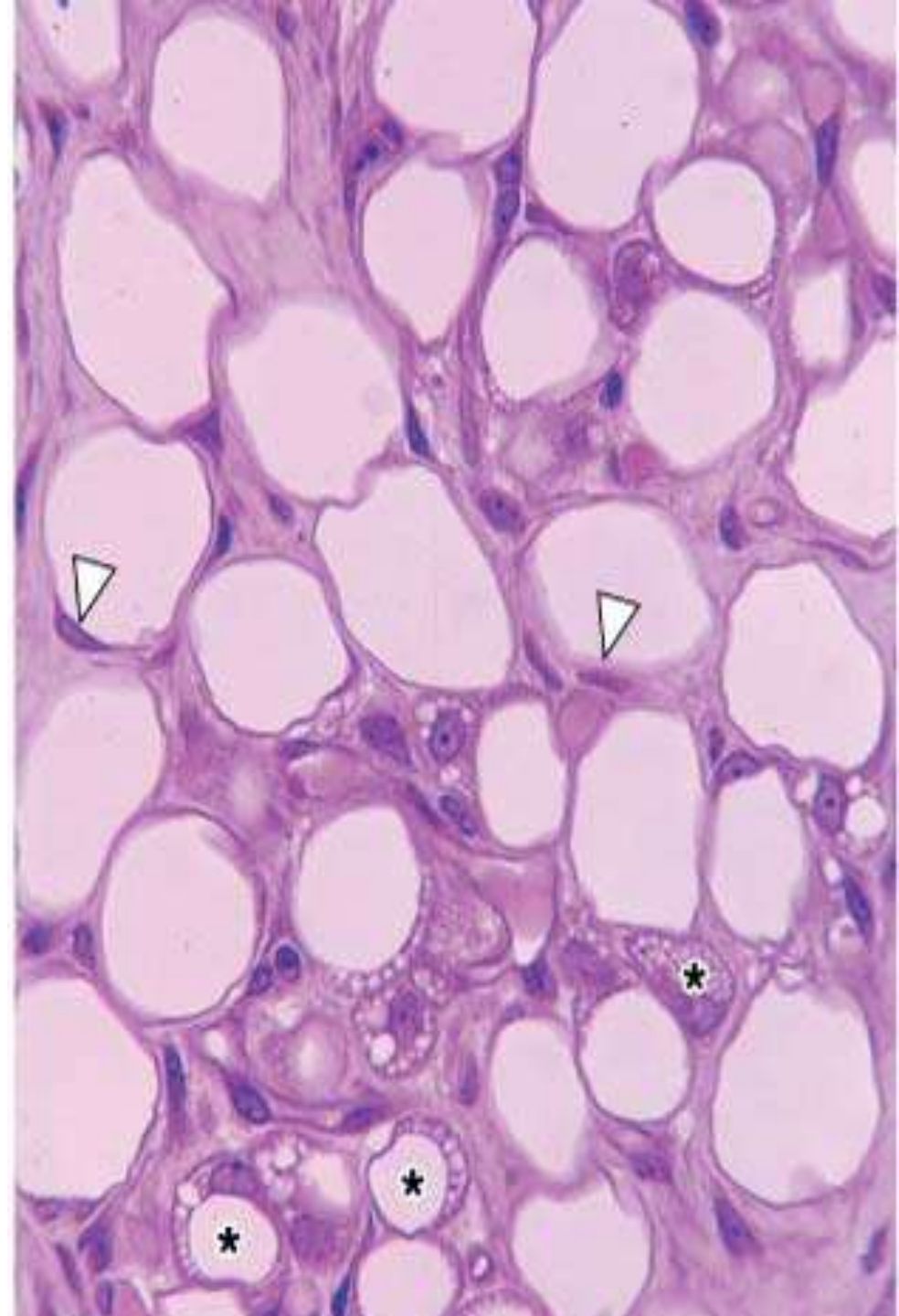
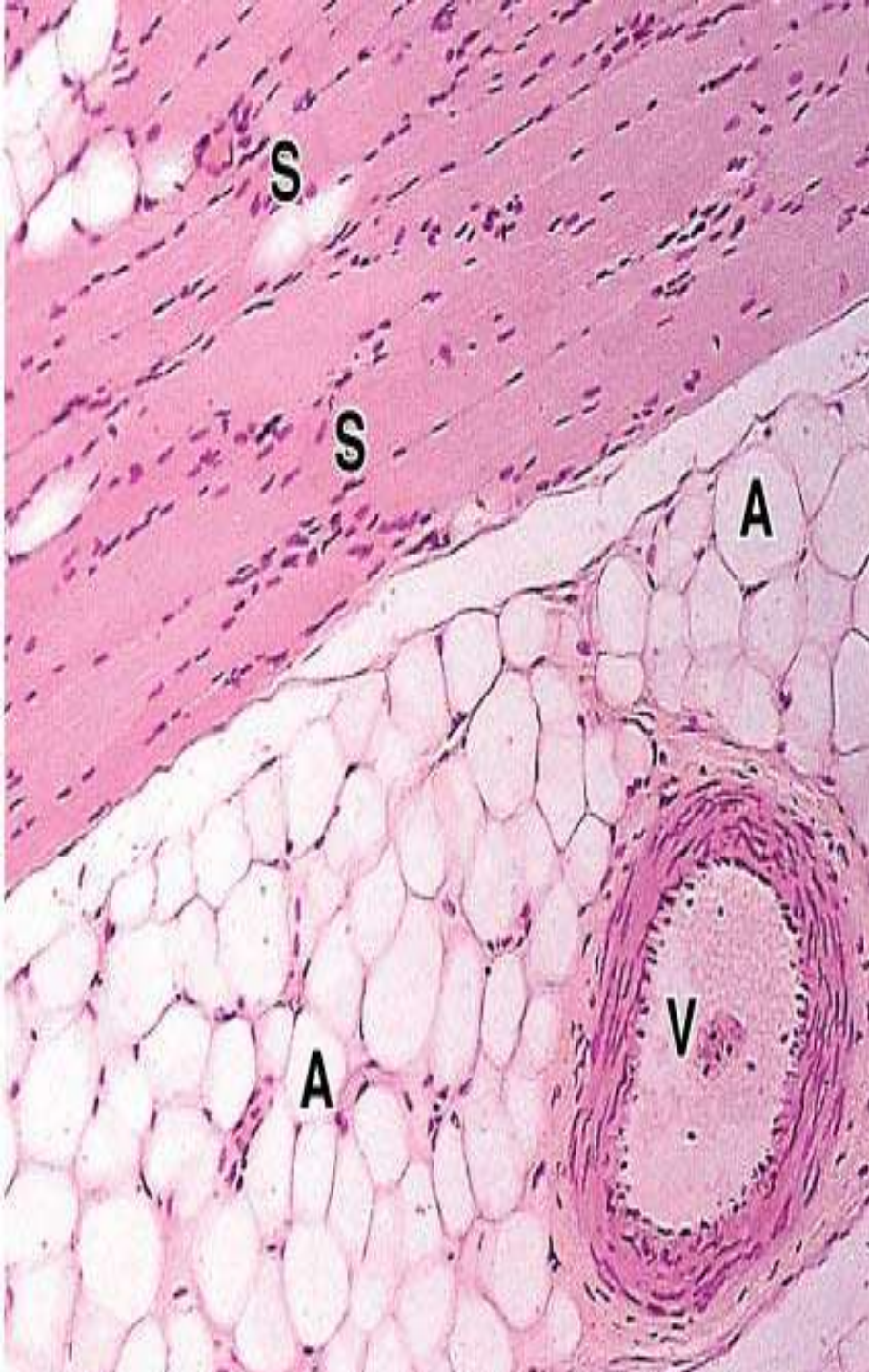
5-There are two types of adipose tissue with different locations, structures, colors, and pathologic characteristics.

White adipose tissue, the more common type, is composed of cells that, when completely developed, contain one large central droplet of whitish yellow fat in their cytoplasm. **Brown adipose tissue** contains cells with multiple lipid droplets interspersed among abundant mitochondria, which give these cells the darker appearance. Both types of adipose tissue have a rich blood supply.

I-WHITE ADIPOSE TISSUE:

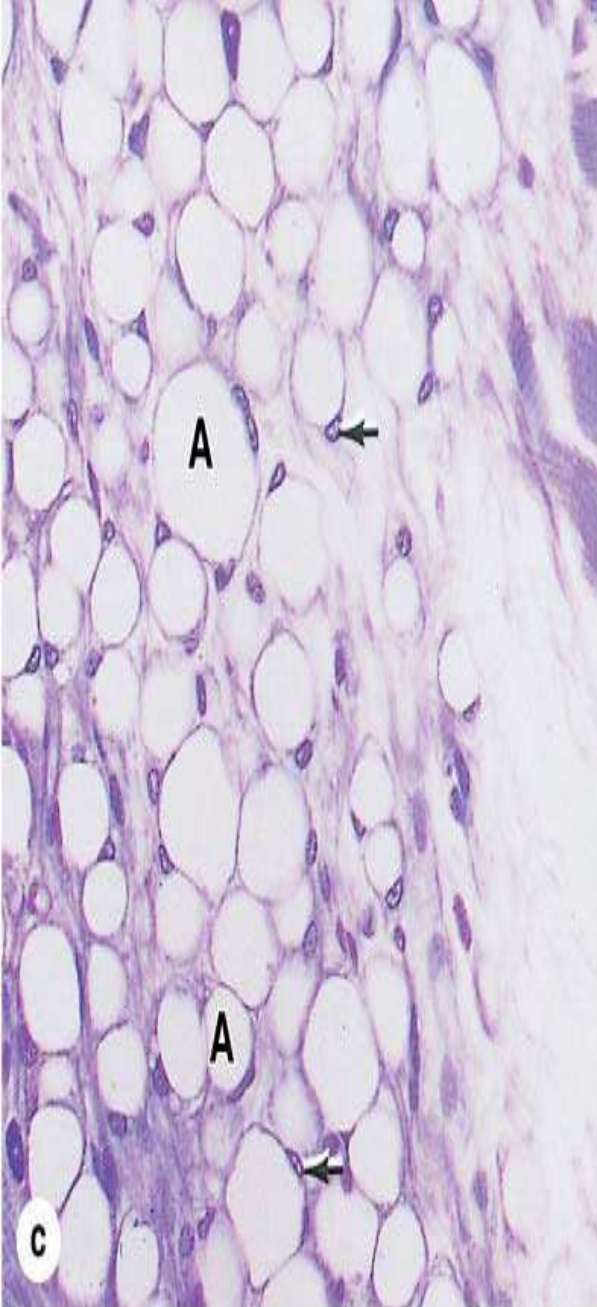
1-Specialized for long-term energy storage, white adipose cells are **spherical** when isolated but are **polyhedral** when closely packed in adipose tissue. Each cell is very large, and contains one huge droplet of lipid that makes up 85% of the cell's weight.

2-White adipocytes are called **unilocular** because triglycerides are stored in a single locus. a unilocular **adipocyte appears** in standard microscope preparations as a thin ring of cytoplasm surrounding the empty vacuole left by the dissolved lipid droplet, sometimes referred to as the **signet ring cell**.



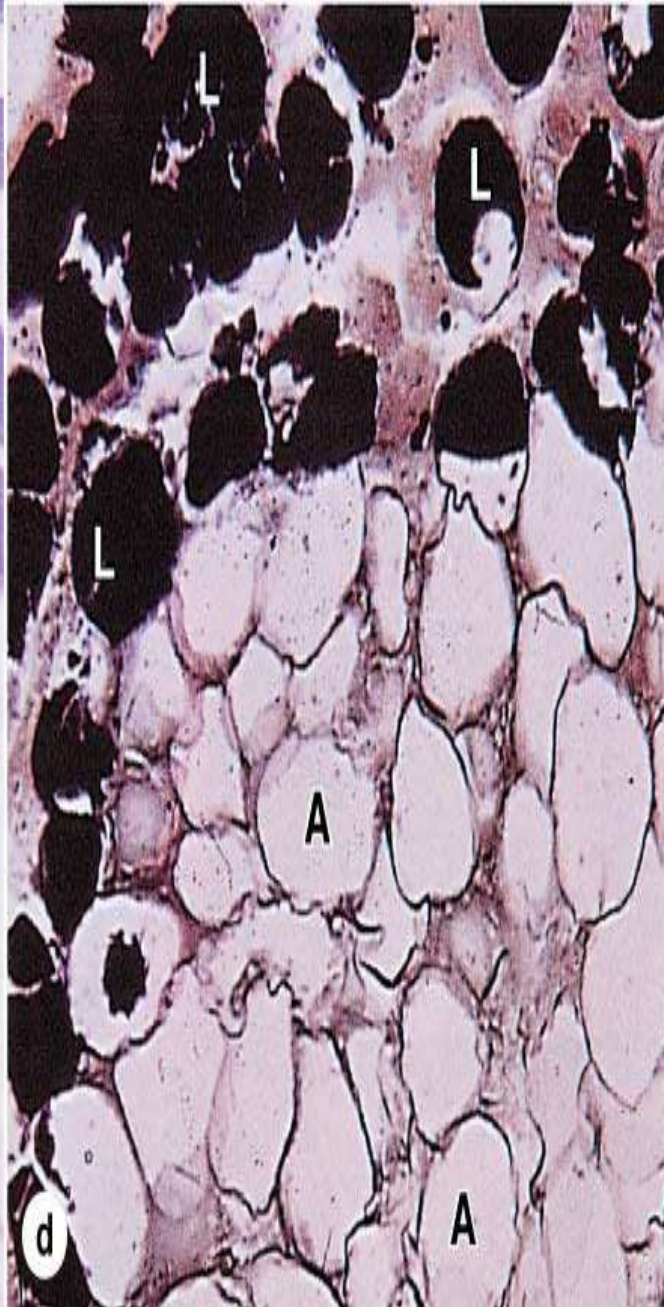
3-The large droplet causes these cells to have eccentric and flattened nuclei. **The rim** of cytoplasm that remains after removal of the stored **triglycerides** may rupture and collapse, distorting the tissue structure.

4-White adipose tissue is subdivided into incomplete lobules by a partition of connective tissue containing a rich vascular bed and nerve network. **Fibroblasts, macrophages,** and other cells make up about half the total number of cells. **Reticular fibers** form a fine interwoven network that supports individual fat cells and **binds them together.** Although blood vessels are not always apparent in tissue sections, adipose tissue is **richly vascularized.**



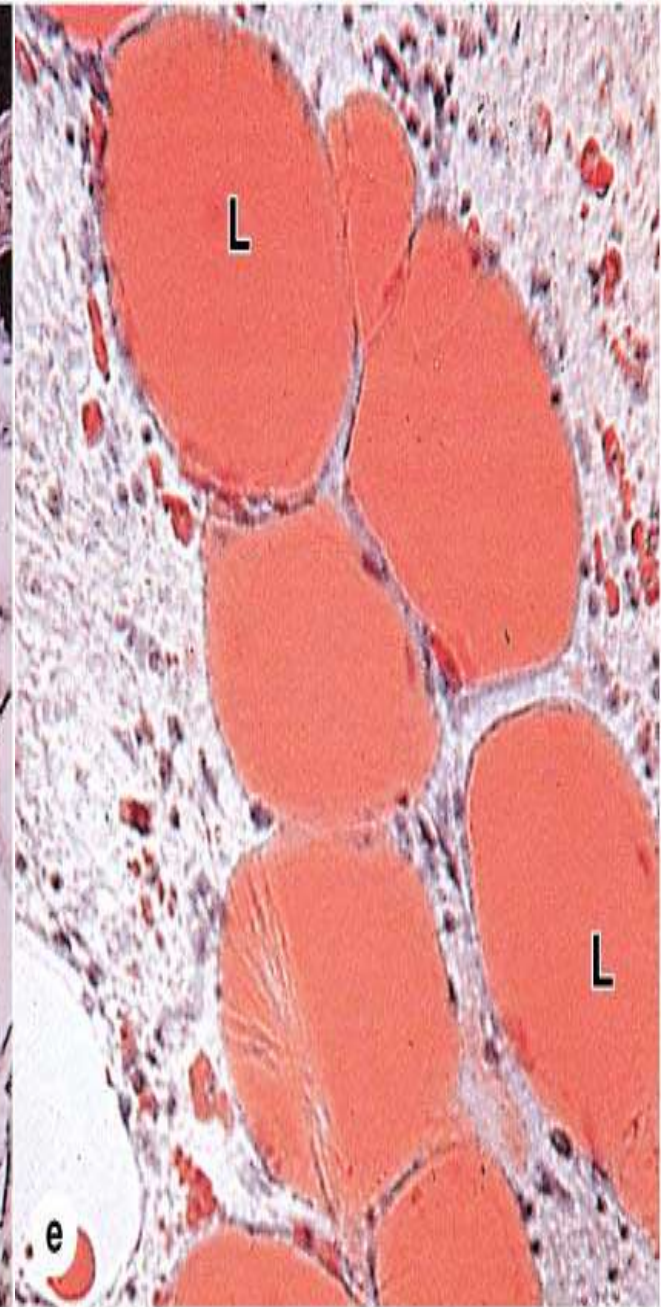
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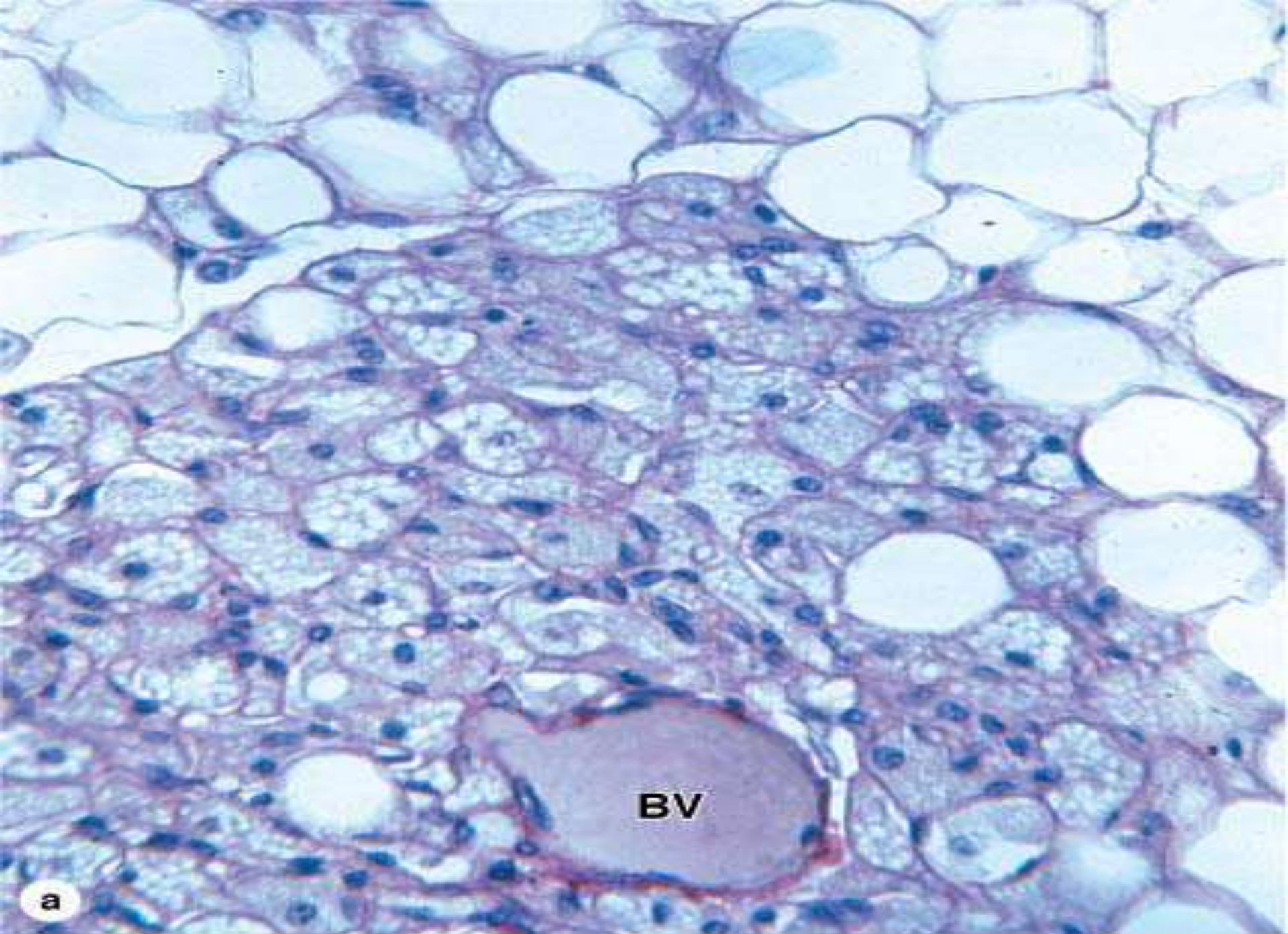
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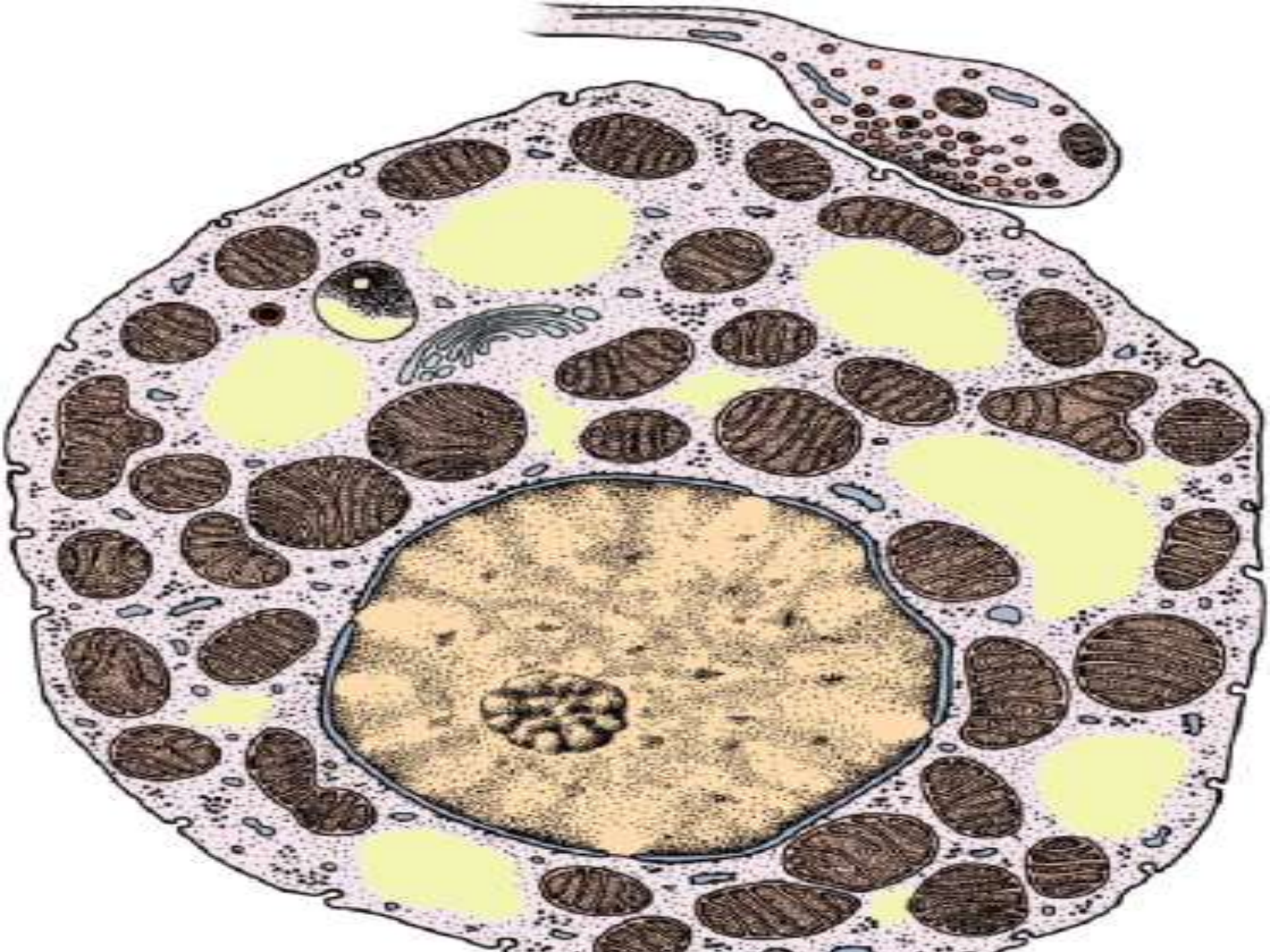
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II-BROWN ADIPOSE TISSUE:

1-The color of brown adipose tissue or **brown fat** is due to both the numerous mitochondria (containing colored cytochromes) scattered through the adipocytes and the large number of blood capillaries in this tissue.

2-Adipocytes of brown fat contain many small lipid inclusions and are therefore called **multilocular**. The many small lipid droplets abundant mitochondria and rich vasculature all help mediate this tissue's principal function of **heat production**.





3- In comparison with white adipose tissue, which is present throughout the body, brown adipose tissue has a much more limited distribution. Cells of brown adipose tissue are polygonal and generally smaller than cells of white adipose tissue but their cytoplasm contains a great number of lipid droplets of various sizes. These adipocytes have spherical and central nuclei and the numerous mitochondria have abundant long cristae.

4-Brown adipose tissue resembles an endocrine gland in that its cells assume an almost epithelial arrangement closely associated with blood capillaries. The tissue is subdivided by partitions of connective tissue into lobules that are better delineated than the lobules of white adipose tissue. Cells of this tissue receive direct sympathetic innervation.