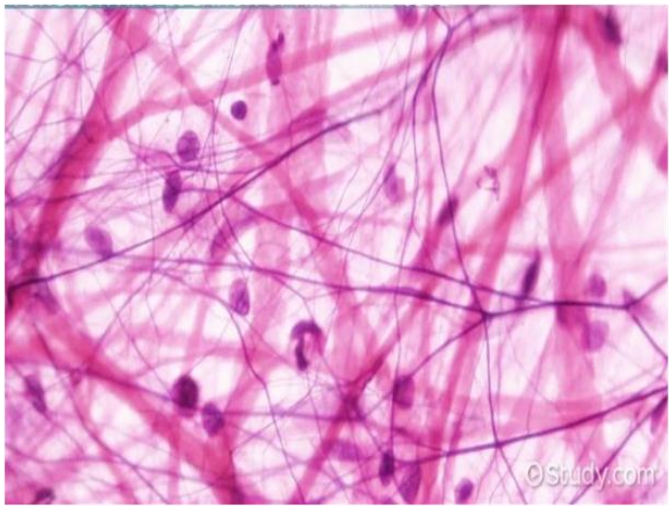
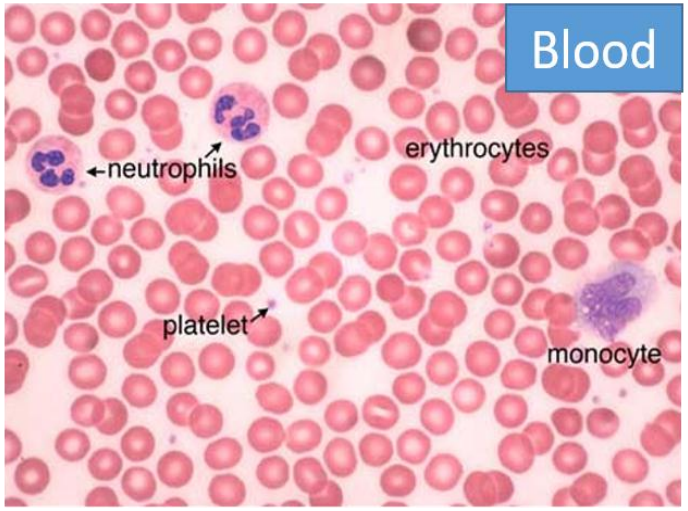
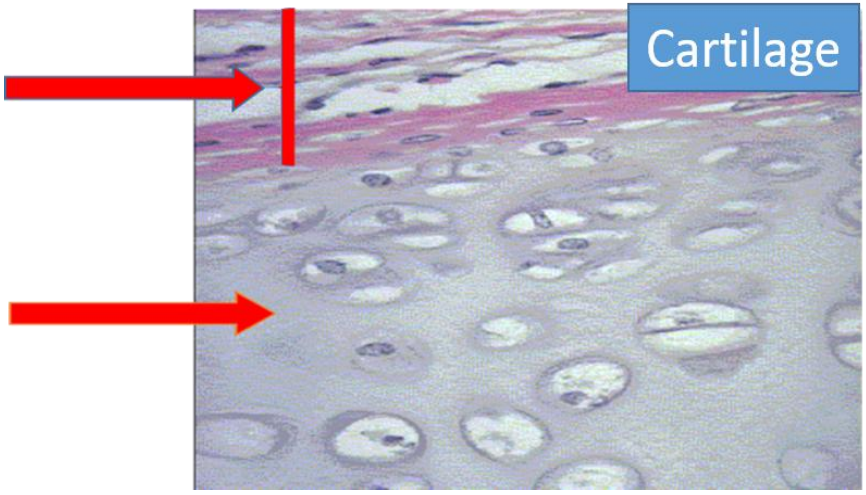
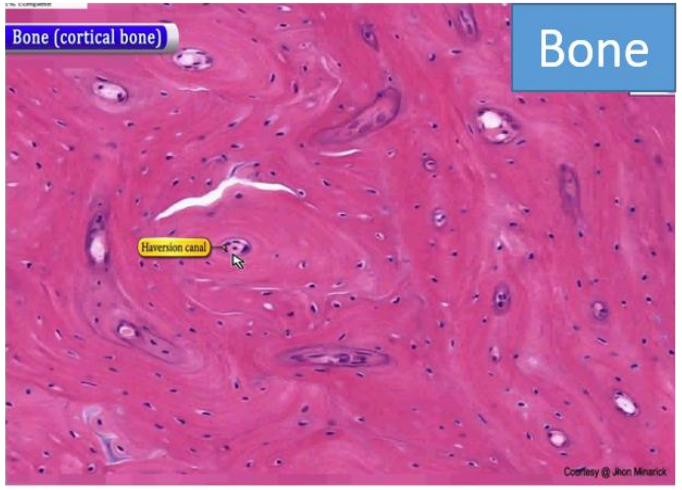
Modified CT


©Study.com


Blood
neutrophils
erythrocytes
platelet
monocyte


Cartilage


Bone
Bone (cortical bone)
Haversion canal
Courtesy @ Jhon Minarick

Common characteristics of CT:

1. **Several types of cells** with different function , widely-separated by extracellular matrix .
2. **Extracellular matrix: abundant non-living extracellular matrix**, which separates the living cells = (fibers +ground substance)
3. **Variable degrees of vascularity**: some types of connective tissue have a rich supply of blood vessels, other is poorly-vascularized e.g. dense CT and cartilage is avascular.
4. **Origin**: all types of connective tissues arise from **mesoderm**

Classification of C.T.
Depend on ground substance

Jelly like ground substance

Connective tissue proper:

it includes:

- Loose areolar connective tissue.
- Dense irregular connective tissue
- Dense regular connective tissue.
- Elastic connective tissue.
- Reticular connective tissue.
- Adipose connective tissue.
- Mucoid connective

Modified types

- **Blood =fluid**
- **Cartilage= firm**
- **Bone = hard**

Supporting connective tissue

- Cartilage and bone are modified CT in which ground substance is hardened to provide support for soft tissue

- Cartilage and bone form the skeleton of the body

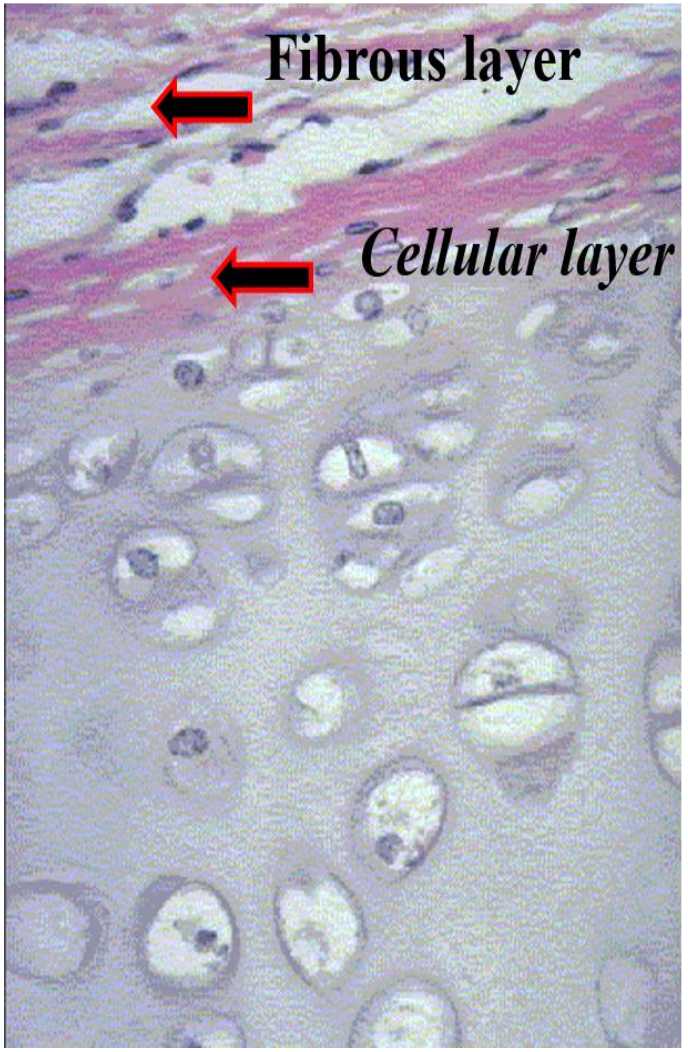
CARTILAGE

Characteristic features of cartilage

- Modified connective tissue with firm ground substance & flexible
- Cartilage cells are isolated in lacunae (small cavities in the ground substance contain cells)
- Extracellular matrix (ground substance +fibers)
- **Avascular** (nutrients diffuse through matrix from surrounding CT or from synovial fluid in joint cavities)
- Cartilage is usually covered by **perichondrium** which is rich in blood vessels
- Cartilage has **No lymphatic or nerves**

PERICHONDRIUM

- Ensheaths the cartilage
- Present in **most** of the hyaline , elastic cartilage , **absent** in fibrocartilage
- Fibro-cellular membrane that consists of two layers :
  - **Outer fibrous** layer houses the blood vessels that nourish chondrocytes
  - **Inner vascular & cellular** layer (chondrogenic layer) this layer contains chondroblasts which are capable of forming new cartilage



Function :

1. It is responsible for nourishment of chondrocytes
2. It is responsible for growth

Structure of cartilage

Extracellular matrix

1. Ground substance

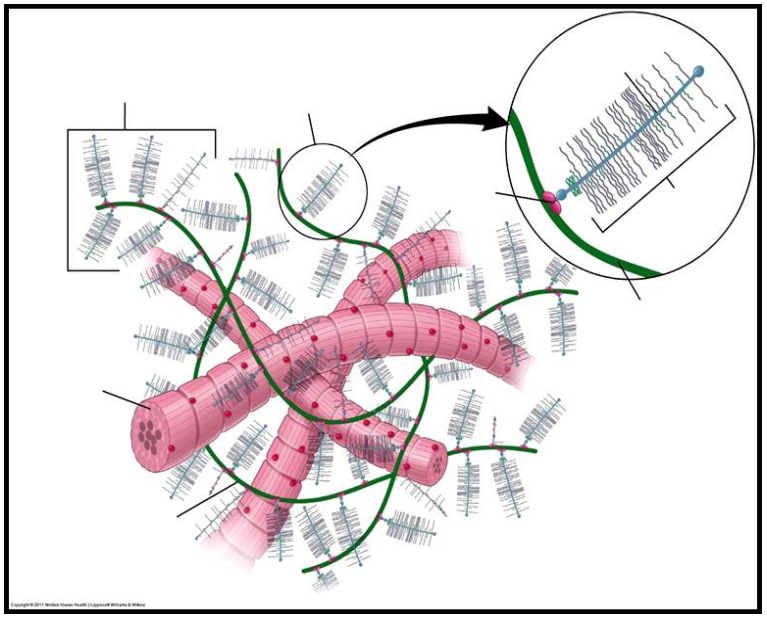
- Glycosaminoglycanse e.g. (chondroitin sulfates & keratan sulfate) bound to hyaluronic acid
- Proteoglycans & glycoprotein
- Adhesive glycoprotein
  e.g. **chondronectin**

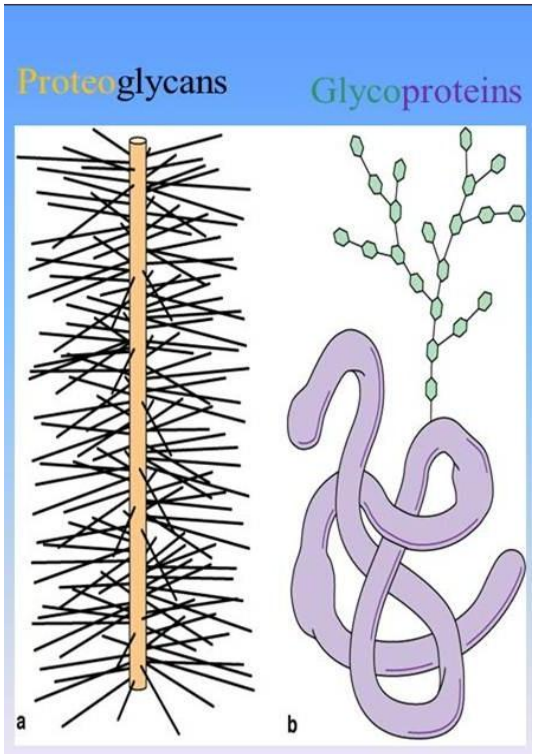
2. Fibers

- Collagen type II
- Collagen type I
- Elastic fibers

Cartilage cells

- Chondroblasts
- Chondrocytes





Extracellular MATRIX

Ground substance

It is responsible for firmness & flexibility of cartilage

- ❖ Produced by cartilage cells
- ❖ Basophilic
  - ➢ Water **60-70 %**
  - ➢ Glycosaminoglycans (chondroitin sulfates & keratan sulfate) bound to hyaluronic acid
  - ➢ Proteoglycans & glycoprotein
  - ➢ Adhesive glycoprotein e.g. **chondronectin**

Territorial matrix

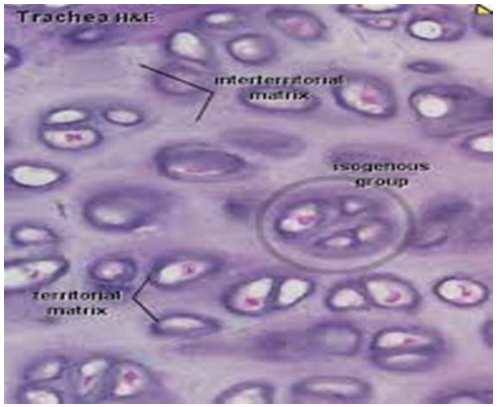
surrounds lacuna (space in which chondrocyte present)

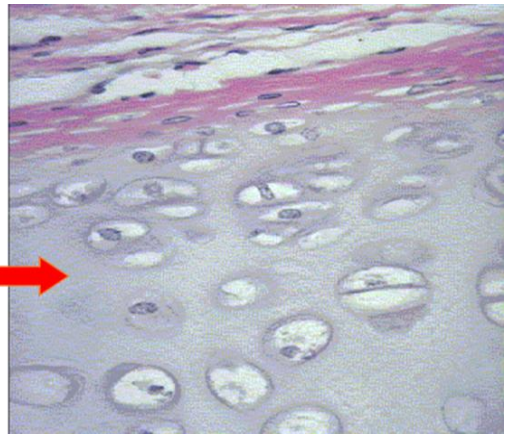
➢ Interterritorial matrix

Between the lacunae

Fibers

- ➢ Collagen type II
- ➢ Collagen type I
- ➢ Elastic fibers





Cells of cartilage
1. CHONDROBLAST

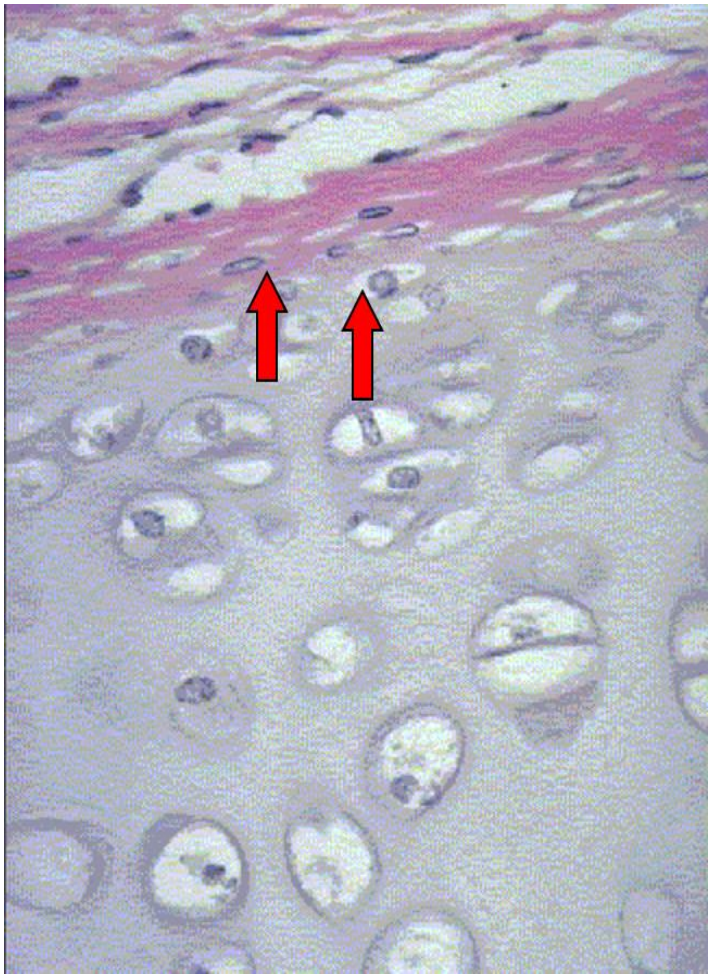
Origin: cellular layer of perichondrium

Site: Lines border between perichondrium and matrix

Function:

- Synthetically active, produce ground substance and fibers = Synthesize type II collagen, proteoglycans and chondronectin.

- Progenitor of chondrocytes when reside in a space called the **lacuna** ------ chondrocytes



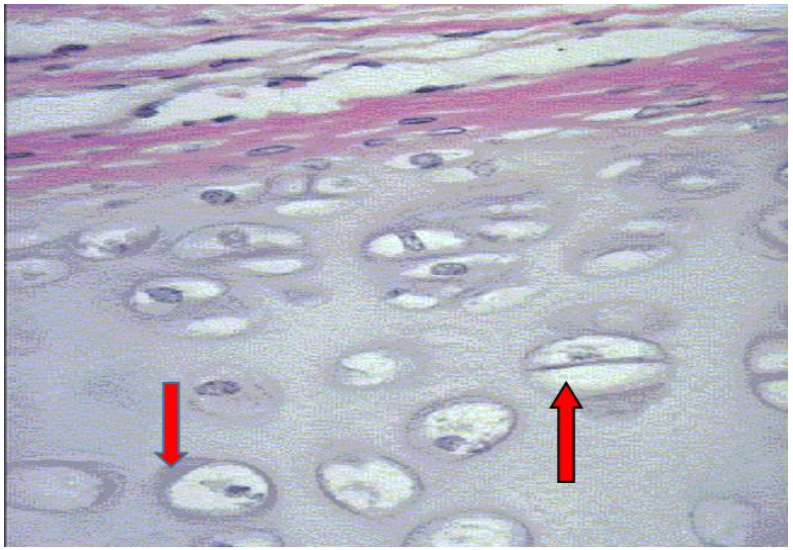
2. CHONDROCYTE

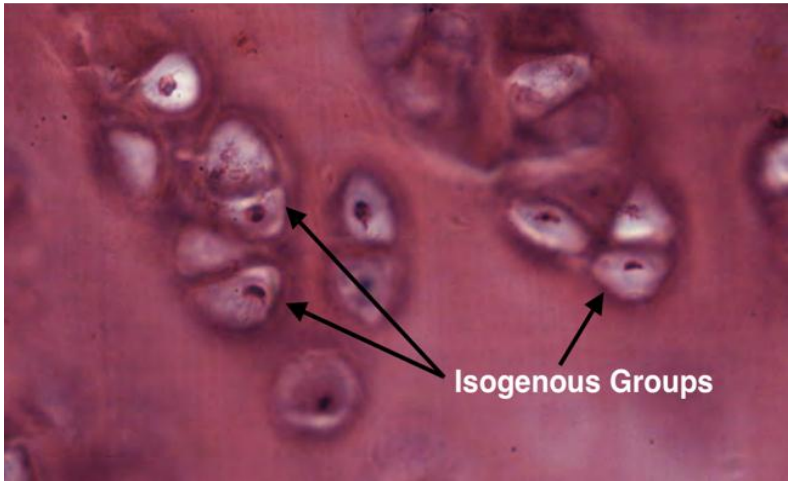
Mature cartilage cell

Origin : From chondroblast

Site: Reside in a space called the **lacuna** form isogenous cell group called (**Cell nest**)

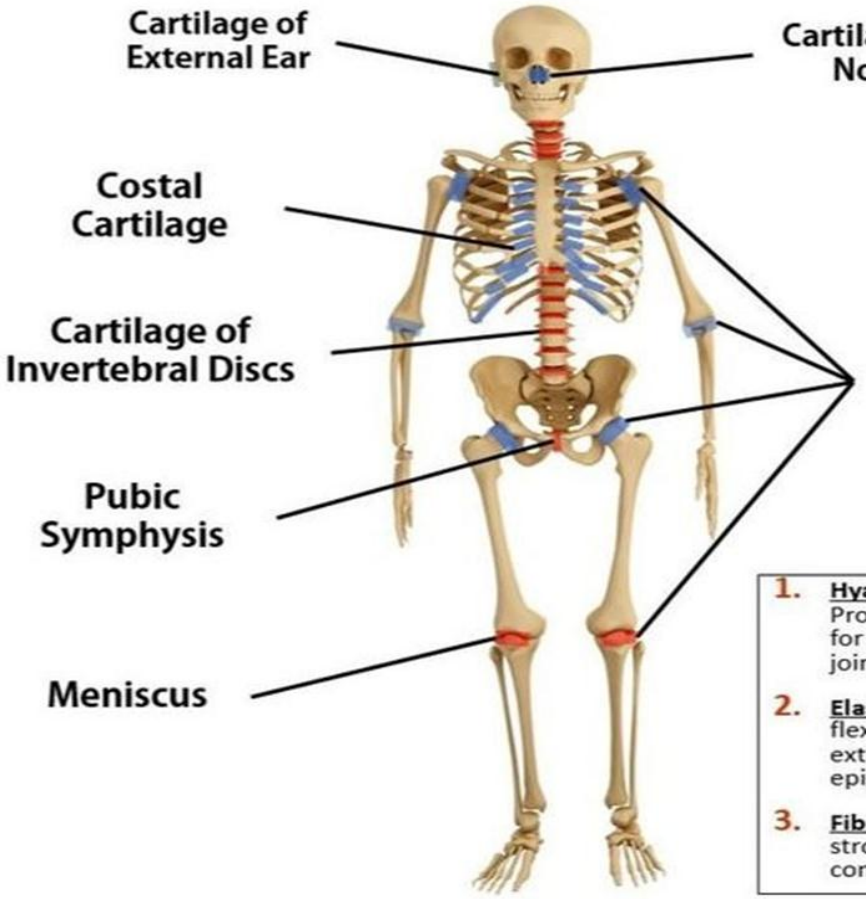
Function : Maintain the extracellular matrix



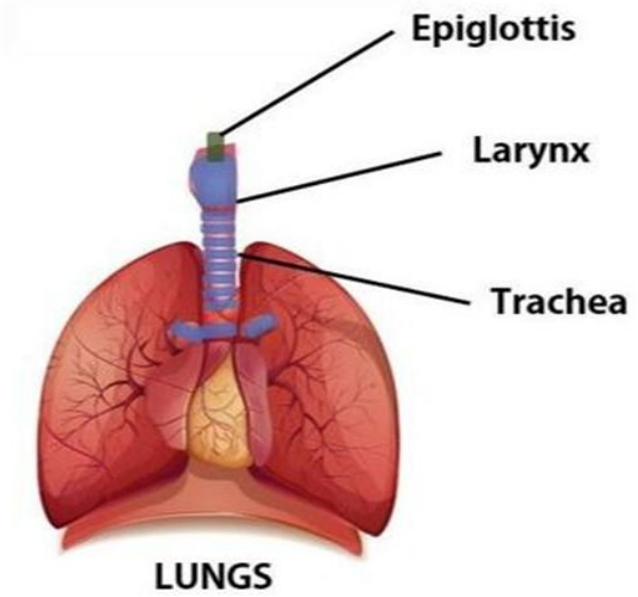


TYPES OF CARTILAGE

- ❑Hyaline cartilage
- ❑ Elastic cartilage
- ❑White fibrocartilage

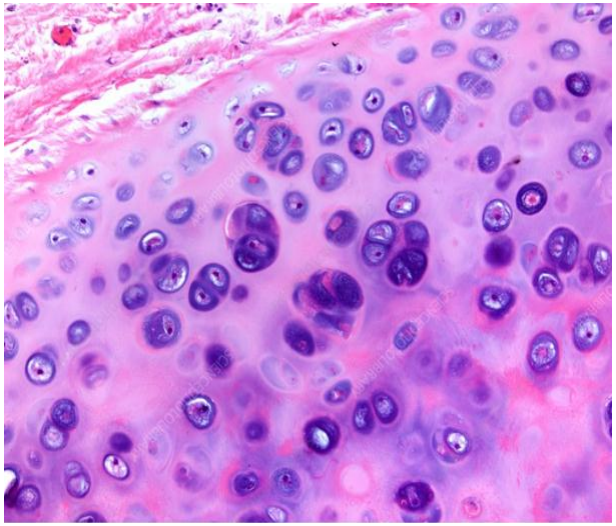


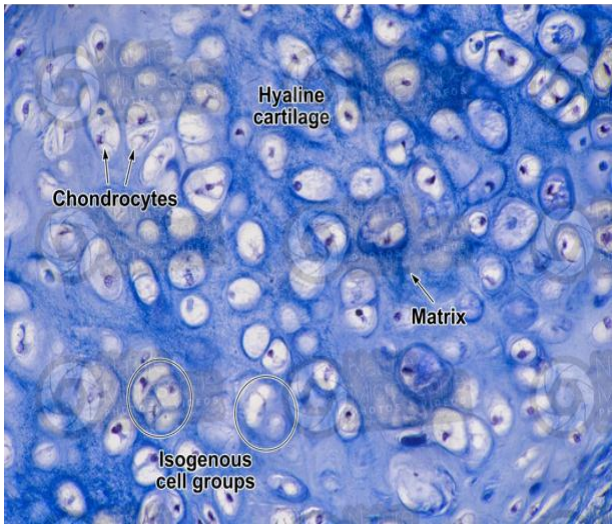
1. **Hyaline Cartilage** = Provides smooth surface for gliding action at joints.
2. **Elastic Cartilage** = very flexible; makes up the external ear and the epiglottis
3. **Fibrocartilage** = resists strong forces of compression and tension.

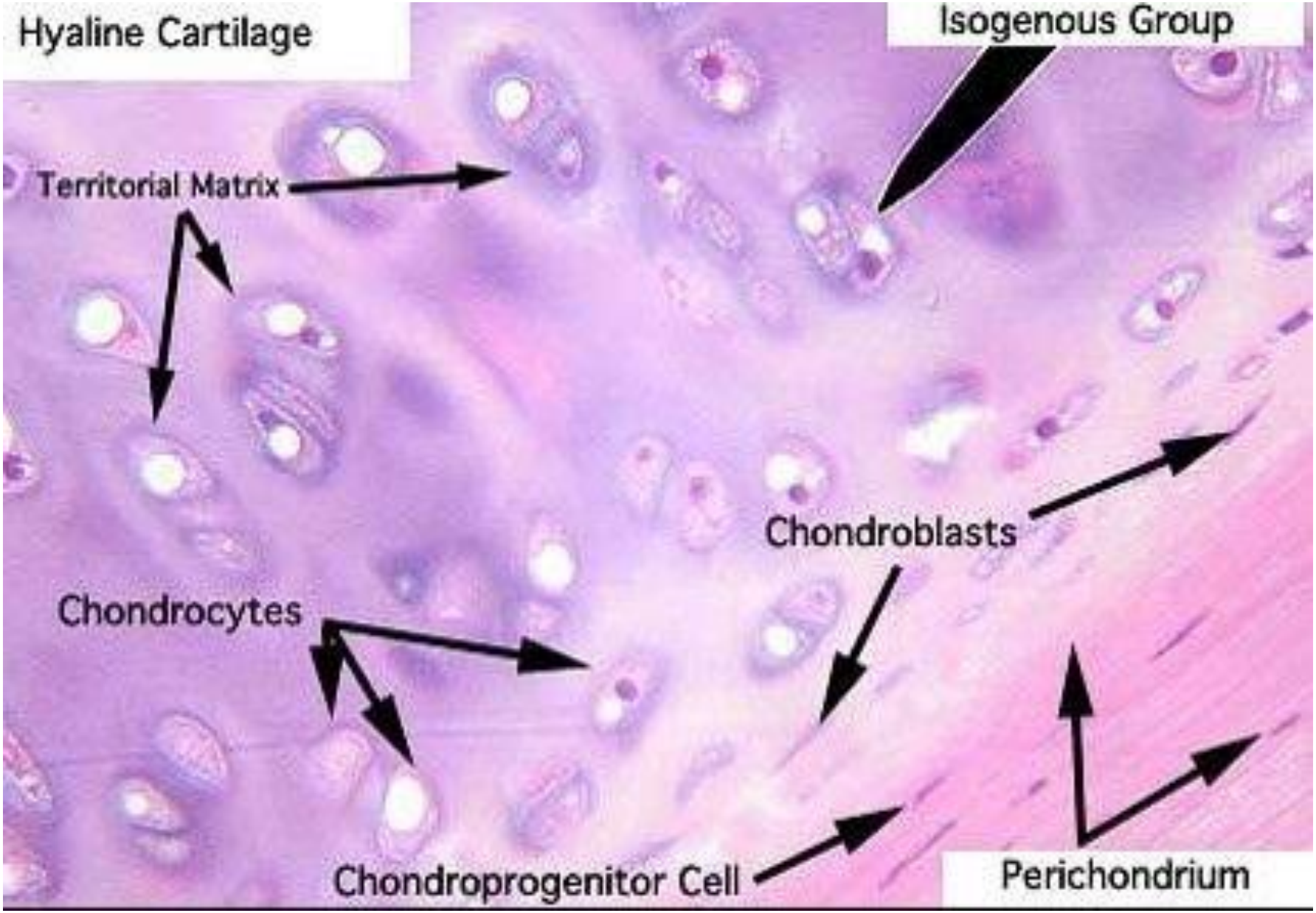


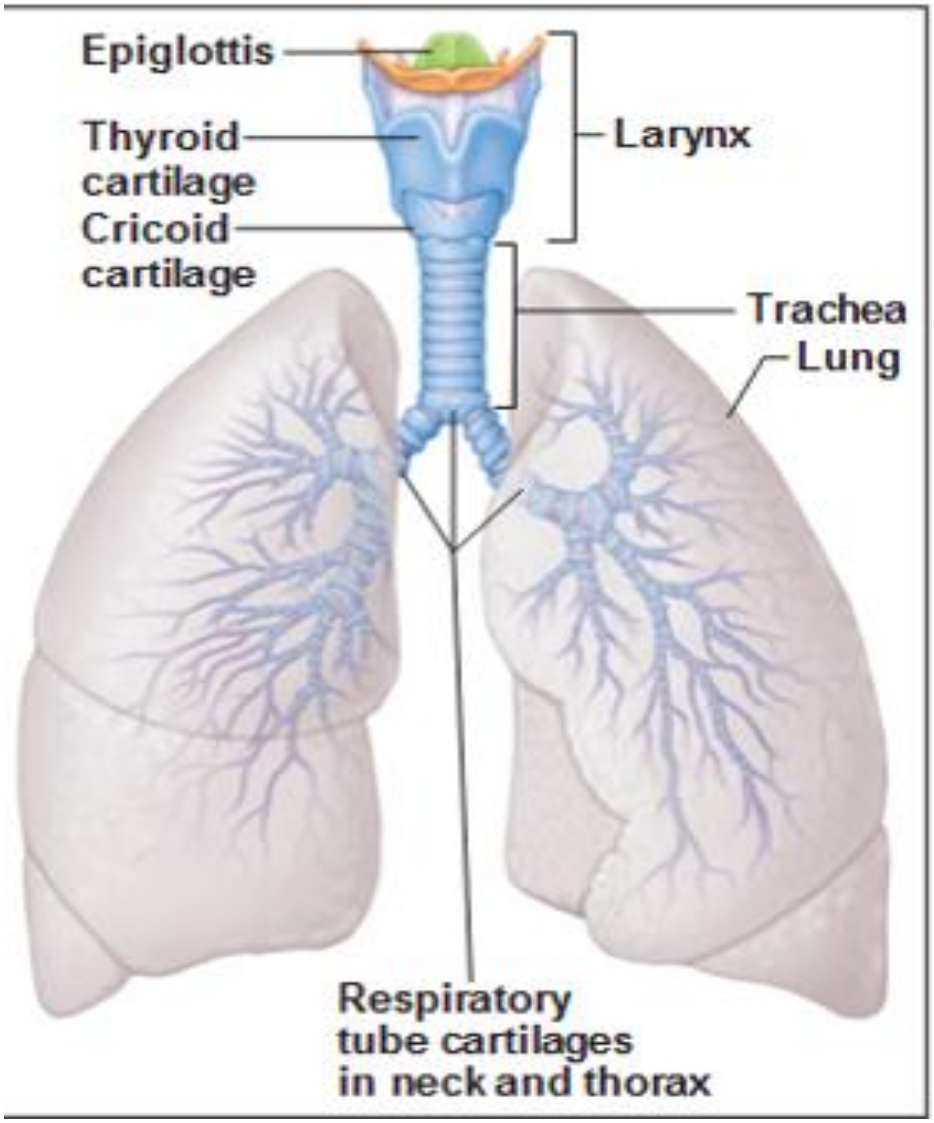
HYALINE CARTILAGE

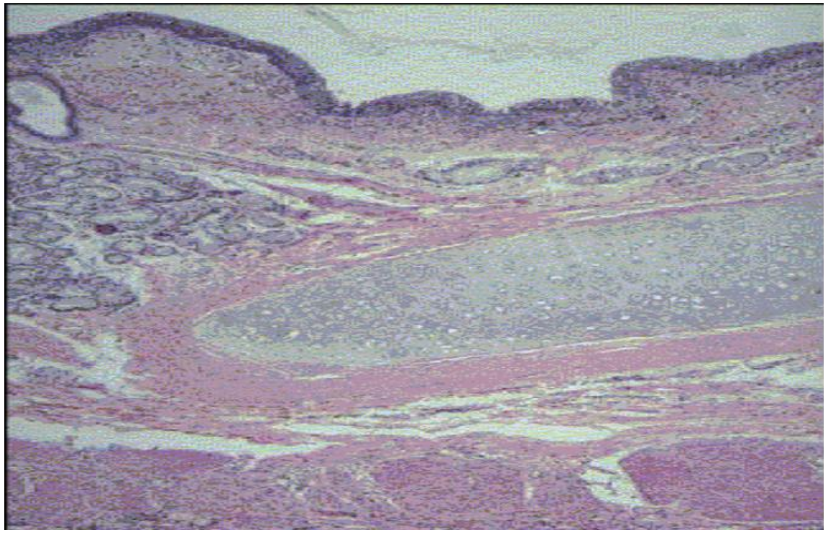
- **Sites:** nasal septum , larynx, Tracheal rings, costal cartilage & articular surfaces of joints
- **Perichondrium :** may or may not present
- **Cartilage cells:** Present singly or in groups of 2 -8 cells inside lacunae called cell nest
- **Cartilage fibers:** Collagen type II
- **Ground substance:** Homogenous, clearly Pale basophilic with glassy appearance
- **Functions:**
  - supportive
  - bone formation in fetal skeleton
  - Epiphyseal bone growth
  - Provide smooth articulation for joints






Hyaline Cartilage
Isogenous Group
Territorial Matrix
Chondroblasts
Chondrocytes
Chondroprogenitor Cell
Perichondrium


Epiglottis
Thyroid cartilage
Cricoid cartilage
Larynx
Trachea
Lung
Respiratory tube cartilages in neck and thorax

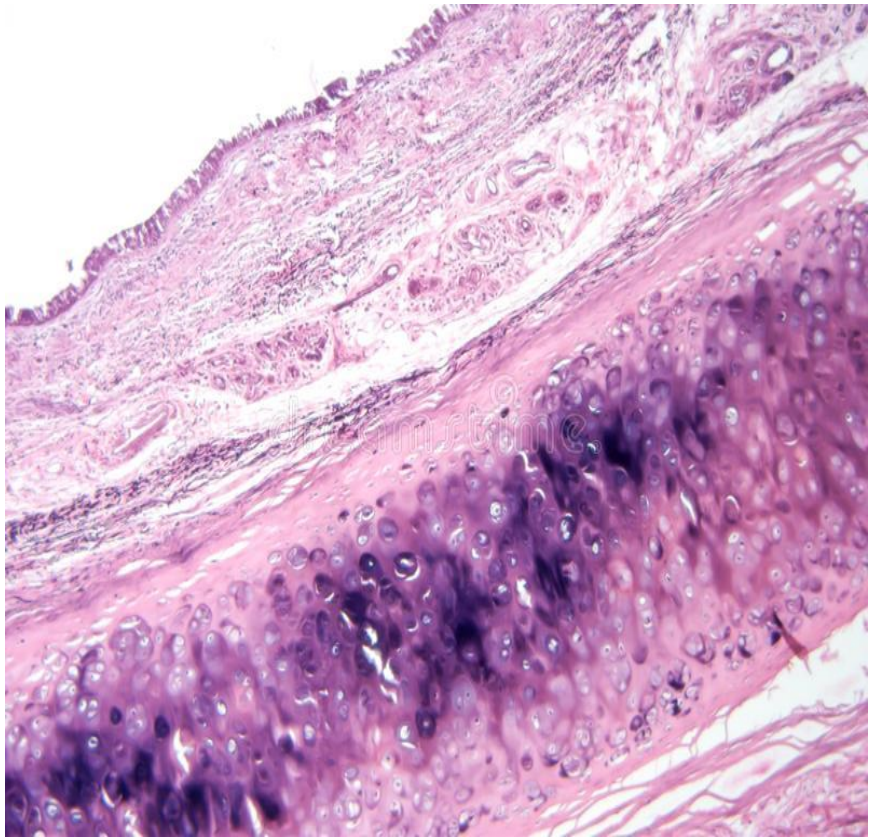


ELASTIC CARTILAGE

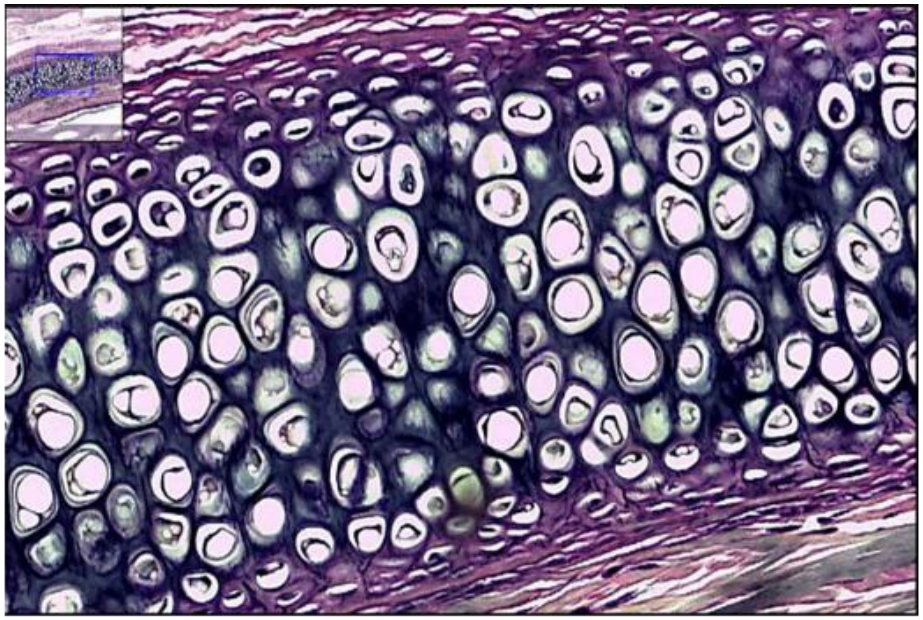
- **Sites:** Auricle, ext. auditory meatus, auditory tube, epiglottis
- **Perichondrium :** always present
- **Cartilage cells:** small , more numerous, packed more closely

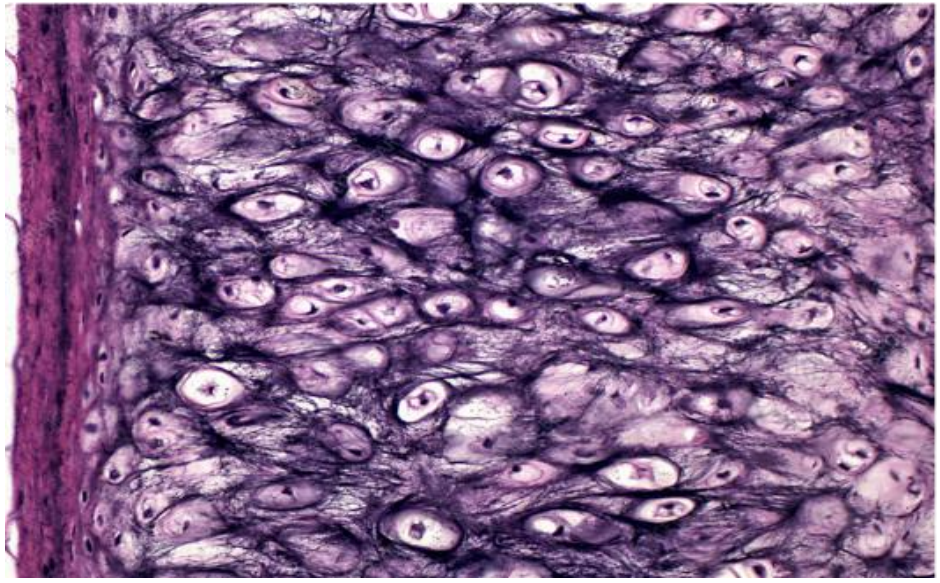
in groups of 1-3 cells inside lacunae

- **Ground substance: (little)**
- **Cartilage fibers :** Rich in elastic fibers + collagen type II
- Elastic fibers stain with orcein & VVG
- **Functions:** supportive with resilience

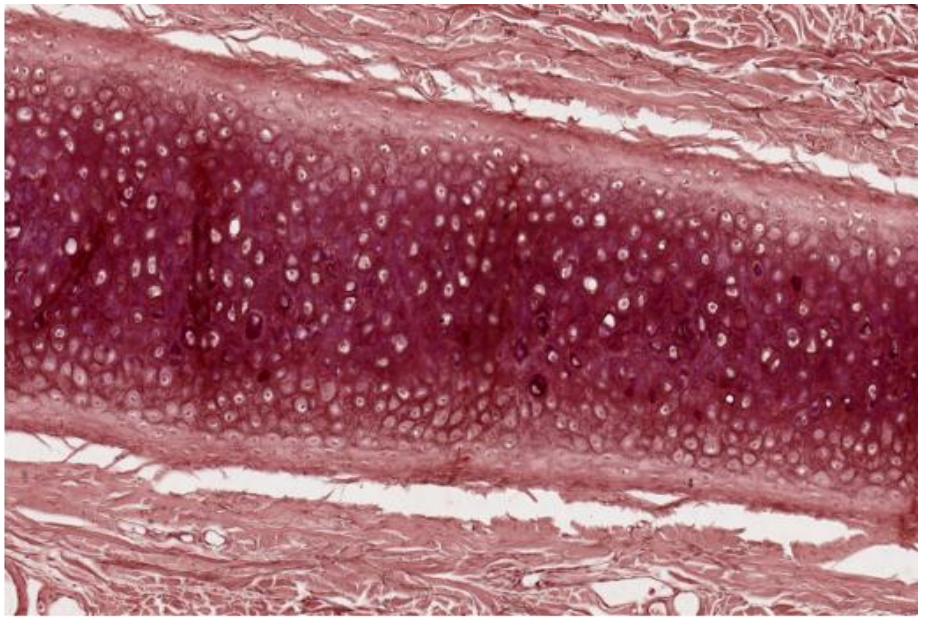


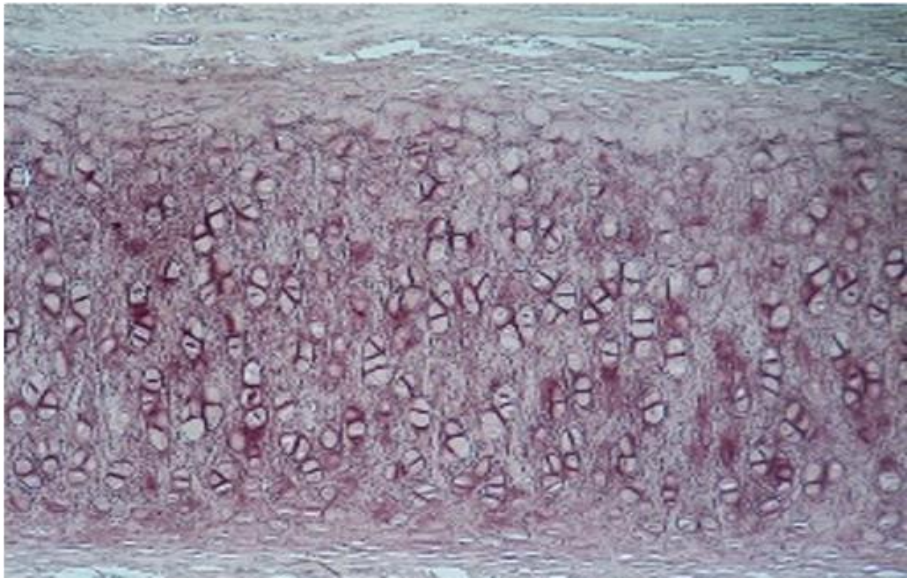
VVG stain





Orcein stain



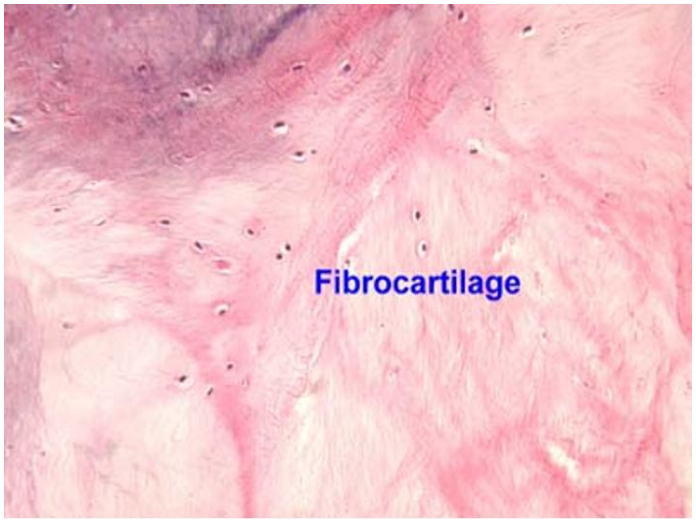


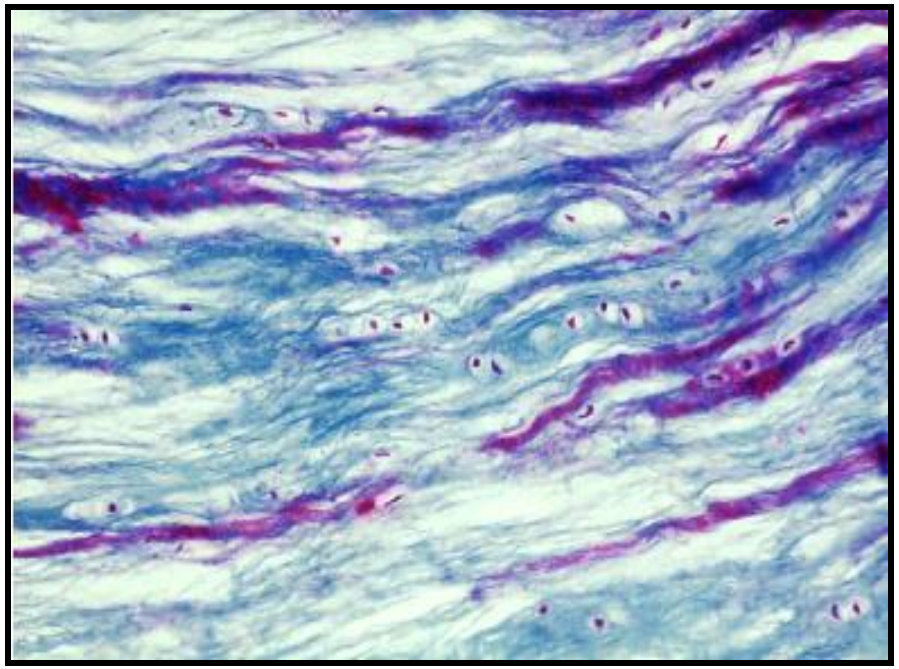
White FIBROCARTILAGE

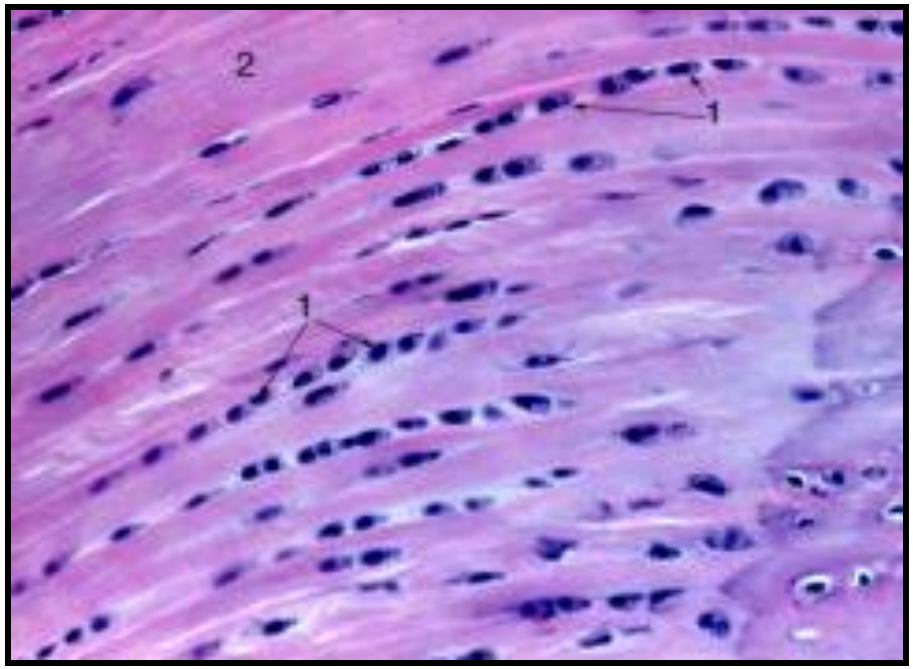
- **Sites:** intervertebral discs, pubic symphysis, sternoclavicular joint, articular disc of Tempromandibular joint.
- **Perichondrium :** Never covered
- **Cartilage cells:** fewer, smaller, scattered singly or in rows

1-2 cells inside lacunae

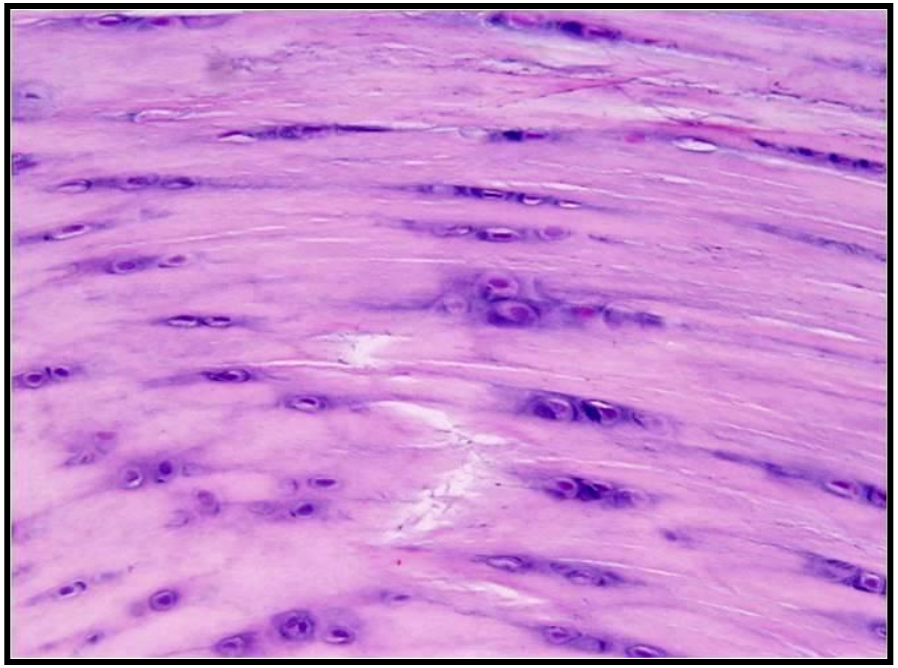
- **Ground substance:** **little**
- **Cartilage fibers:** **mainly** collagen type I & few collagen II
- **Functions:** supportive with tensile strength






2
1
1


White fibrous T



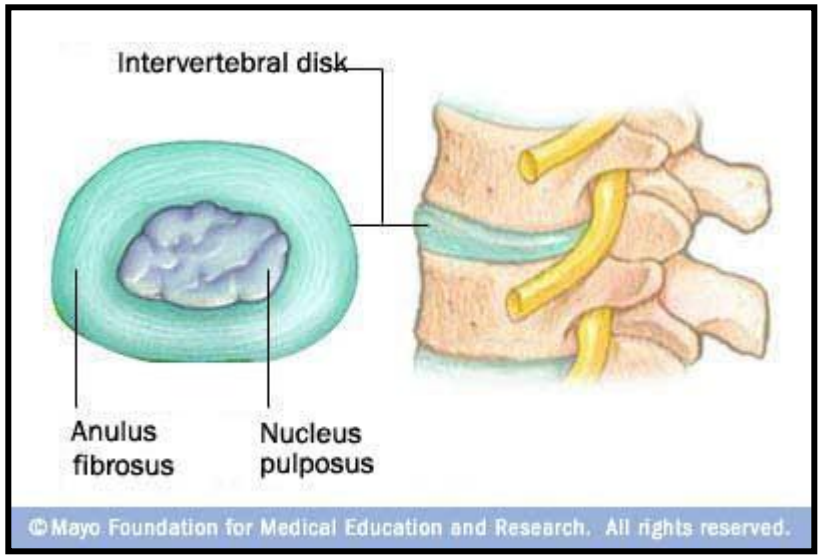
Intervertebral disc

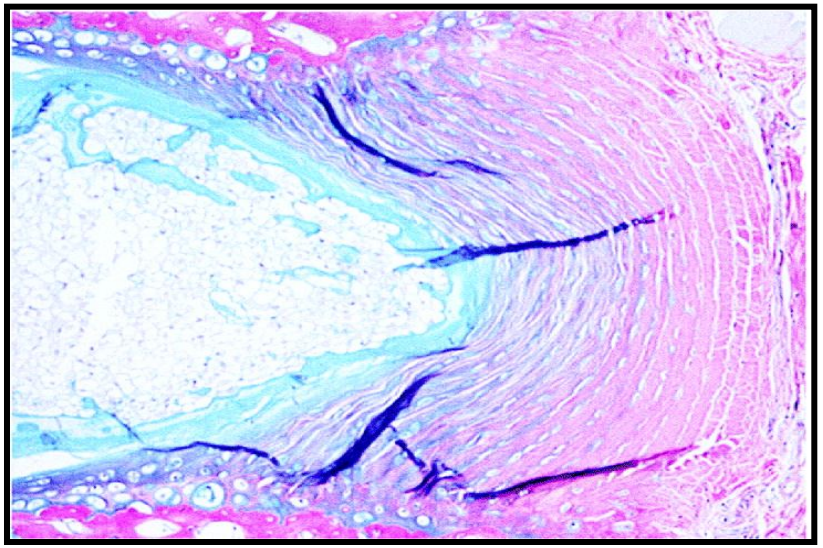
consist of fibrocartilage plates between the vertebrae and act as mechanical shock absorbers.

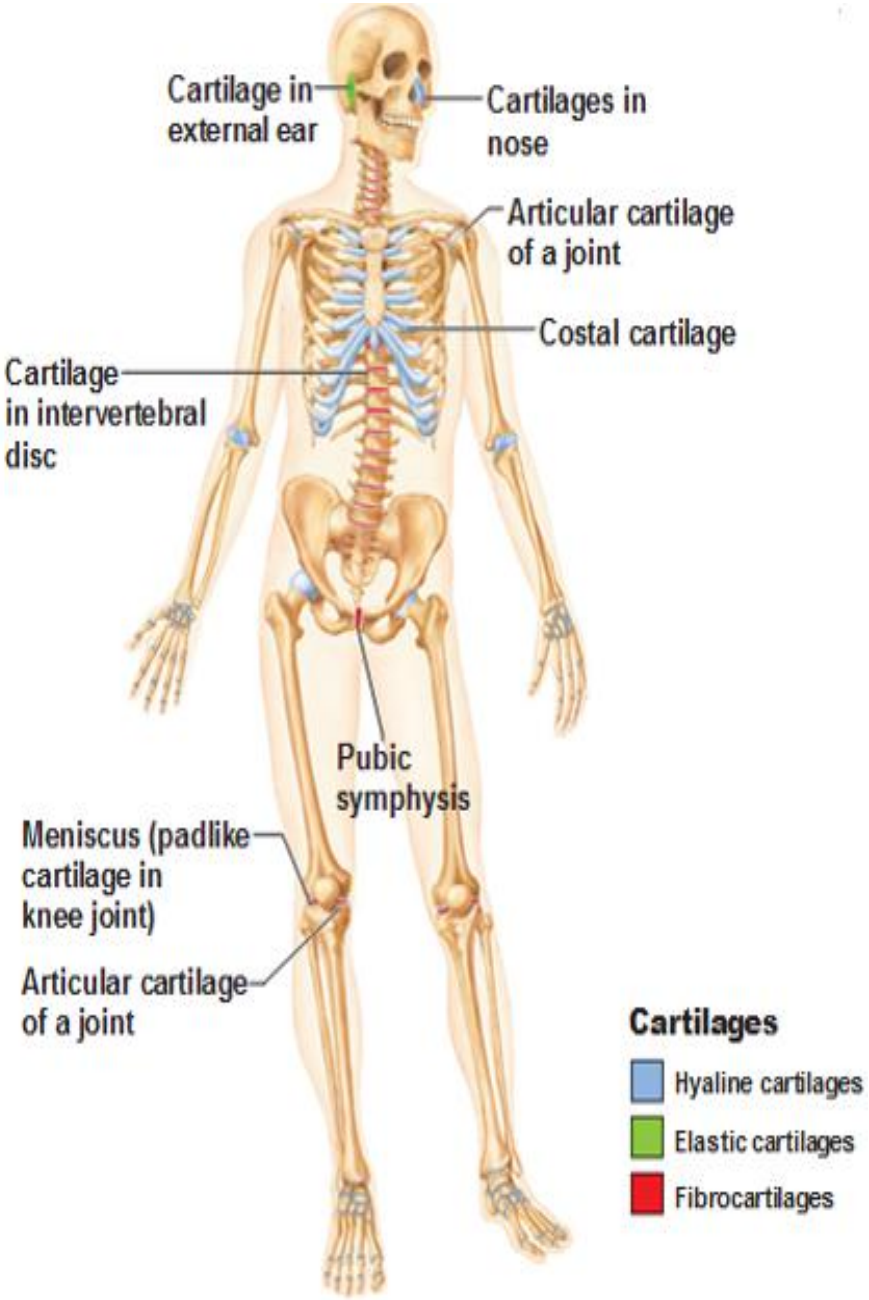
In sections they are seen to be formed of two components:

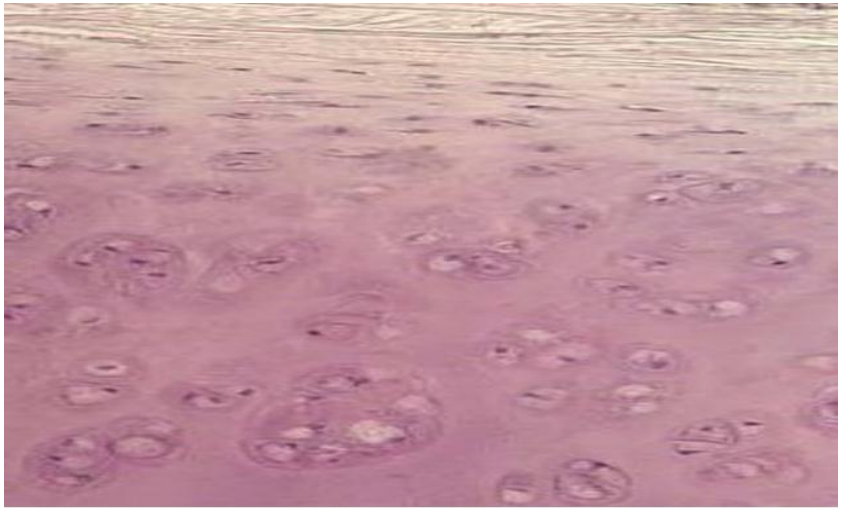
annulus fibrosus, which is the outer region consisting of orderly concentric arrangements of cells and matrix dominated by **type I collagen** = white fibrocartilage

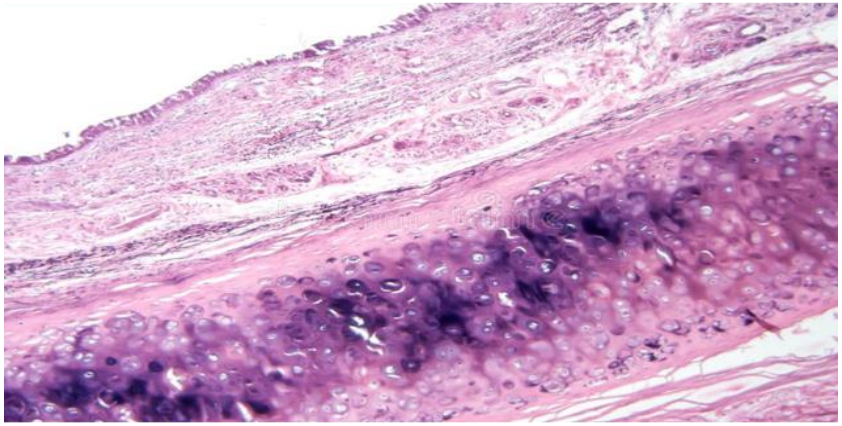
nucleus pulposus (large vacuolated cells)

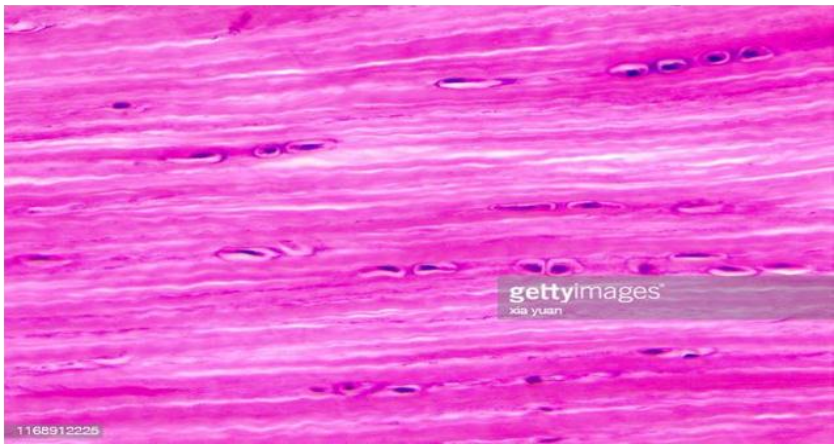





Cartilage in external ear
Cartilages in nose
Articular cartilage of a joint
Costal cartilage
Cartilage in intervertebral disc
Pubic symphysis
Meniscus (padlike cartilage in knee joint)
Articular cartilage of a joint
Cartilages
Hyaline cartilages
Elastic cartilages
Fibrocartilages



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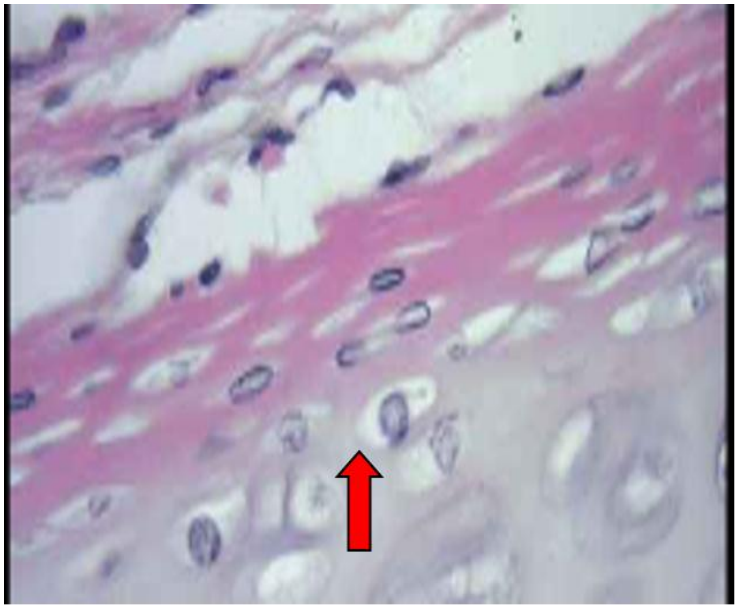
CARTILAGE GROWTH

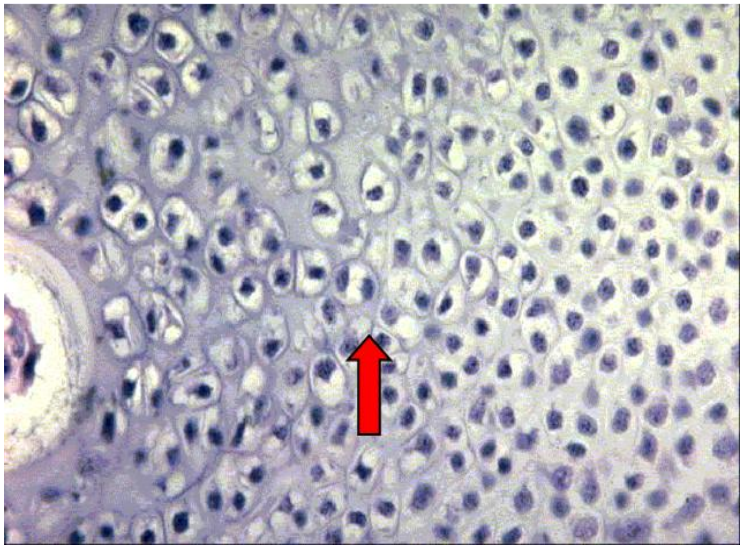
❑Appositional

Addition of new cartilage over the surface of existing cartilage.

❑Interstitial

Newly formed cartilage grows by multiplication of cells throughout its substance.





	Hyaline	Elastic	White fibrocartilage
Perichondrium	Covered with perichondrium except inside joint cavity	Always covered with perichondrium	Never covered with perichondrium
Nutrition	From perichondrium Inside joint cavity from synovial fluid	From perichondrium	From synovial fluid
Extracellular matrix	• Bluish grey color in fresh state • Pale basophilic with glassy appearance • No apparent fibers because they have the same refractive index as the ground substances • Collagen type II	Yellowish color in fresh state Large number of elastic fibers & collagen II Stained by orcein & VVG	White in fresh state Bundle of collagen I + collagen II
Characters	Smooth & firm	Very flexible can bear mechanical stress	Great strength with flexibility and rigidity
Chondrocytes	▪ Widely scattered ▪ Cell nest 1-8 / lacunae	Numerous 1-3 / lacunae	Few in row between collagen bundles 1-2 / lacunae
Sites	1. Skeleton of embryo 2. Epiphyseal plate in growing bone 3. Nose , larynx , trachea 4. Costal cartilage 5. Articular surface of joint	1. Ear pinna 2. External auditory canal n 3. Epiglottis	1. Intervertebral disc 2. Symphysis pubis 3. Temporomandibular joint

BONE

Functions of Bone:

- Allows body to move by giving attachment to different body muscles
- Supports soft tissues
- Protects vital organs (cranium, thoracic cavity)
- Contains bone marrow ---------- Blood formation
- Metabolic function : Reservoir of Ca++, PO4 to maintain constant concentrations in body fluids

Bone covering

- **Periosteum:**

cover the external surface of bone , formed of two layers

- Outer fibrous

This layer support the bone & gives attachment to the tendon of muscles , at these site collagen fibers are more thickened forming sharpey's fibers that penetrate deep into the bone substance to fix periosteum and prevent its separation

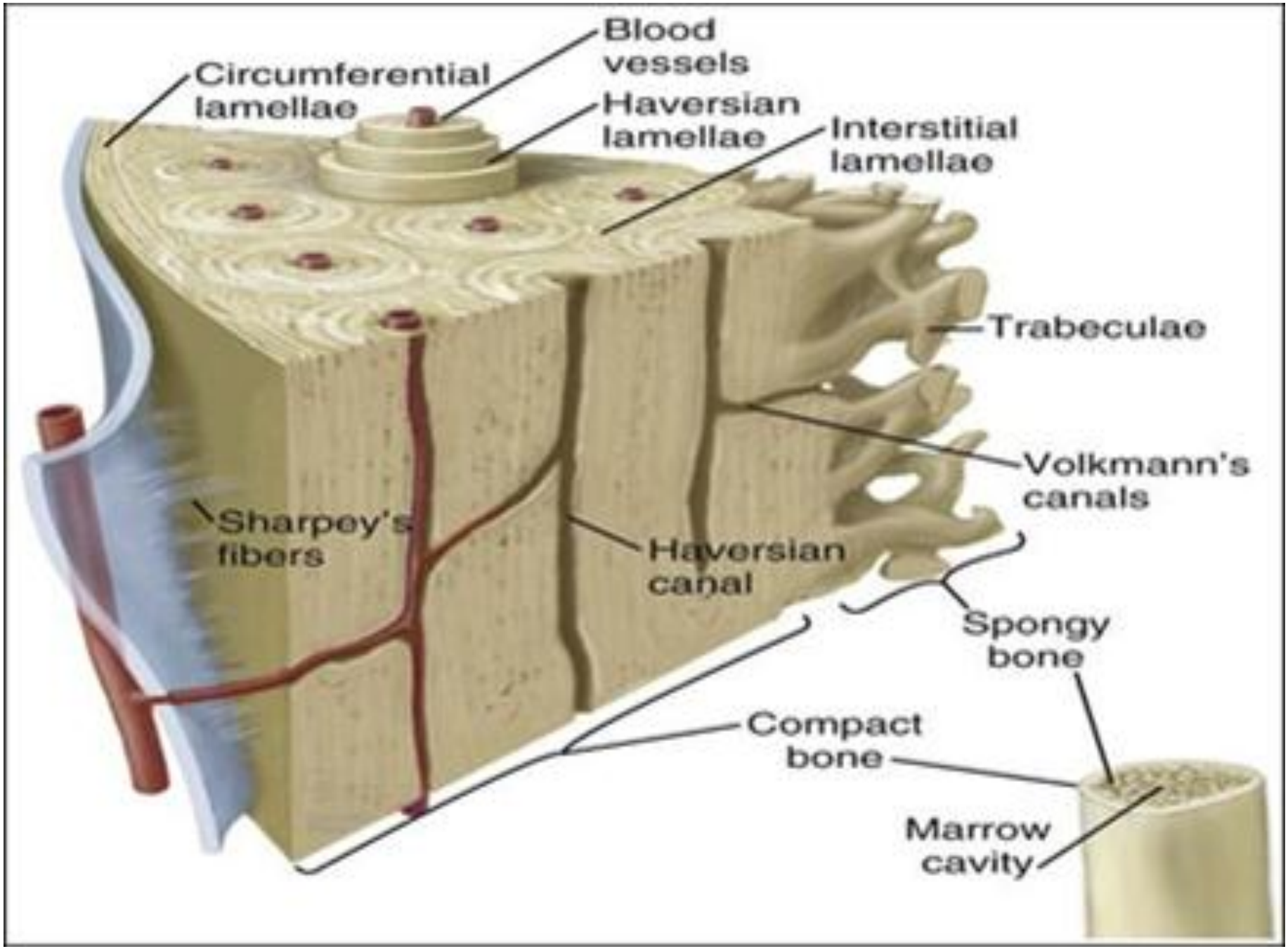
- Inner vascular & cellular formed of osteogenic cells

(osteoprogenitor & osteoblasts) and blood vessels important for

Nutrition of bone & supply of osteoblasts

- **Endosteum:**

lines the bone marrow cavity formed **only of cellular** layer of osteogenic cells & blood vessels


Blood vessels
Circumferential lamellae
Haversian lamellae
Interstitial lamellae
Trabeculae
Volkmann's canals
Sharpey's fibers
Haversian canal
Spongy bone
Compact bone
Marrow cavity

Bone Components

Bone is composed of cells lying in extracellular calcified matrix

- **Bone matrix:** composed of :
  - **Water** :**25%** of bone weight permits ion exchanges
  - **Organic components** = **30%** of bone weight include :
    - **Ground substance** formed of :
      - proteoglycans bound to hyaluronic acid
      - Adhesive glycoproteins e.g. osteocalcin & osteonectin
    - **Matrix fibers**
      - type I collagen fibers
      - Collagen forms osteoids: strands of spiral fibers that form matrix
  - **Inorganic components:** **45%** of bone weight

Calcified material in the form of calcium phosphates (Calcium hydroxyapatite) & calcium carbonates (calcium salts are responsible for the hardens of bone)

❑ Bone cells (4)

1. Osteoprogenitor cells (mother cells of bone)

Origin : arise from UMCs in the connective tissue present where bone formation is initiated

Site :

- present in cellular layer of periosteum
- Endosteum
- Lining Haversian canals

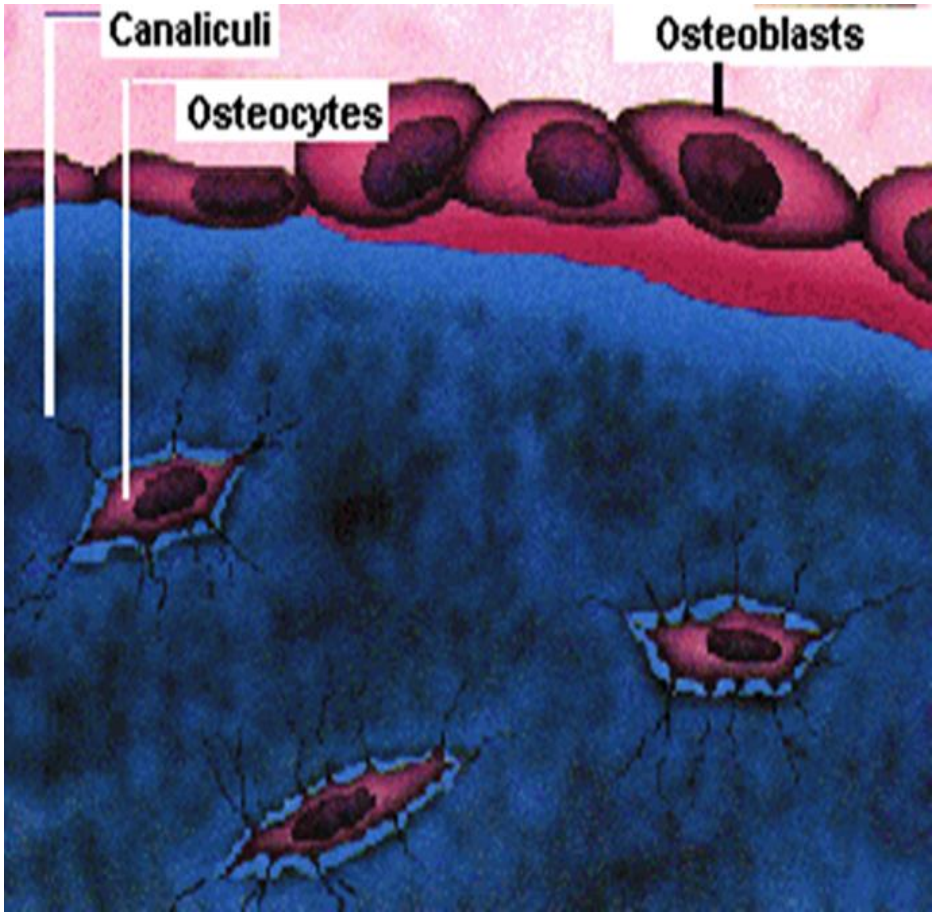
Function

Proliferate and differentiate to osteoblasts

2.Osteoblasts = bone-forming cells

Origin : Osteoprogenitor cells

Site : Lines border between **Periosteum** and matrix



Function :

- Synthesize organic components of matrix (collagen fibers type I, proteoglycans, glycoproteins.)
- Secretion of alkaline phosphatase enzyme essential for deposit of Ca++, PO4.

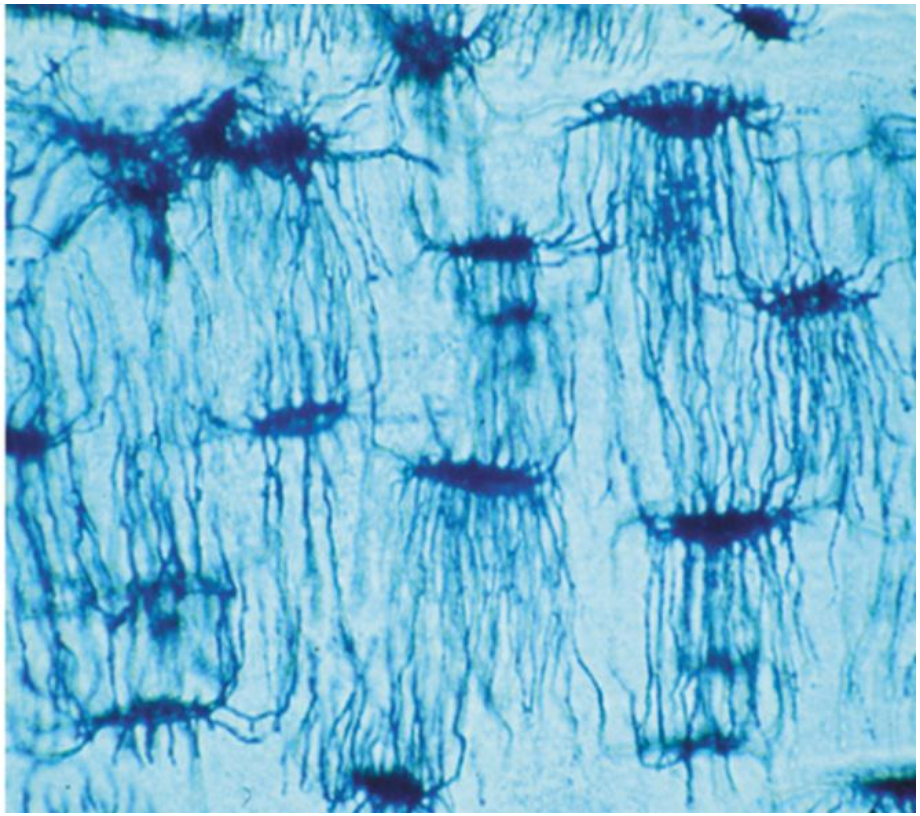
3.Osteocytes = called **unit bone cells**

Origin : **Osteoblasts**

Site : Mature bone cells that sit in lacunae

- Osteocyte with cytoplasmic extensions in the canaliculi
- Gap junctions between osteocytes provide nutrition

Function : Maintain bony matrix, long living cells

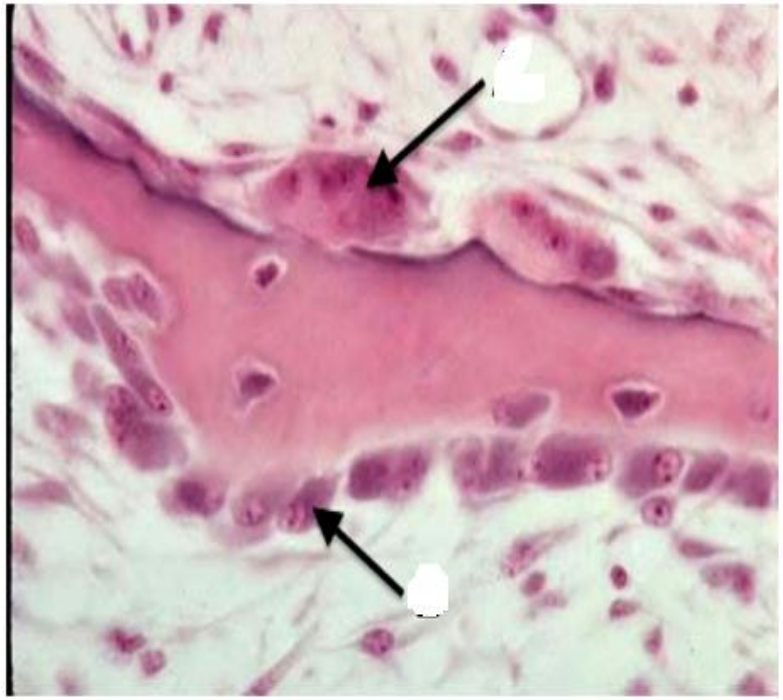


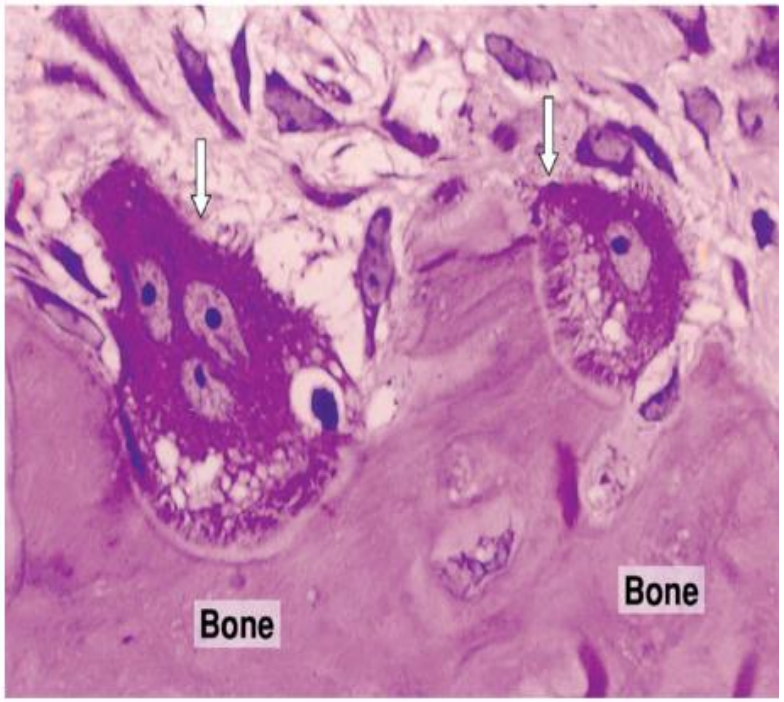
4.Osteoclasts = bone macrophages = **bone-eating cells**

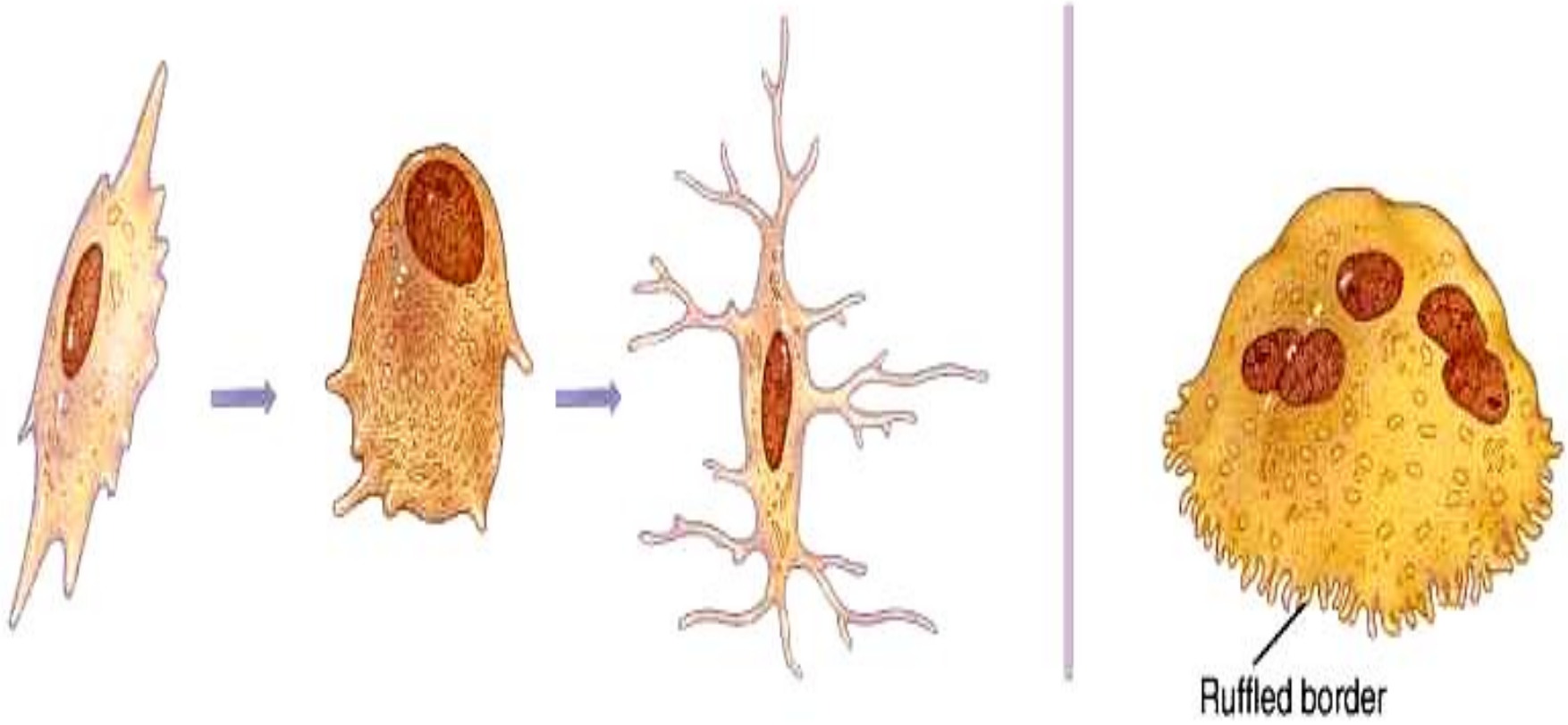
Origin : Derived from monocytes of the blood engulf bony material

Site : Large, multinucliated cells lying in Howship's lacunae

Function : Secrete enzymes that digest matrix = bone resorption & removal of inorganic & organic matrix







Osteogenic cell (develops into an osteoblast)

Osteoblast (forms bone tissue)

Osteocyte (maintains bone tissue)

Osteoclast (functions in resorption, the destruction of bone matrix)

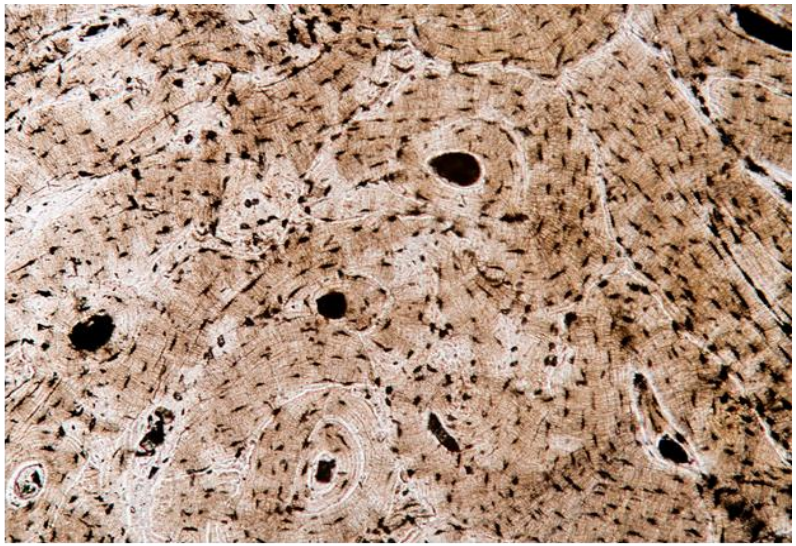
Cell	Origin	Function
1. Osteoprogenitor cells **Mother cells of bone**	From UMC in the CT	Proliferate & differentiate to osteoblast
2. Osteoblast **Bone forming cells**	From osteoprogenitor cells	Secretion of organic component of bone matrix Secretion of alkaline phosphatase essential for Calcium salts deposition
3. Osteocytes **Unit bone cells**	From osteoblast after being entrapped by calcified matrix	Maintenance of the bone matrix
4. Osteoclast **Bone macrophages** **Bone eating cells**	From blood momocytes	Bone resorption = removal of the inorganic & organic bone matrix

Methods of histological study of bone

There are **two methods** :

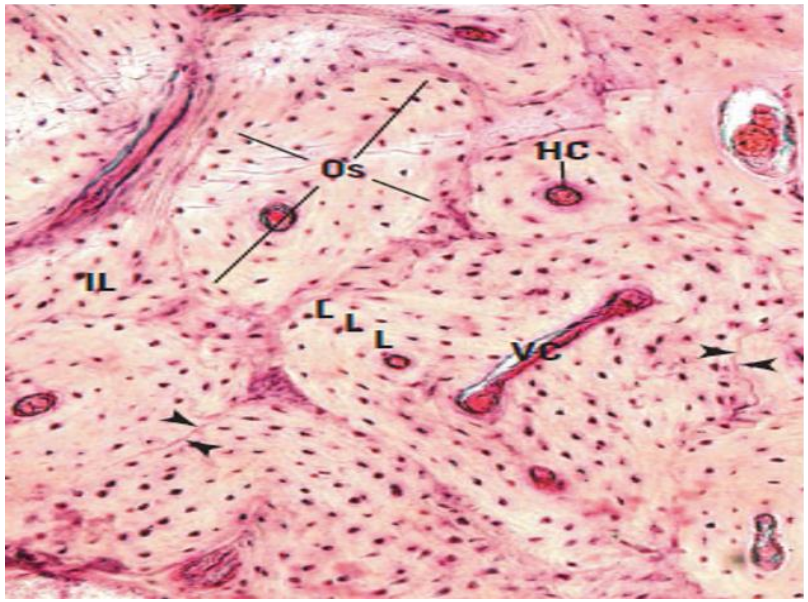
1. **Unstained ground bone**

In which the bone is grinned by special bone – grinding machine to produce very thin slices of bone the bone is mounted on glass slide , covered with a glass coverslip then examined directly by LM



2. **Stained decalcified sections** :

The calcium salts are removed from bone using strong acid solution e.g. nitric acid or chelating agent e.g. EDTA thus the bone became soft and is embedded sectioned & stained as usual with routine H&E stain



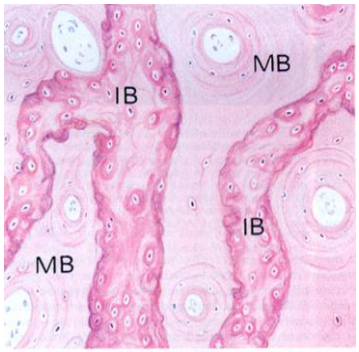
Types of bones

1. **Primary bone = woven bone =** Immature weak bone

- Deposited during prenatal development & bone repair
- It is temporary and replaced later on by secondary bone

Characters

1. Low calcium
2. Irregular collagen
3. Abundant irregular osteocytes



2. secondary bone

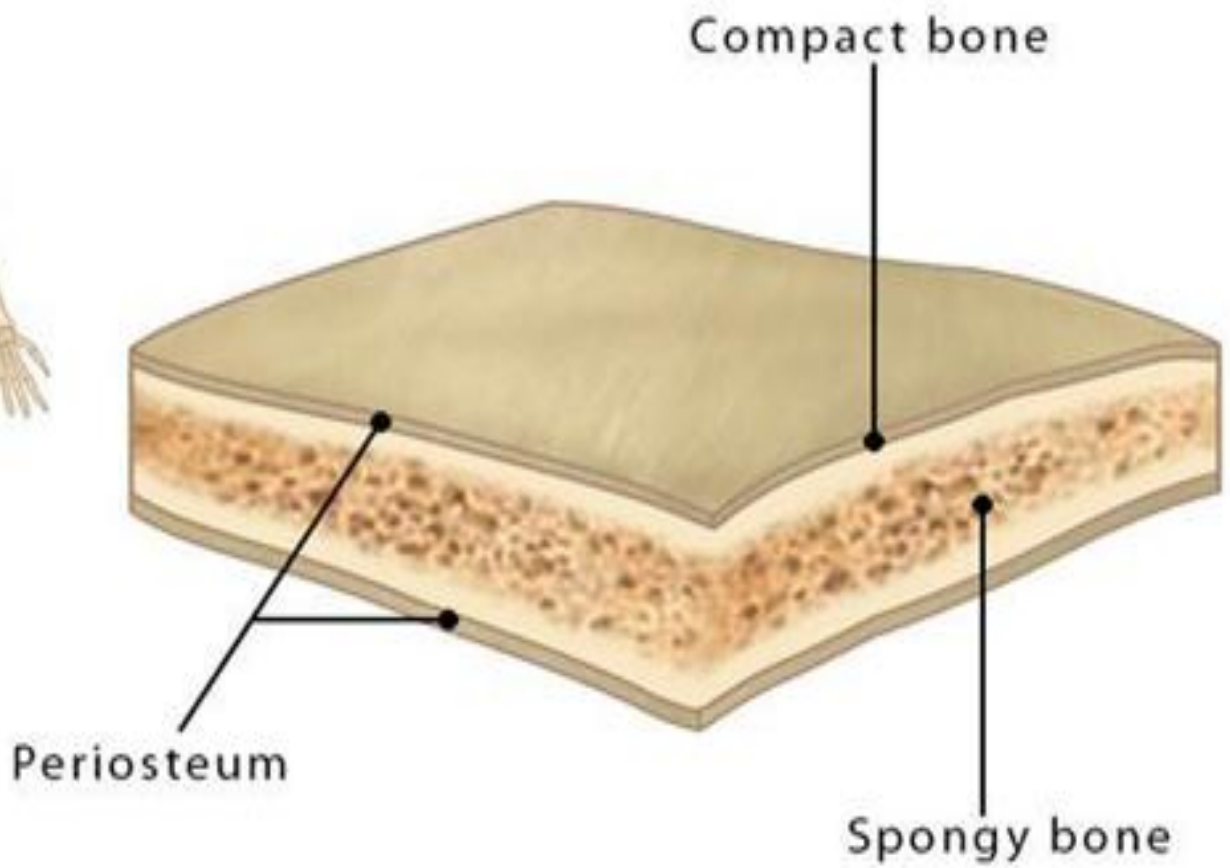
= Mature

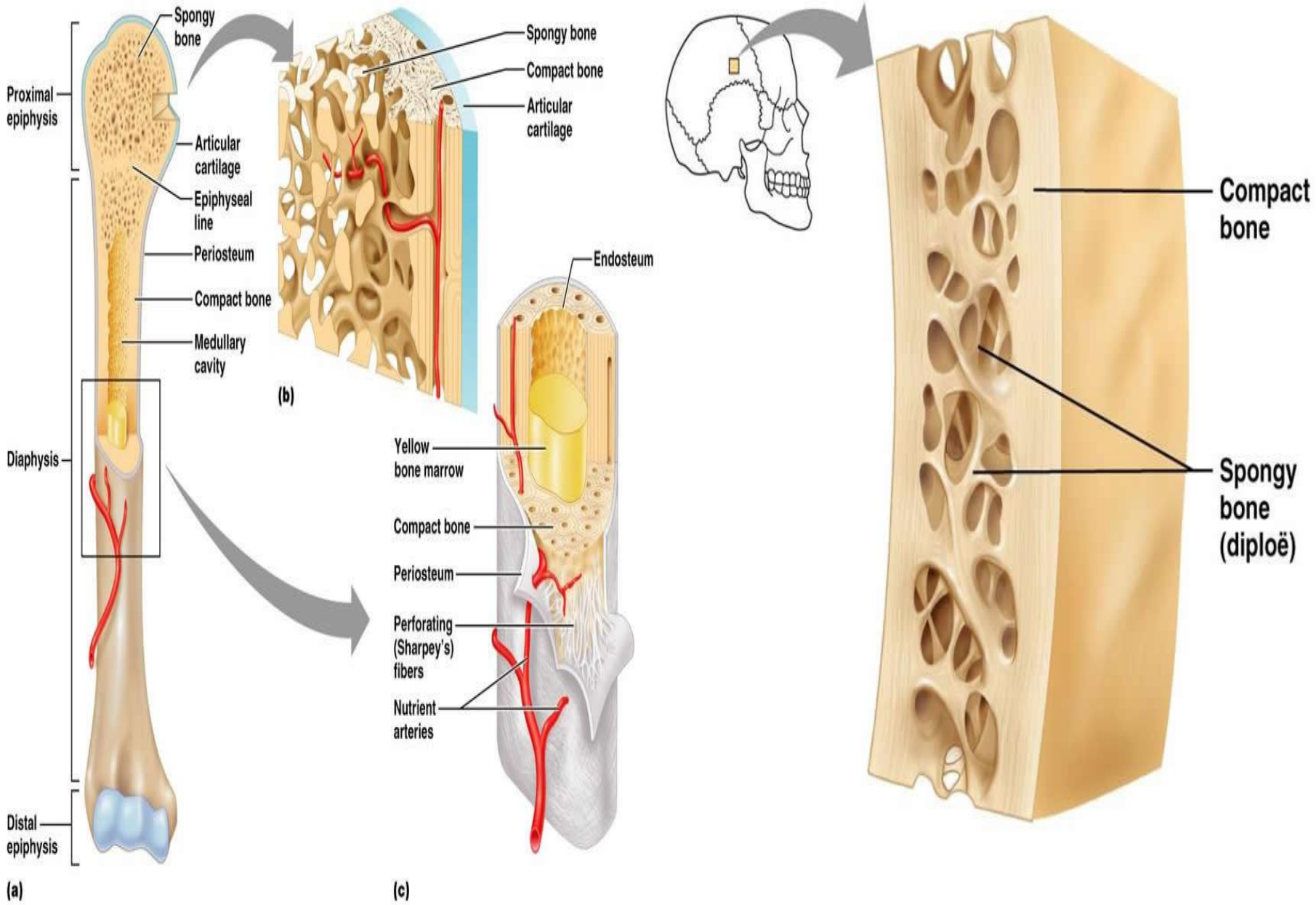
strong bone that replaces primary bone

Characters

1. High calcium content so it is stronger
2. Regular collagen form lamellae
3. Less abundant osteocytes regularly arranged along the lamellae

Flat Bone




Spongy bone
Proximal epiphysis
Articular cartilage
Epiphyseal line
Periosteum
Compact bone
Medullary cavity
Diaphysis
Distal epiphysis
(a)
Spongy bone
Compact bone
Articular cartilage
(b)
Endosteum
Yellow bone marrow
Compact bone
Periosteum
Perforating (Sharpey's) fibers
Nutrient arteries
(c)
Compact bone
Spongy bone (diploë)

Articular cartilage: covers epiphysis

Epiphysis: ends of bone

Epiphyseal plate: growth plate

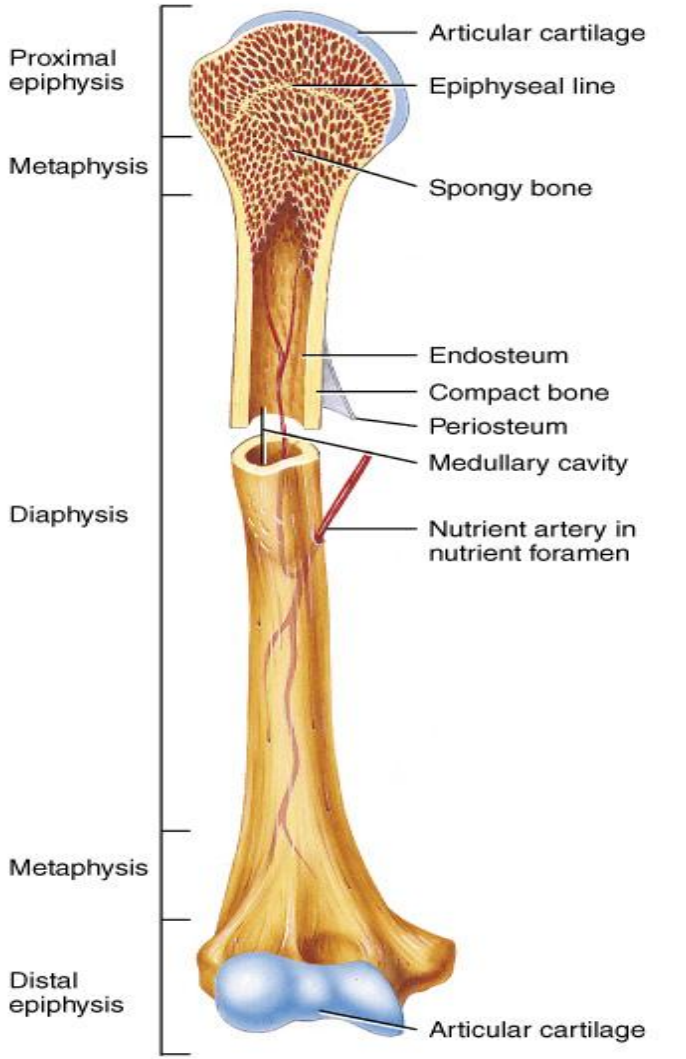
Metaphysis: epiphysis and diaphysis

Diaphysis: shaft of long bone

Periosteum: bone covering
Sharpey's fibers: periosteum attaches to underlying bone

Endosteum: thin layer lining the medullary cavity

Medullary cavity: Hollow chamber in bone
- red marrow produces blood cells
- yellow marrow is adipose



(a) Partially sectioned humerus (arm bone)

Mature bone

❑ Compact bone

- ➢ Is also called **dense bone** = Lamellar bone =Ivory bone
- ➢ Found in:
- ❖ metaphysis & diaphysis of long bone
- ❖ Outer & inner tables of flat bone
- ➢ Compact bone is composed of closely packed osteons.
- ➢ An osteon is also called a **Haversian system**.
- ➢ Haversian system or osteon is a Structural and functional unit of the compact Bone

❑ Spongy bone

- ➢ is also referred to as cancellous (trabecular) bone, It is non-lamellar bone or bundle bone
- ➢ Found in :
- ❖ Epiphysis of long bone
- ❖ Diploe of flat bone
- ➢ The mineralized tissue is seen as plates and bars.
- ➢ Trabeculae are the bars seen in the spongy bone.
- ➢ Multiple marrow spaces are also present.

Histology of Compact Bone

=**dense bone** = Lamellar bone = Ivory bone

Site : it is found in :

1. Diaphysis (shaft) of long bones e.g. humerus & femur
2. Outer & inner tables of flat bone e.g. skull

• Has a single centrally located bone marrow cavity

Covering :

❑ **Periosteum.** The outer surface of the bones is covered by a double-layered coat.

➢**The outer fibrous** layer of periosteum is dense connective tissue.

➢ Support osteogenic layer

Function : Nutrition , supply osteoblast for bone formation (repair- Growth he bone

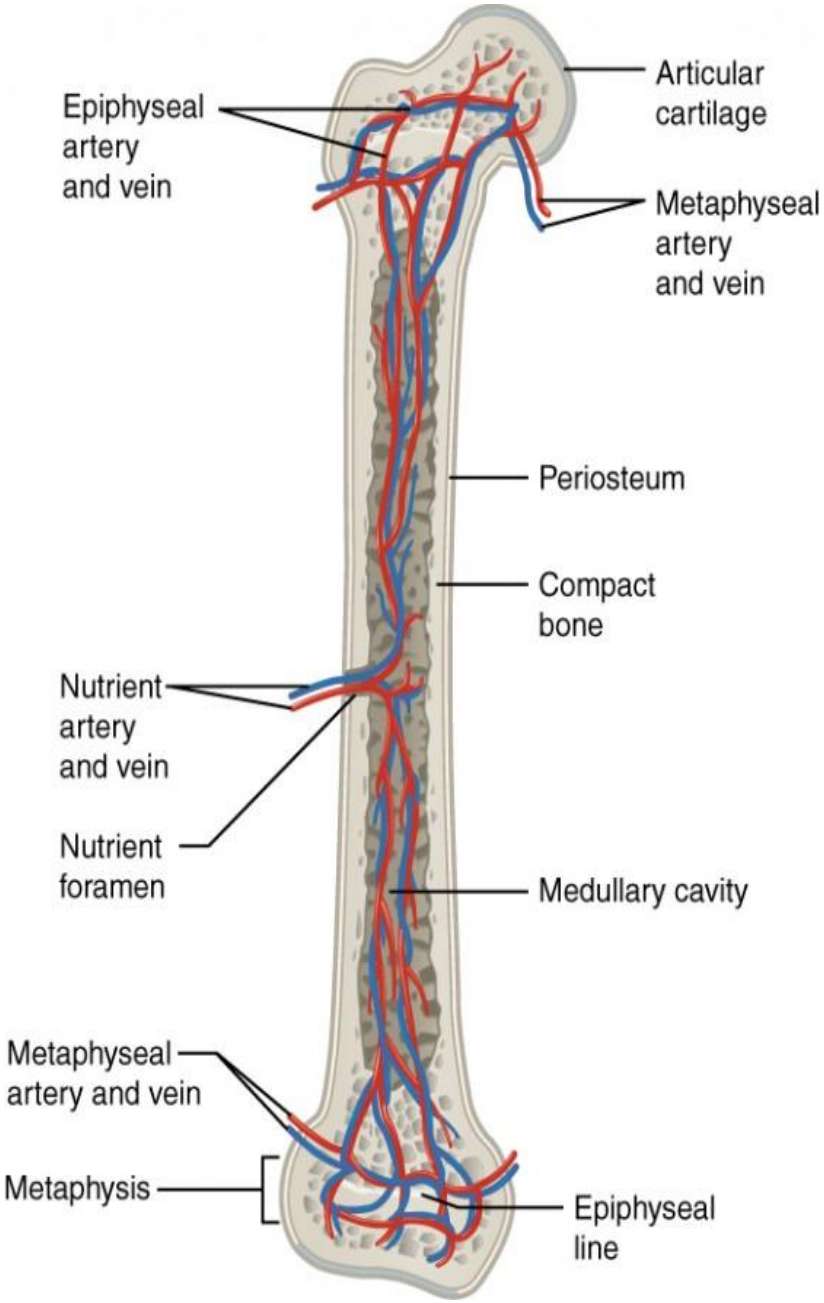
❖ Gives attachment to tendons of muscle

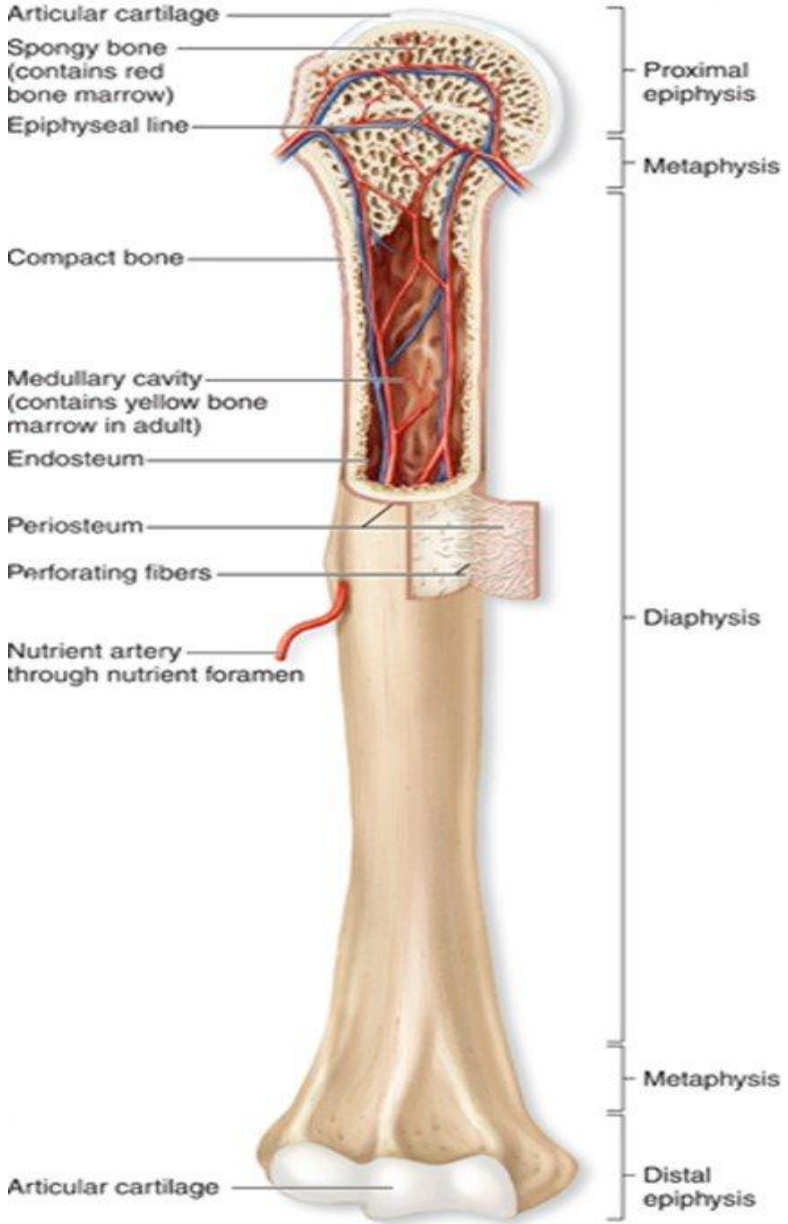
❖At these site collagen fibers penetrate deep into the bone forming sharpey‘ s fibers fix periosteum to inside of the bone

➢**The inner cellular** is a loose CT containing osteoprogenitor cells.

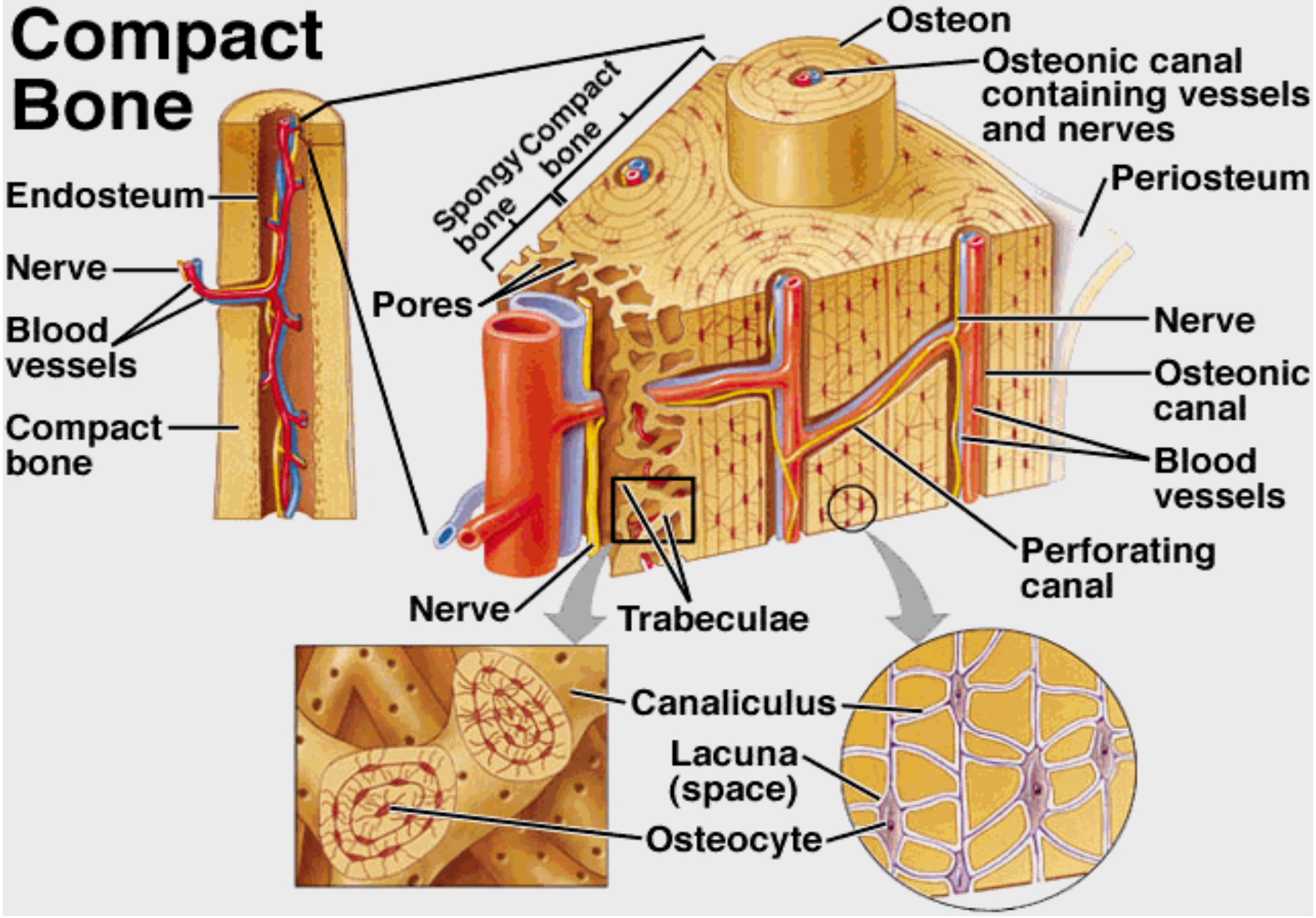
❑ **Endosteum :** lines the internal surface of bone formed of osteogenic cells & blood vessels

The same function as the cellular layer of periosteum


Epiphyseal artery and vein
Articular cartilage
Metaphyseal artery and vein
Periosteum
Compact bone
Nutrient artery and vein
Nutrient foramen
Medullary cavity
Metaphyseal artery and vein
Metaphysis
Epiphyseal line


Articular cartilage
Spongy bone (contains red bone marrow)
Epiphyseal line
Compact bone
Medullary cavity (contains yellow bone marrow in adult)
Endosteum
Periosteum
Perforating fibers
Nutrient artery through nutrient foramen
Articular cartilage
Proximal epiphysis
Metaphysis
Diaphysis
Metaphysis
Distal epiphysis

Compact Bone



Bone tissue: it is called bone lamellae

- It is regular in compact bone
- Formed of type I collagen fibers and osteocytes in lacunae
- Osteocytes communicate together through bony canaliculi to maintain nutrition

In compact bone :

1. External (outer) circumferential lamella
2. Internal (inner) circumferential lamella
3. Haversion system (osteon)
4. Interstitial lamella

Filling the spaces between Haversian system

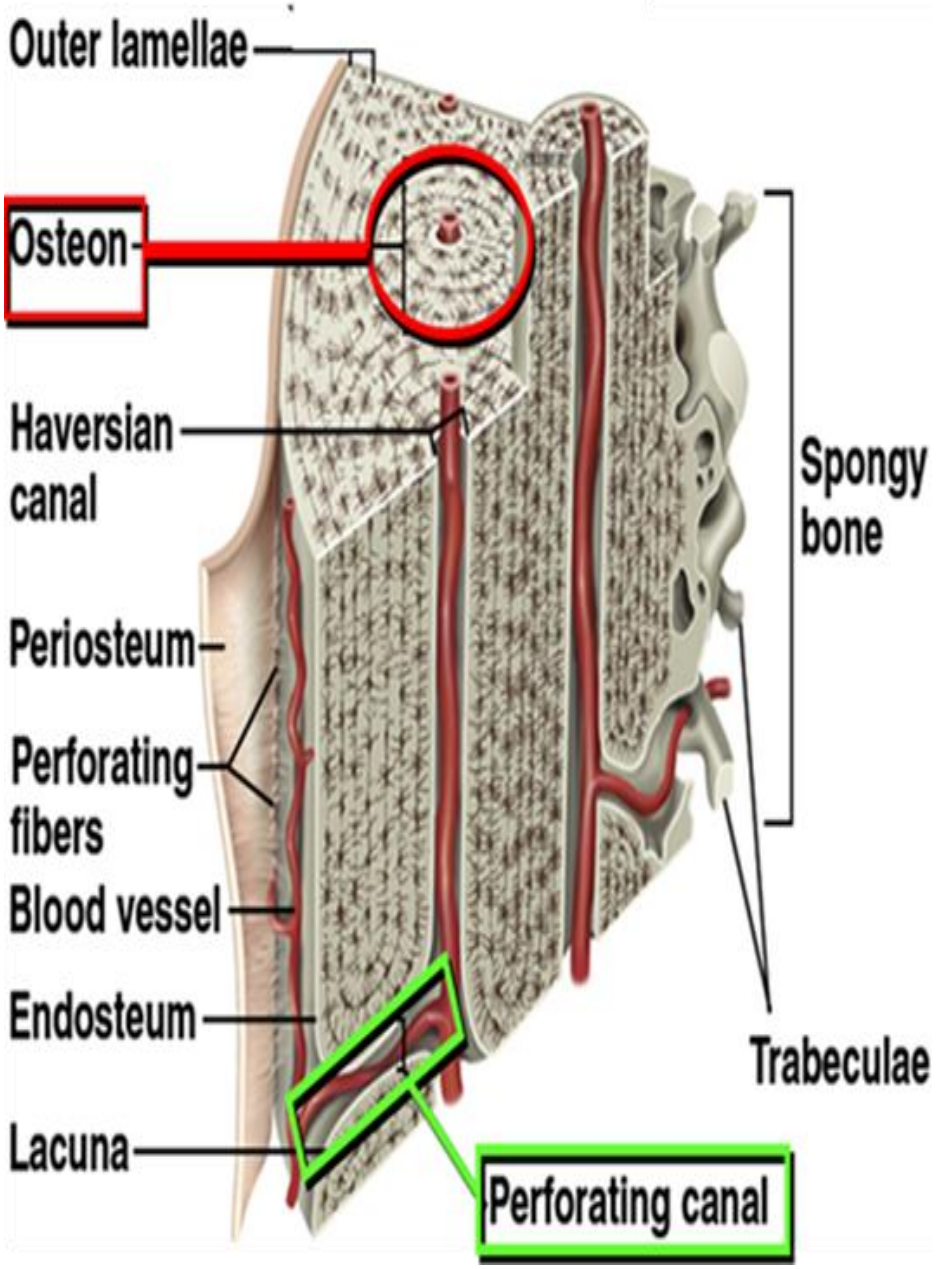
Represent the that left behind during the process of

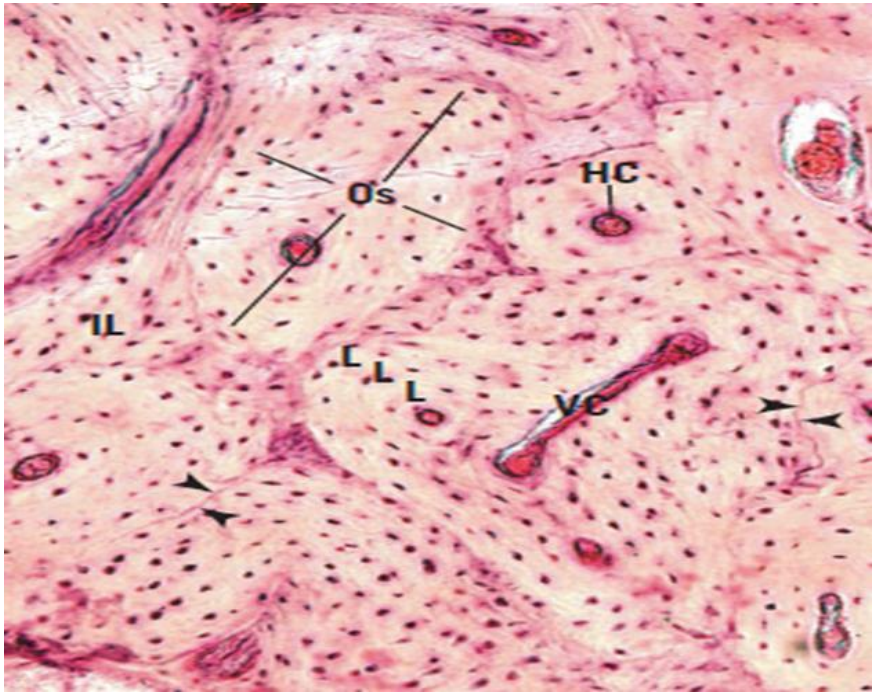
continuous renewal of bone

OSTEONS
=Haversian system

Definition :

- Osteon (Haversian system) is the whole complex of concentric lamellae of the bone surrounding a canal containing blood vessels, nerves, and loose connective tissue is called a **Haversian system,** or **osteon** .
- Haversian canals communicate with marrow cavity, periosteum, other canals through Volkmann's canals
- In each lamella, type I collagen fibers are parallel to each other.
- Lacunae containing osteocytes are found between , and occasionally within, the lamellae.
- One bone marrow cavity in young age contain active bone marrow (Red BM)
- In adult contain yellow inactive bone marrow


Outer lamellae
Osteon
Haversian canal
Periosteum
Perforating fibers
Blood vessel
Endosteum
Lacuna
Spongy bone
Trabeculae
Perforating canal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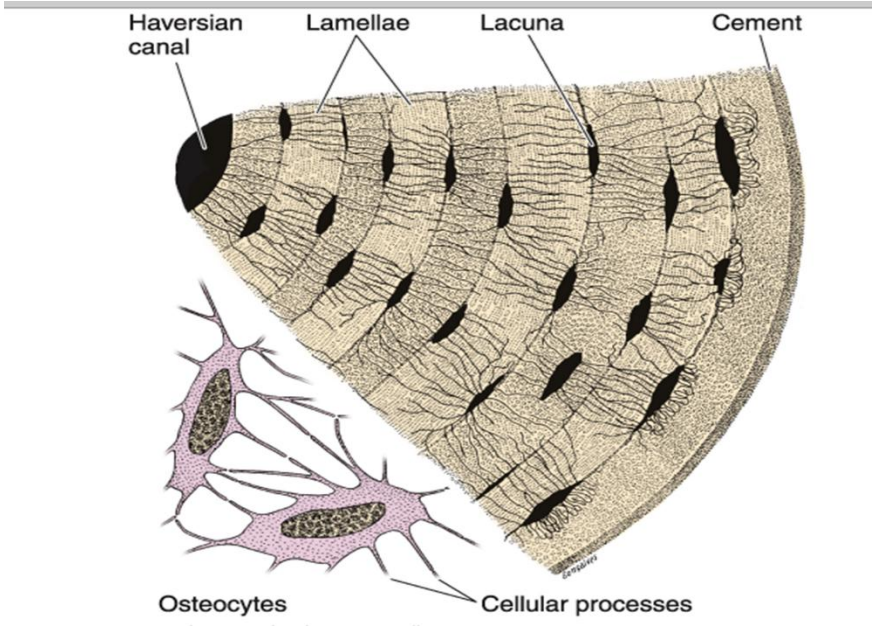
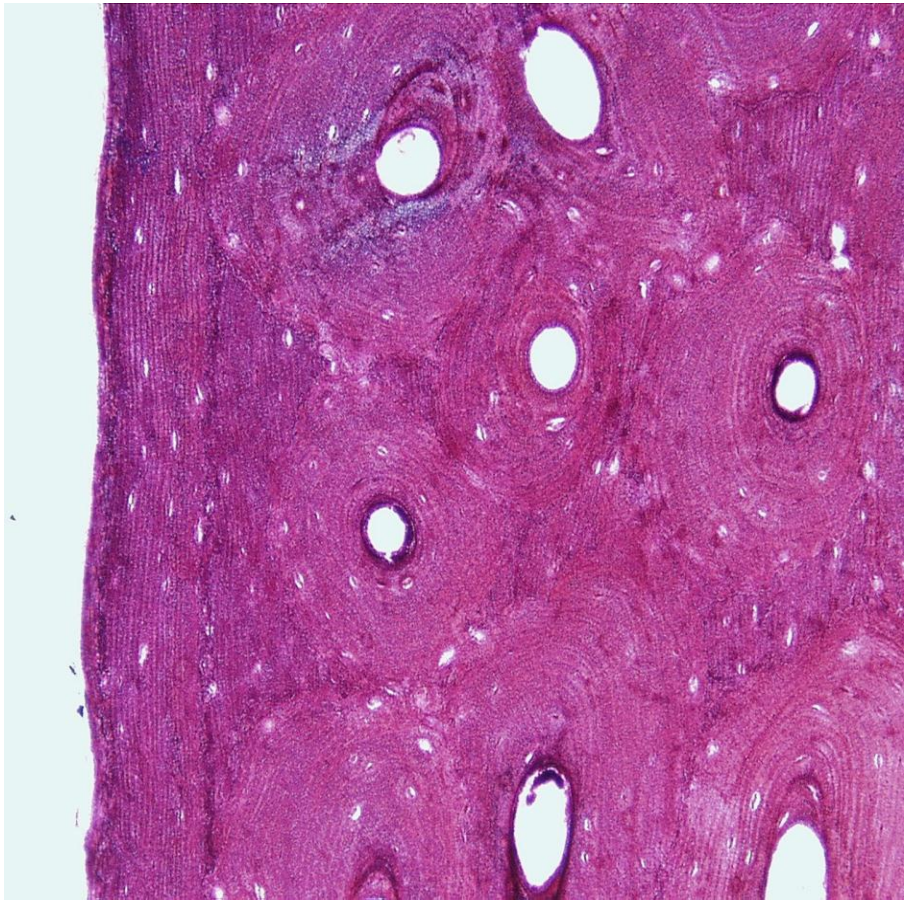
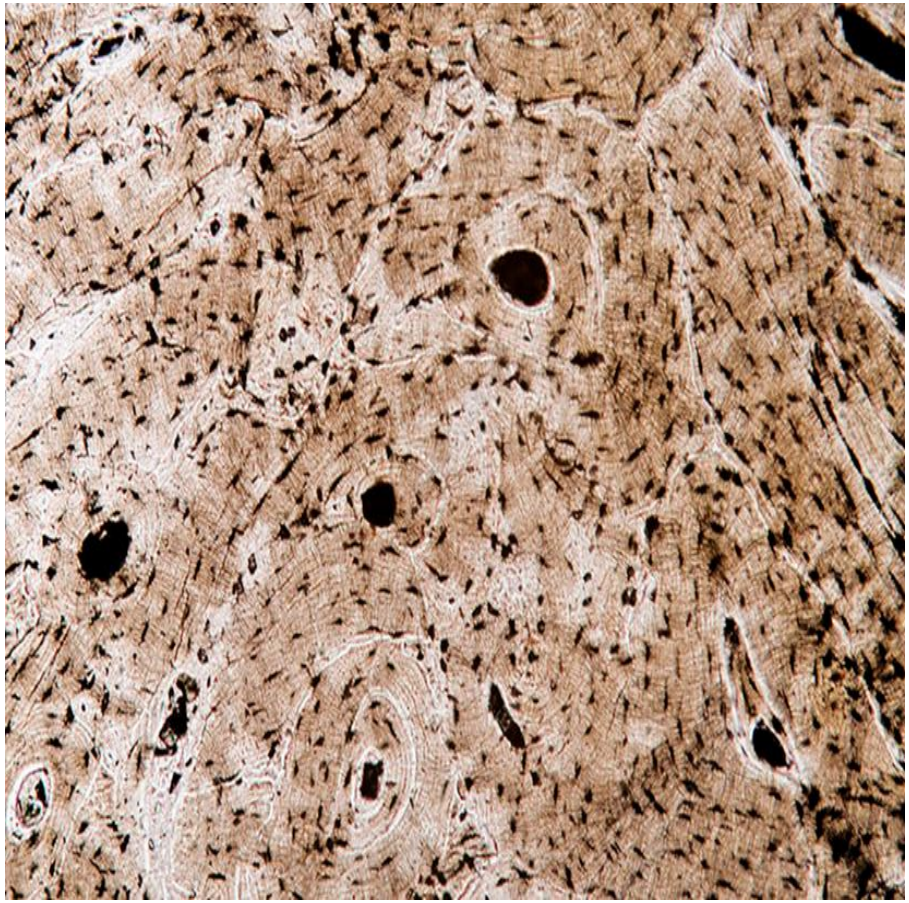

Haversian canal
Lamellae
Lacuna
Cement
Osteocytes
Cellular processes

OSTEONS





Cancellous bone
= Spongy bone=trabecular bone

It contains many bone marrow cavities giving the bone a spongy appearance

Site : Flat bone , Epiphysis of long bone

Bone covering :

1. **Periosteum**
2. **Endosteum**

Bone tissue : Formed of two main components

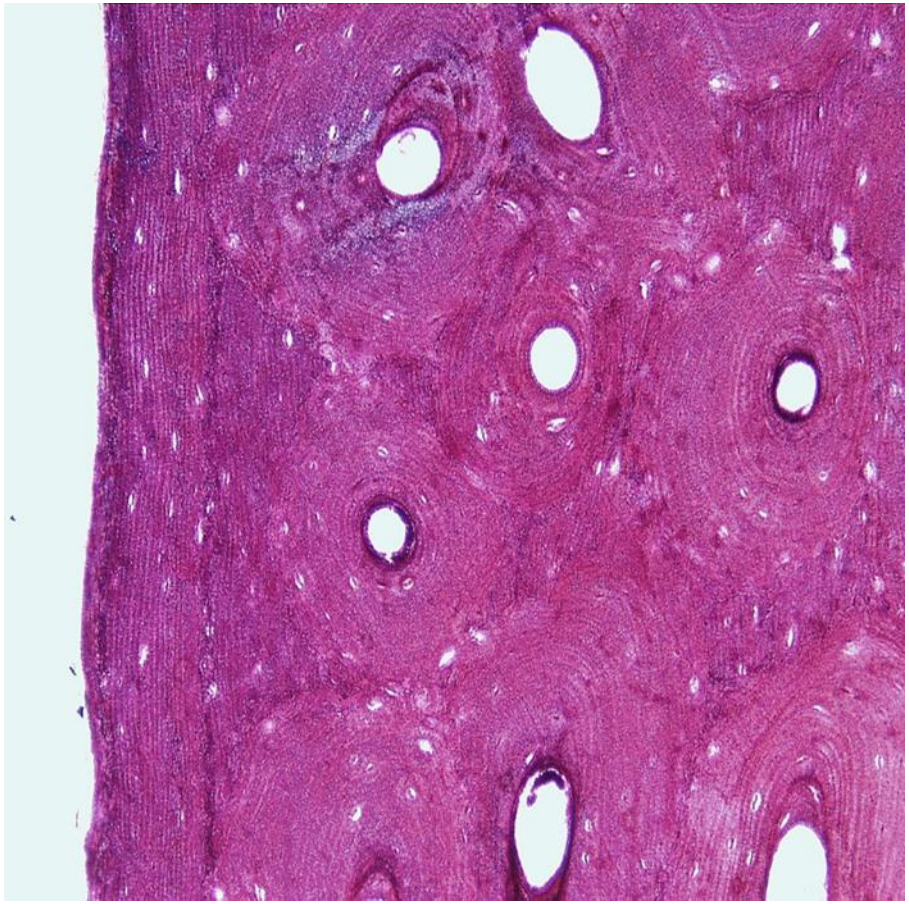
1. **Bone trabeculae**

- irregular & anastomosing bone lamellae with scattered osteocytes in lacunae
- Poorly developed Haversian system

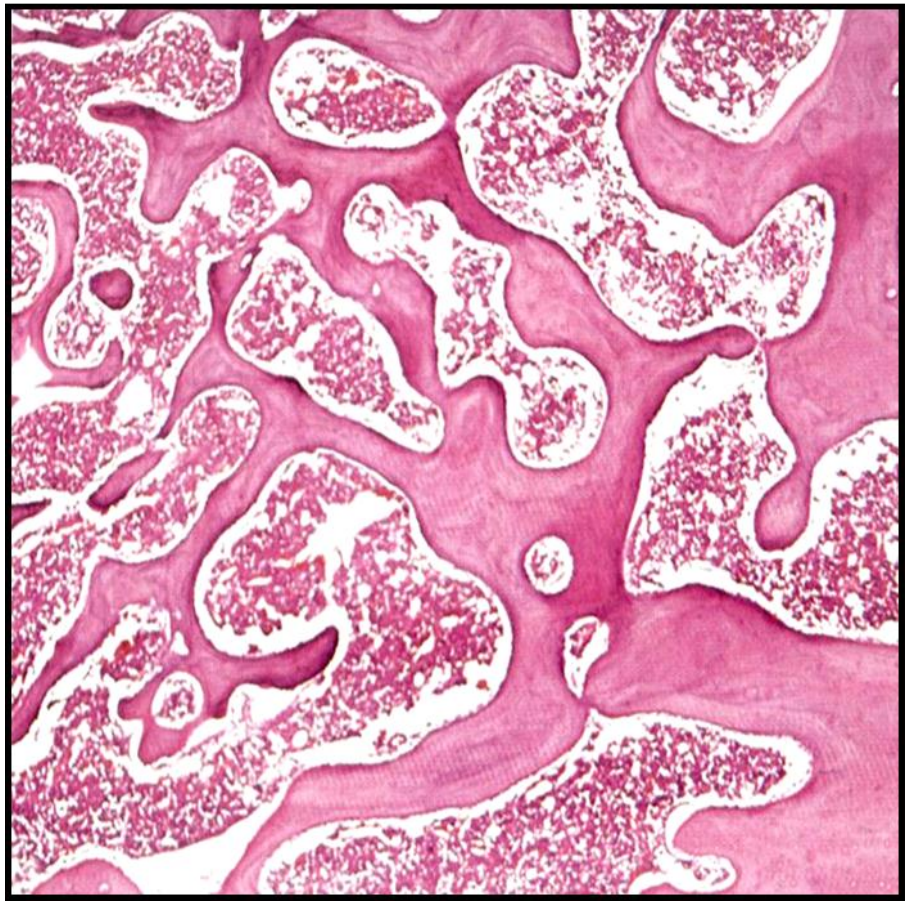
2. **Bone marrow cavities :**

Multiple irregular BM cavities contain active red bone marrow

Compact bone



Cancellous bone



	Compact bone	Cancellous bone
Naked eye appearance	Dense with no hole	Spongy with many hole
Sites	Shaft of long bones Outer & inner tables of flat bones	Flat bone Epiphysis of long bone
Periosteum	Present	Present
Endosteum	Lines central single marrow cavity	Lines multiple marrow cavities
Marrow cavity	Central single	Multiple cavities
Bone lamellae	Regular , parallel form Haversian system , circumferential and interstial lamellae	Irregular , incomplete lamellae Form bone trabeculae
Haversian system	Mature , well developed	Immature , primitive Haversian
Matrix	Well organized collagen	Irregular collagen
Nutrition	Bone nutrient vessels , periosteal vessels . Volkman canal , Haversian canals, canaliculi of all osteocytes	Bone nutrient vessels , periosteal vessels, multiple marrow cavities, bone canaliculi

	Bone	Cartilage
Characters	Hard , inflexible	Firm & flexible
Covering	Periosteum & endosteum	Perichondrium Except White fibrocartilage & articular surface of hyaline
Matrix	Rich in Ca ++ , less hydrated 25% water	Well hydrated 60-70 % water
CT fibers	Collagen I well organized into lamellae	Collagen II Elastic fibers Collagen I in WFC
Cells	4 Types Osteocytes single inside lacunae communicating by processes	2 Types Chondrocytes single or in group inside lacune forming cell nest
Vascularity	Vascular	Avascular

BONE FORMATION

The process of bone formation is called **ossification**

Formation of Bone in an Embryo

- Bone may develop (**directly**) from mesenchyme
- Replacement of cartilage (**indirectly**).

Postnatal :

- Growth of bones until adulthood
- Remodeling of bone
- Repair of fractures

BONE FORMATION

Formation of Bone in an Embryo

begins at the 6th week of embryo development and continues up to age of 25 weeks

two patterns

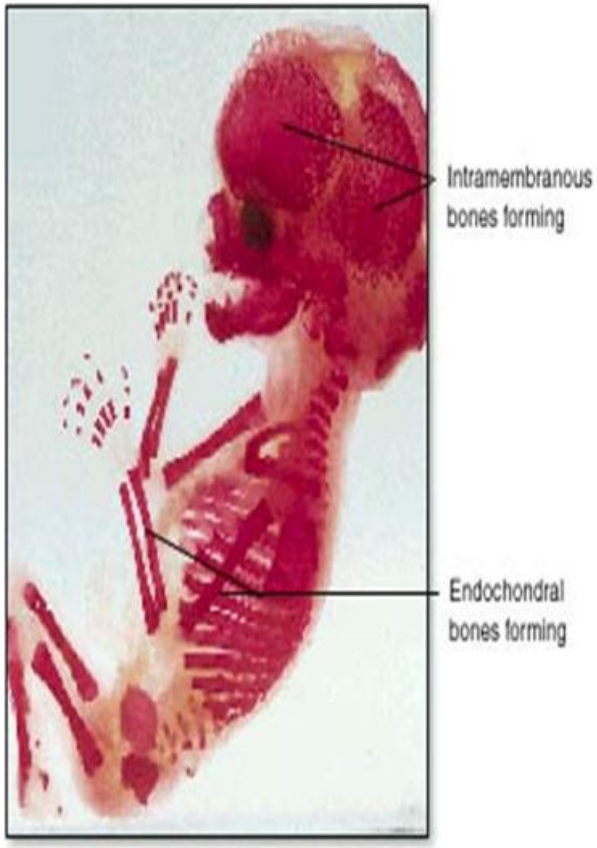
- **Intramembranous ossification**

  Flat bones of the skull , mandible & clavicle are formed in this way

- **Endochondral ossification**

  cartilage formation and ossification occurs during the sixth week of embryonic development

  - The replacement of cartilage by bone
  - Most bones of the body are formed in this way including long bones

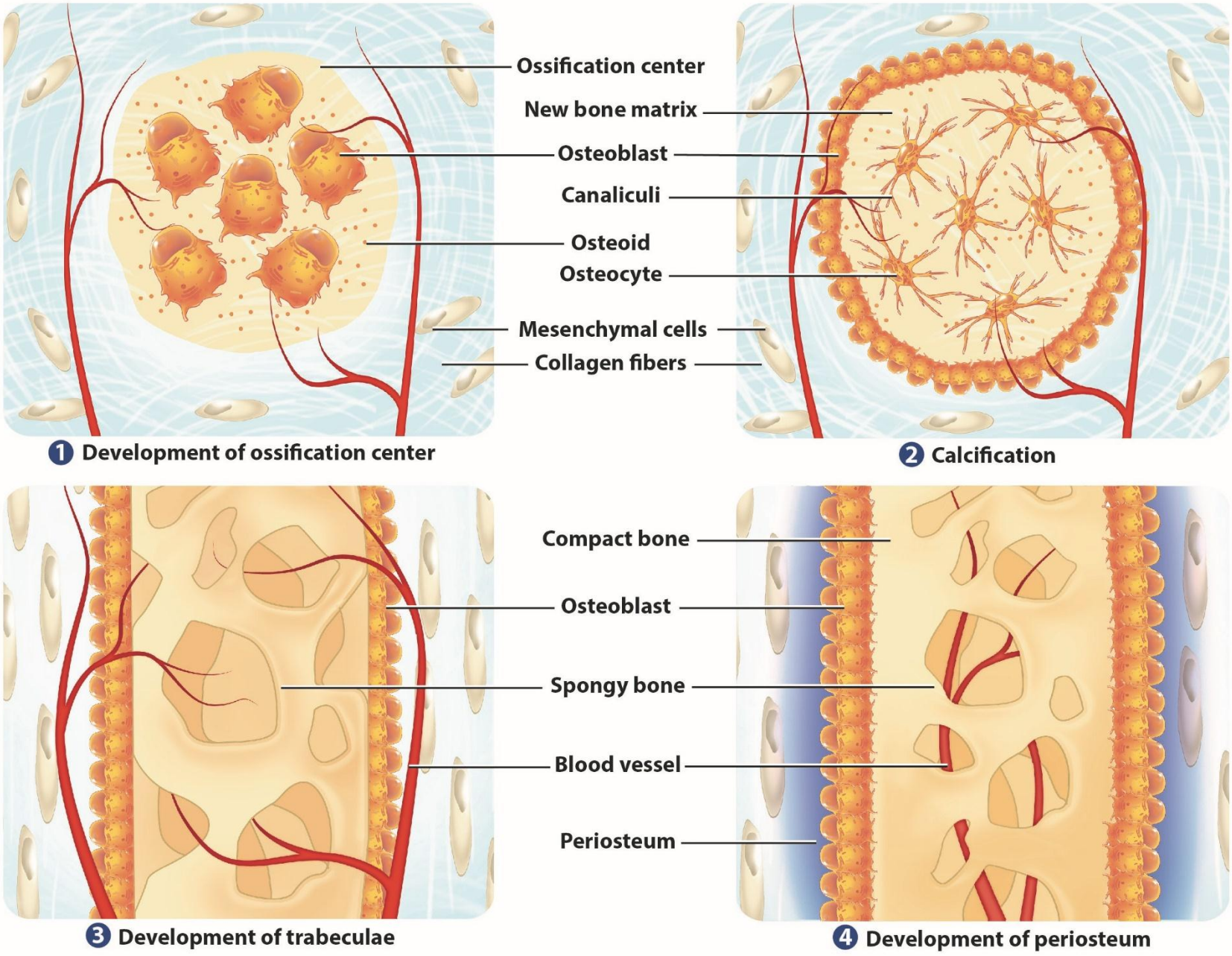


Intramembranous Ossification

- In the mesenchymal connective tissue membrane
- Mesenchyme cells differentiate into osteoblasts an ossification center appears. **Osteogenic islands.**
- Osteoblasts secrete bone matrix within the fibrous membrane
- Osteoblasts surround themselves with bone matrix, forming osteocytes = Osteoblasts mature into osteocytes

= It is **osteoid stage.**

- Osteoid becomes mineralized through crystallization of Ca++ salts using enzyme alkaline phosphatase and is called primary ossification center(OC). It is **ossification stage and formation of spicules.**
- Blood vessels begin to grow spicules that meet and fuse together.
- **Woven Bone (primary spongy bone).**
- Osteoclasts erode the primary bone matrix . **It is remodeling or Secondary bone formation.**


Ossification center
New bone matrix
Osteoblast
Canaliculi
Osteoid
Osteocyte
Mesenchymal cells
Collagen fibers
1 Development of ossification center
2 Calcification
Compact bone
Osteoblast
Spongy bone
Blood vessel
Periosteum
3 Development of trabeculae
4 Development of periosteum

Endochondral (indirect) Ossification

Bone develops from pre-existing model of hyaline cartilage

- Formation of primary ossification center (**OC**) and marrow cavity in shaft of model
- Cartilage model stem cells give rise to osteoblasts
- The periosteal bone collar (perichondral ossification) bony collar developed by osteoblasts
- Proliferation,hypertrophy,calcification of the cartilage (chondrocytes swell and die) = bone laid down and marrow cavity created
- Formation of primary marrow cavity and Periosteal bud- small cluster of blood vessels
- Secondary ossification centers and secondary marrow cavities are formed in the ends of the bone
- primary and secondary marrow cavities united
- Cartilage remains as articular cartilage and epiphyseal (growth) plates
- growth plates provide for increase in length of bone during childhood and adolescence

Stages of Endochondral Ossification

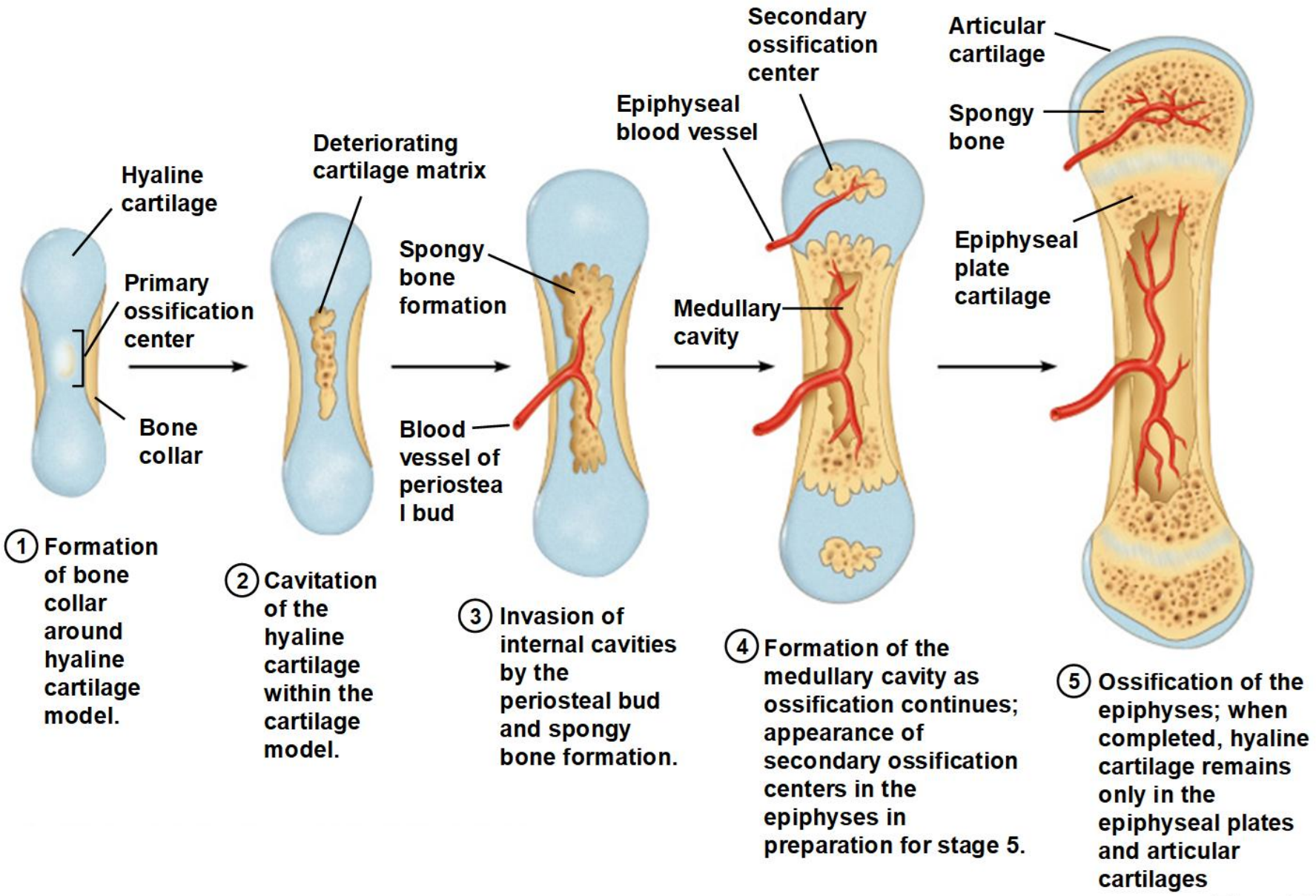
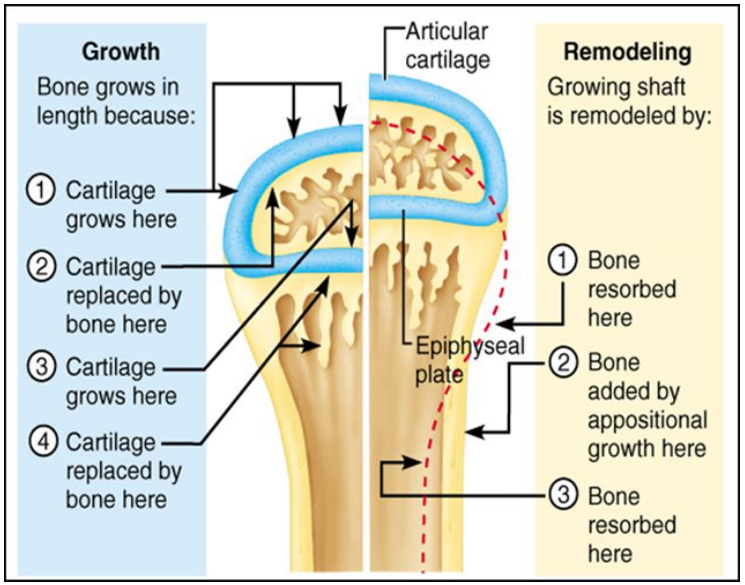


Figure 6.8

Bone Growth

bone growth during childhood and adolescence

- Bones increase in length = **interstitial growth** of epiphyseal plate
  - growth plates provide for increase in length of bone during childhood and adolescence



- Bones increase in width = **appositional growth**

osteoblasts lay down matrix in layers on outer surface and osteoclasts dissolve bone on inner surface

Structure of the epiphyseal plate

Zone of reserve cells (resting cartilage): A thin layer of small, randomly oriented chondrocytes adjacent to the bony trabeculae on the articular side of the growth plate.

1. Zone of proliferation: Chrondrocytes are stacked in prominent rows, mitotic figures and the cartilage matrix becomes more basophilic

Zone of maturation: No mitoses; gradual cellular enlargement.

2. Zone of hypertrophy:

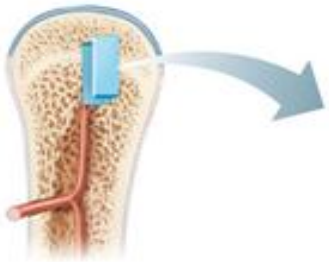
Chrondrocytes and their lacunae increase in size.

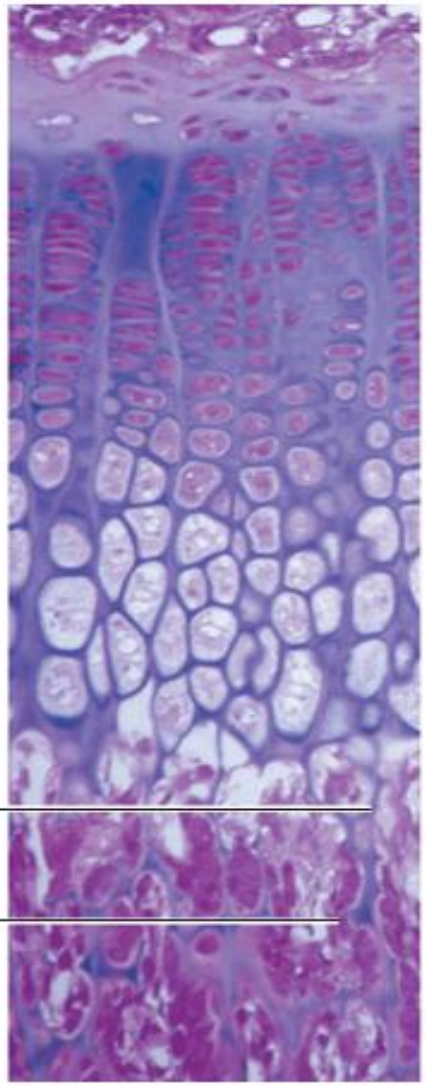
3. Zone of calcification: Deposition of minerals in the matrix surrounding the enlarged lacunae causing cell death.

4. Zone of ossification: Osteoblasts deposit bone matrix on the exposed plates of calcified cartilage.

Zone of resorption: Osteoclasts absorb the oldest bone spicules.

Organization of Cartilage within Epiphyseal Plate of Growing Long Bone





Resting zone – small, inactive cartilage cells

① Proliferation zone
Chondroblasts quickly divide and push the epiphysis away from the diaphysis, lengthening the bone.

② Hypertrophic zone
Older chondrocytes enlarge and signal the surrounding matrix to calcify.

③ Calcification zone
Matrix becomes calcified; chondrocytes die, leaving behind trabeculae-shaped calcified cartilage.
THIS IS NOT YET BONE!
.

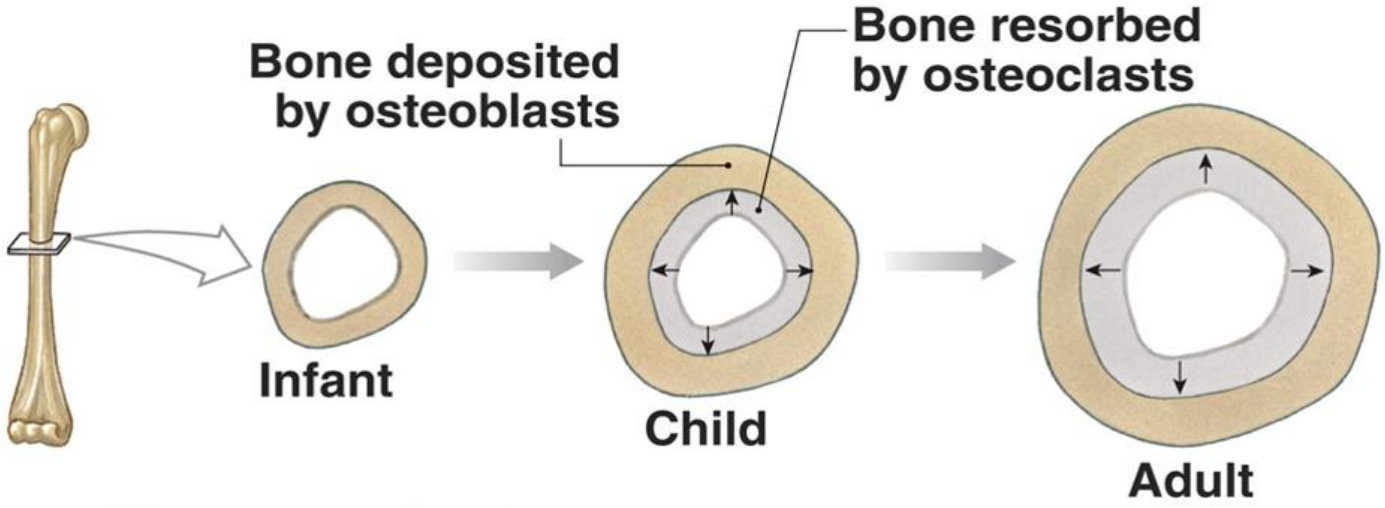
Calcified cartilage spicule

Osseous tissue

④ Ossification zone
***Osteoclasts* digest the calcified cartilage, and *osteoblasts* replace it with actual bone tissue in the shape of the calcified cartilage – resulting in bone trabeculae.**

APPOSITIONAL BONE GROWTH

- Growing bones widen as they lengthen
- Appositional growth – growth of a bone by addition of bone tissue to its surface
- Bone is resorbed at endosteal surface and added at periosteal surface
  - Osteoblasts – add bone tissue to the external surface of the diaphysis
  - Osteoclasts – remove bone from the internal surface of the diaphysis



BONE REMODELING
Remodeling is secondary bone formation

bone continually renews itself

- never metabolically at rest
- enables Ca++ to be pulled from bone when blood levels are low
- osteoclasts are responsible for matrix destruction
- produce lysosomal enzymes and acids
- Osteoclasts erode the primary bone matrix, blood vessels, nerves and lymphatics invade the cavity and osteogenic cells develop in osteoblasts and osteocytes, which create concentric lamellae and osteons.

Remodeling helps reshape growing bones to adapt to changing loads.

- spongy bone replaced every 3 - 4 years
- compact bone every 10 years

Fractures

Any bone break.

Closed reduction - bone ends coaxed back into place by manipulation

- Open reduction – by surgery secured together with pins or wires

➢ blood clot will form around break

-------- fracture hematoma

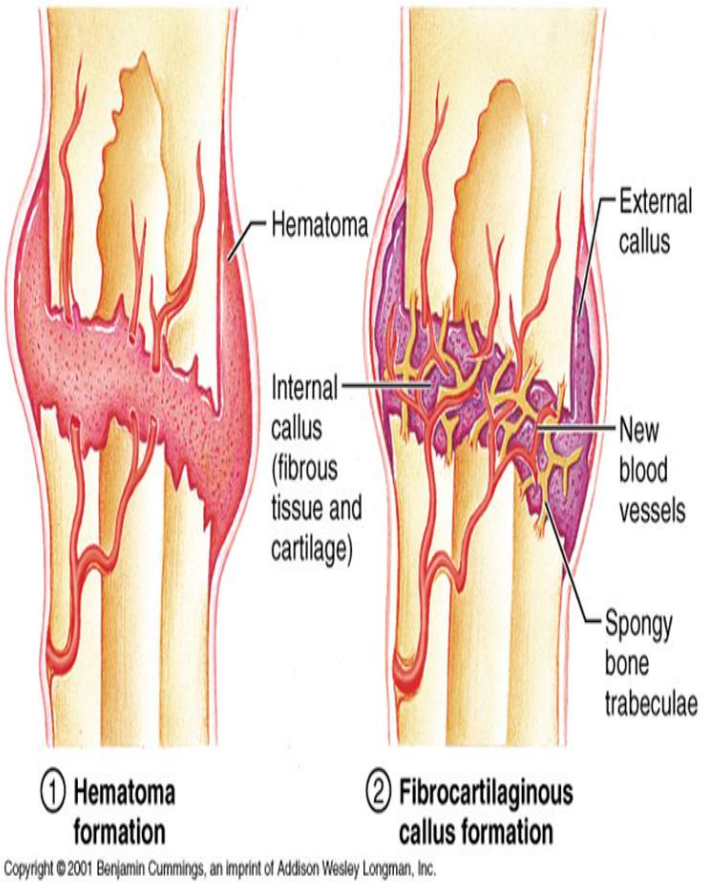
➢ inflammatory process begins

➢ blood capillaries grow into clot

➢ phagocytes and osteoclasts

----------remove damaged tissue

➢ procallus forms and is invaded by osteoprogenitor cells and fibroblasts



- collagen and fibrocartilage turns
- procallus to fibrocartilagenous

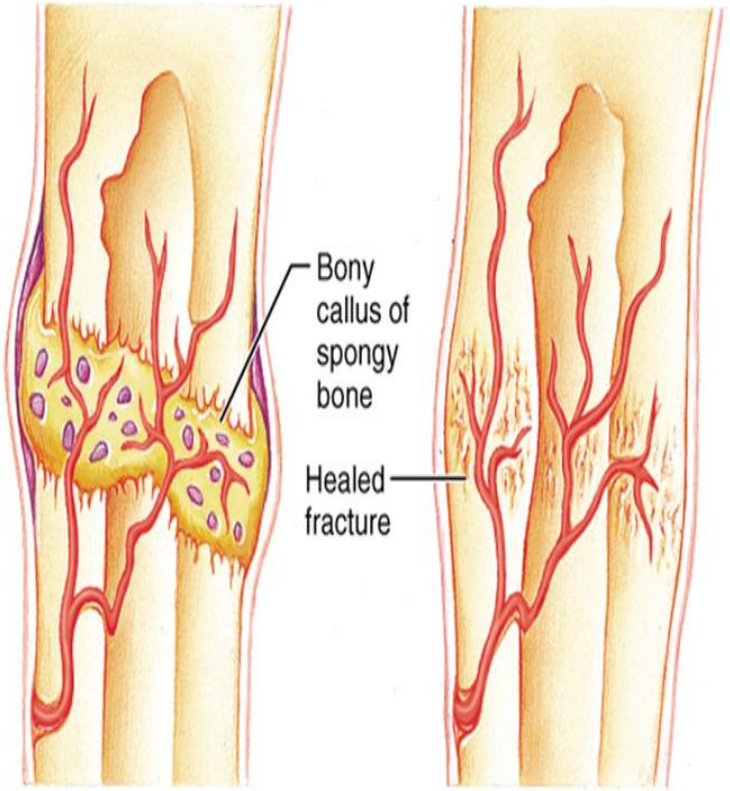
(soft callus)

- broken ends of bone are bridged by callus (spongy bone)

- bony (hard) callus is formed

callus is resorbed by osteoclasts and compact bone replaces spongy bone.

- Remodeling : the shaft is reconstructed to resemble original unbroken bone.



Types of Bone Tissue
(Classification)

According to its architecture:

- Spongy (cancellous)
- Compact (dense)

According to its fine structure:

- Primary (woven)
- Secondary (lamellar)

According to its histogenesis:

- Intramembranous
- Endochondral