

# Cartilage and bone

- Mechanic and supporting function
- Origin: embryonic mesenchyme
- Structure:
  - cells (chondrocytes – in cartilage  
osteocytes, osteoblasts, osteoklasts – in bone)
  - Extracellular matter
    - homogenous, amorphous substance
    - fibers (collagen or elastic – in cartilage, only collagen – in bone)



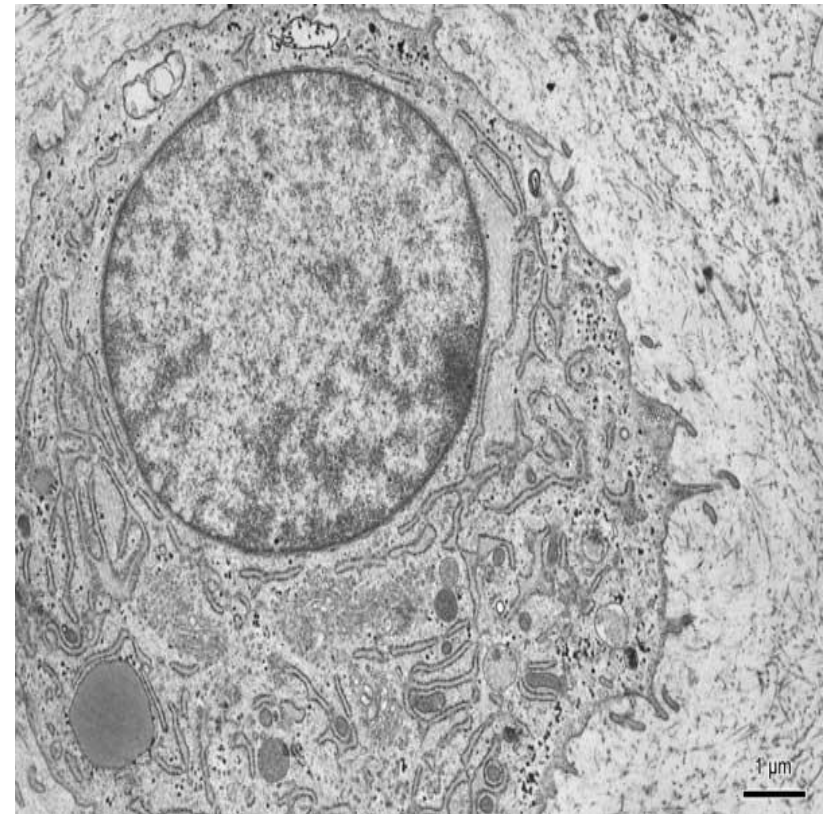
# Cartilage properties

- Avascular tissue, without nerves,
- Decreased reparative ability, regeneration from perichondrium
- Perichondrium – dense collagen c. t. attached to cartilage
  - inner chondrogenic layer
  - outer c. t. layer



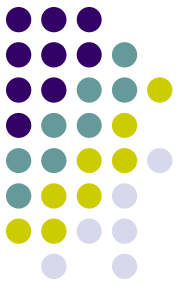
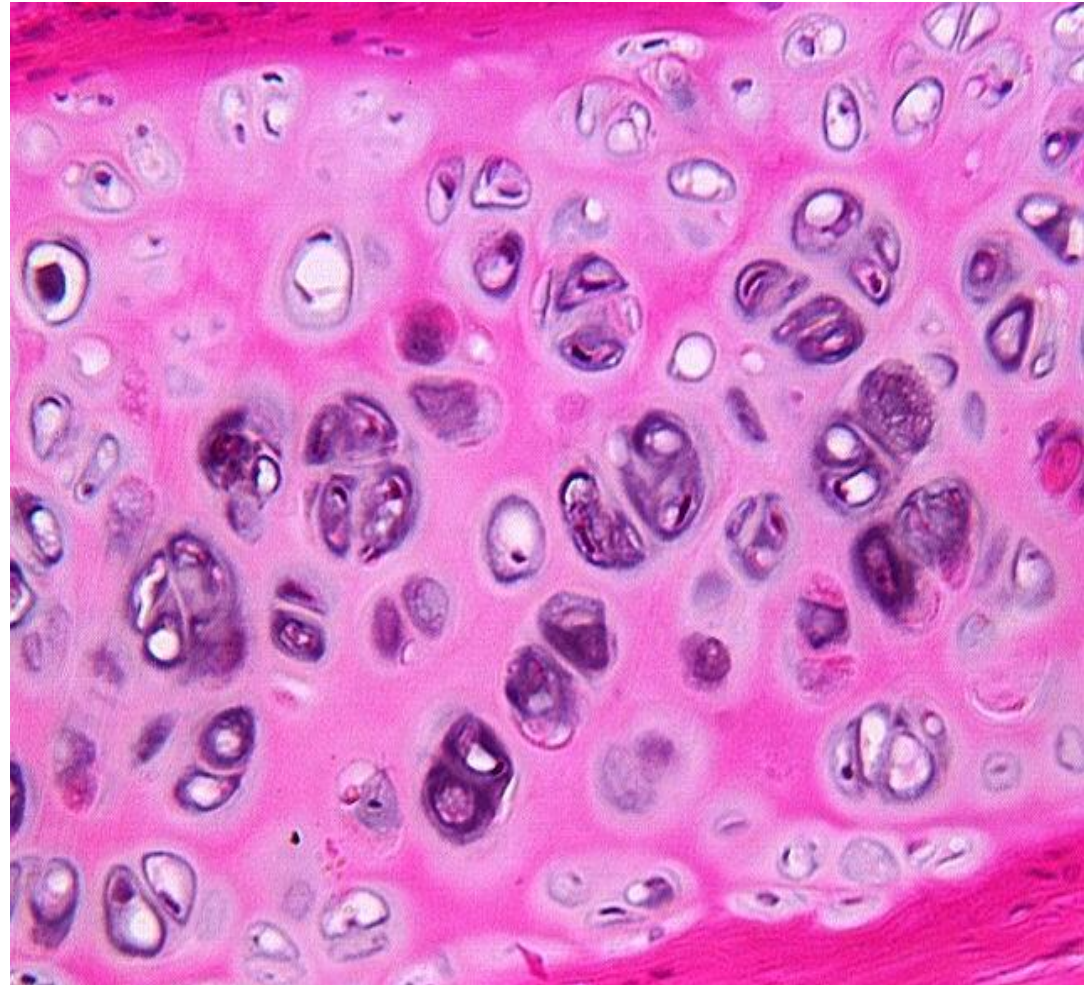
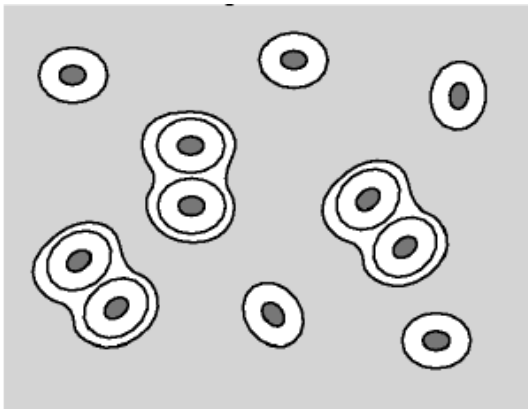
# Cell of cartilage

- chondroblasts
  - immature chondrocytes in inner layer of perichondrium
- ***chondrocytes*** – in cartilage
  - basophilic cells → proteosynthesis, mitochondria, GER, Golgi apparatus, cytoskeleton.
  - produce amorphous matrix and fibers.



- Chondrocytes
  - *isogenous groups*,
  - *lacunae*,
  - *basophilic capsule*  
of territorial matrix

- Isogenous group + adjacent area of extracellular matter (territorial matter) = ***chondron***



# Extracellular matter



- ***Collagen*** II or I fibers
- ***Elastic*** fibers
- ***Glykosaminoglycans***  
–hyaluronic acid,  
chondroitin-sulphate
- Proteoglycans
- Glykoproteins



# Types of cartilage

- **Hyaline** (*hyalos=glass*) – the most frequent, precursor of many bones in skeleton, covers articular surfaces, forms part of ribs skeleton of the nose, trachea, larynx
- **Elastic** - auricula, tuba auditiva, larynx, epiglottis
- **Fibrocartilage** - intervertebral discs, symphysis pubis, articular discs and meniscus

Hyaline cartilage, trachea

Perichondrium

Chondroblasts

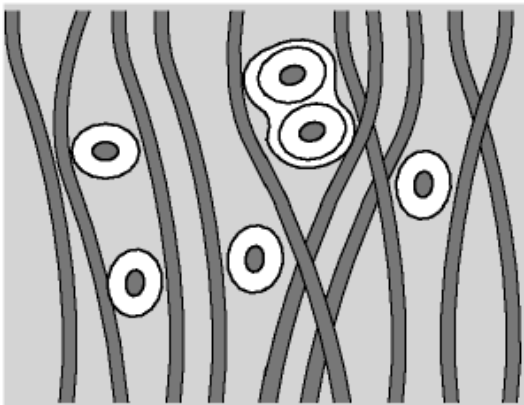
Isogenous (nest) cells



# Elastic cartilage



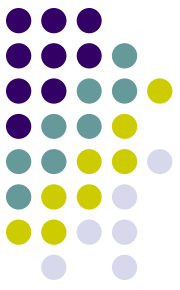
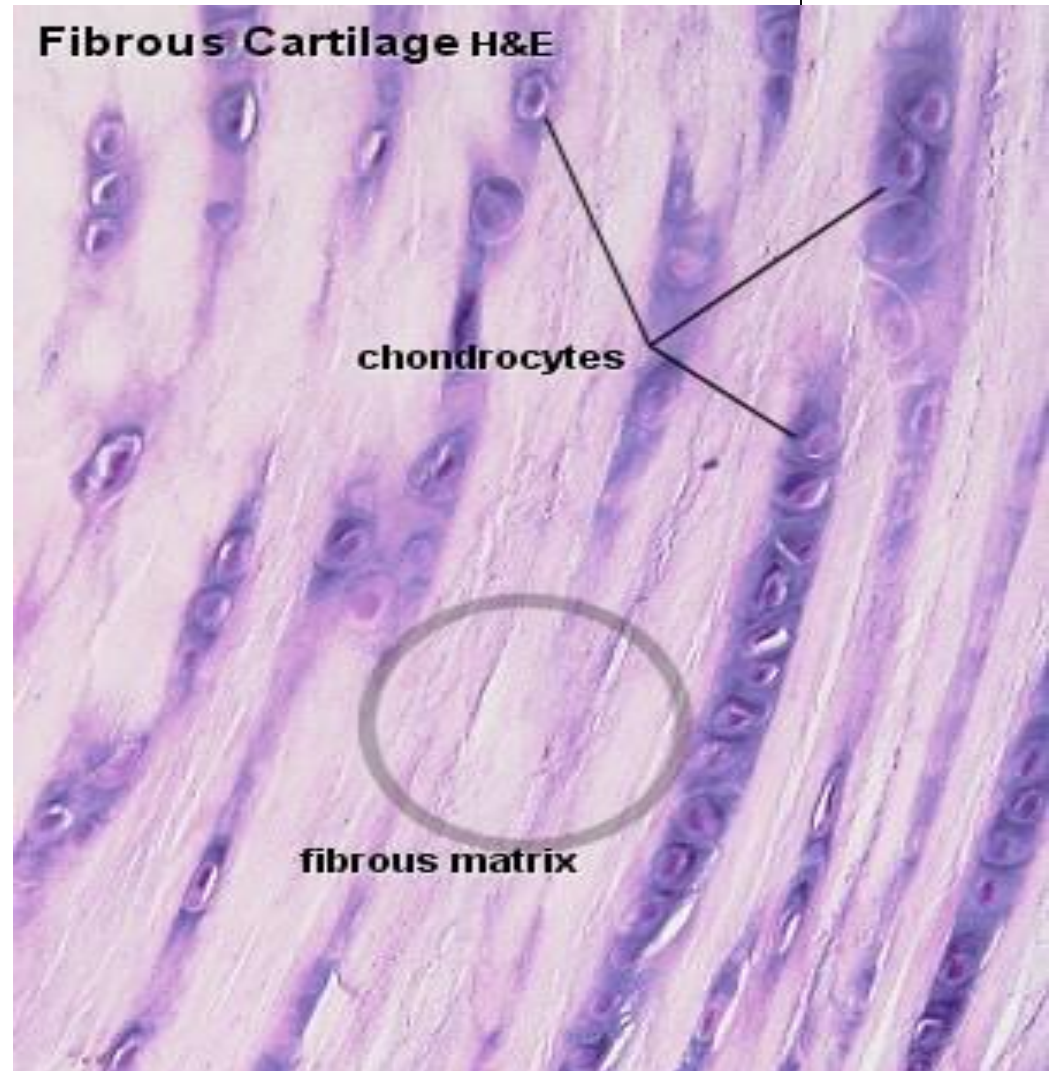
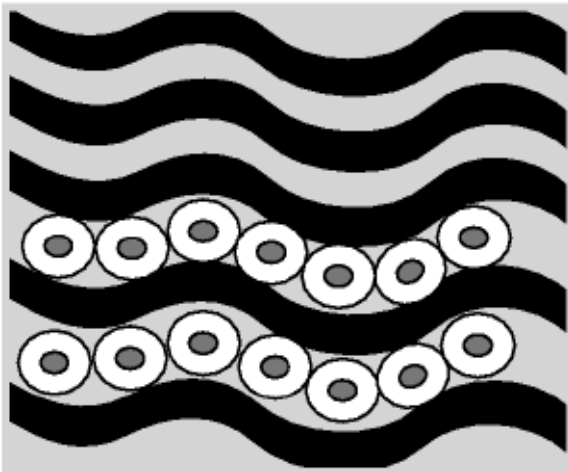
- *elastic fibers in amorphous matrix; special staining: resorcin, fuchsin and orcein.*
- Chondrocytes





# Fibrocartilage

- **Chondrocytes**
- Thick bundles of **collagenous fibers**
- **matrix**
- without perichondrium

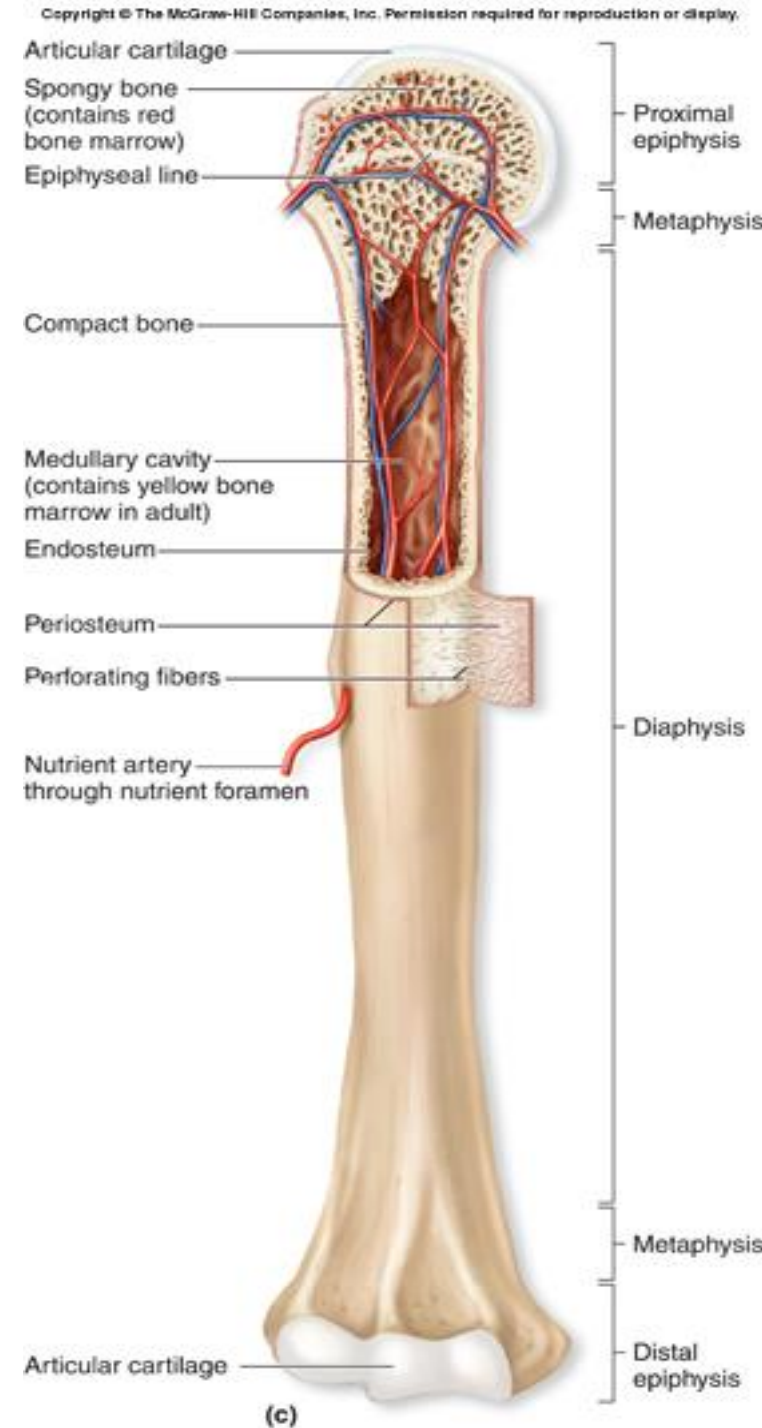


# Bone

- specialized form of c. t.

## ***Bone tissue structure***

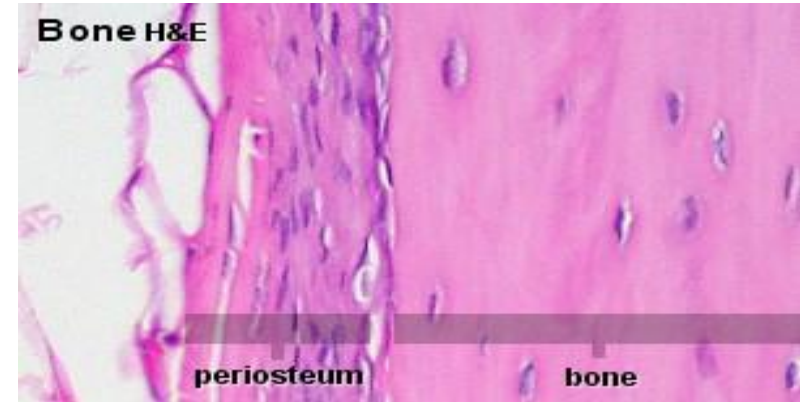
- Bone cells
- Extracellular matrix
  - Organic – collagen fibers  
– amorphous matrix
  - Inorganic – minerals
- Periosteum





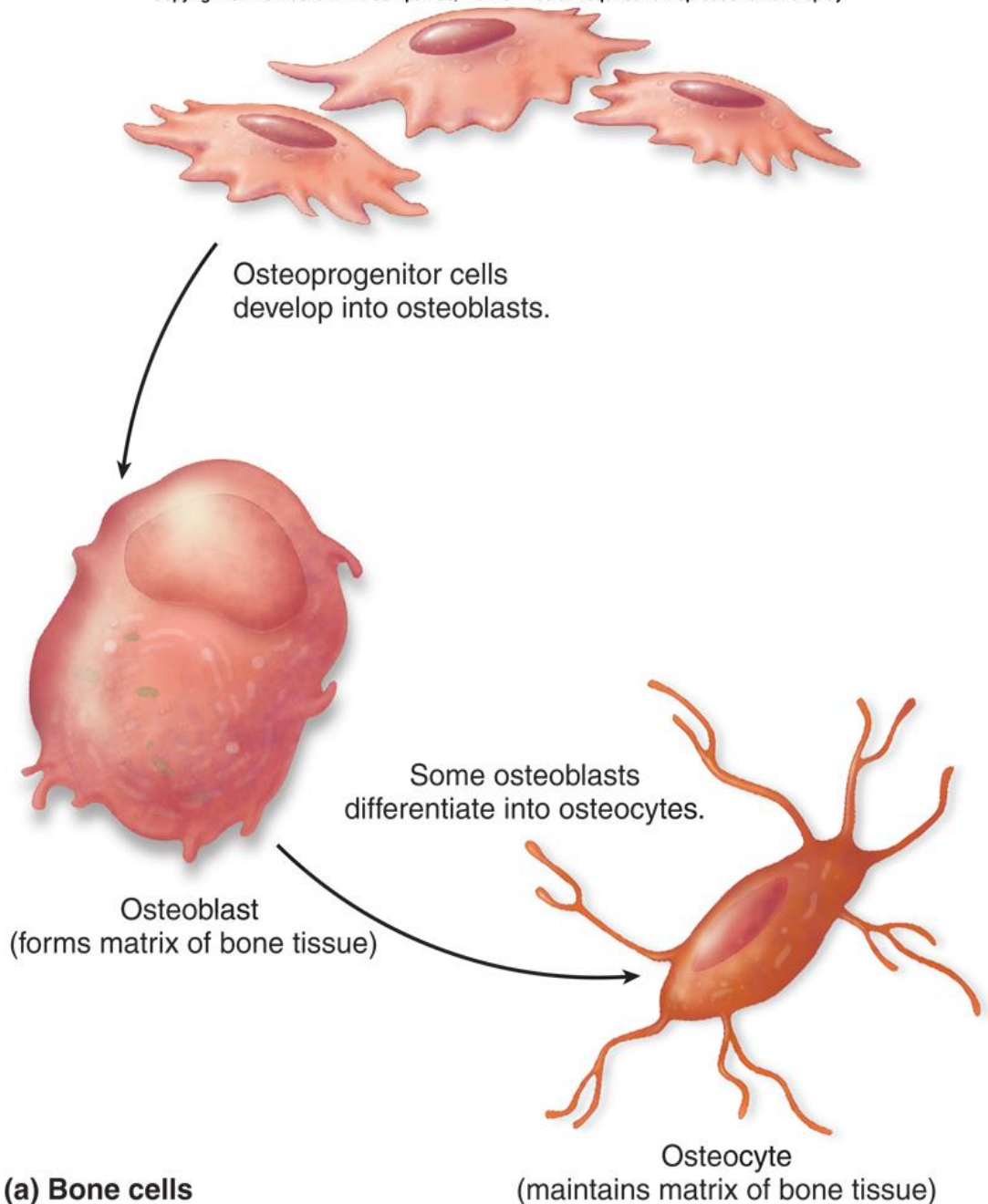
# Bone tissue

- **Periosteum** – covers outer surface of bone:
  - Inner layer (osteoblasts, fibroblasts)
  - outer layer (only fibroblasts)Periosteum is attached by Sharpey's fibers.
- **Endosteum** – membrane with one layer of cells (osteoblasts, osteoclasts), covers inner surface of bone turned to the bone cavity)

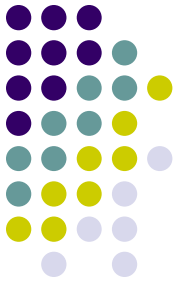


# Bone cells

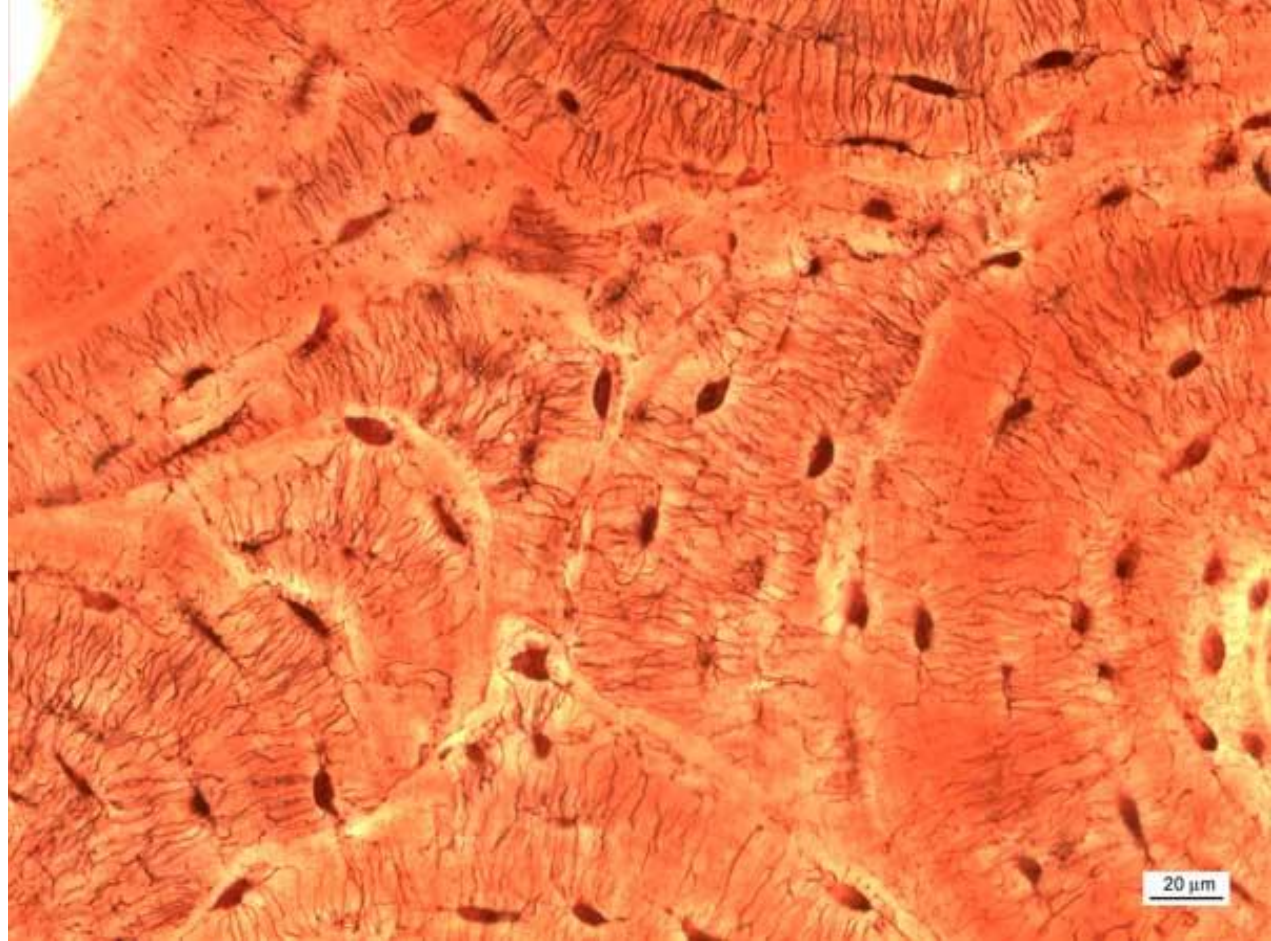
- **osteoprogenitor cells** – stem cells, in periosteum and endosteum
- **osteoblasts** produce organic matter, and transform into **osteocytes**



# Osteocyte

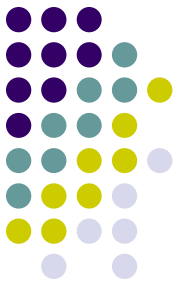


- In *lakuna*,
- Numerous processes in *canaliculi ossium* (cell communication)

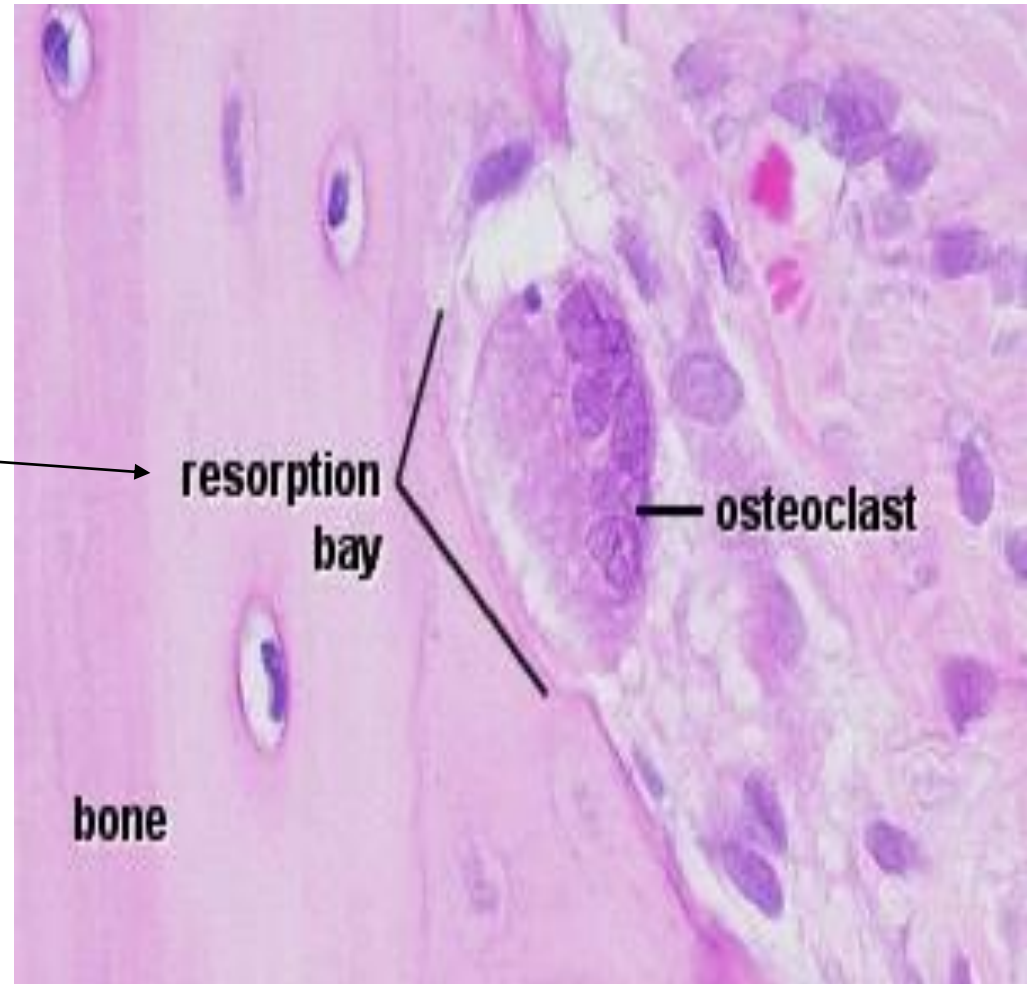


20  $\mu$ m

# Osteoclasts



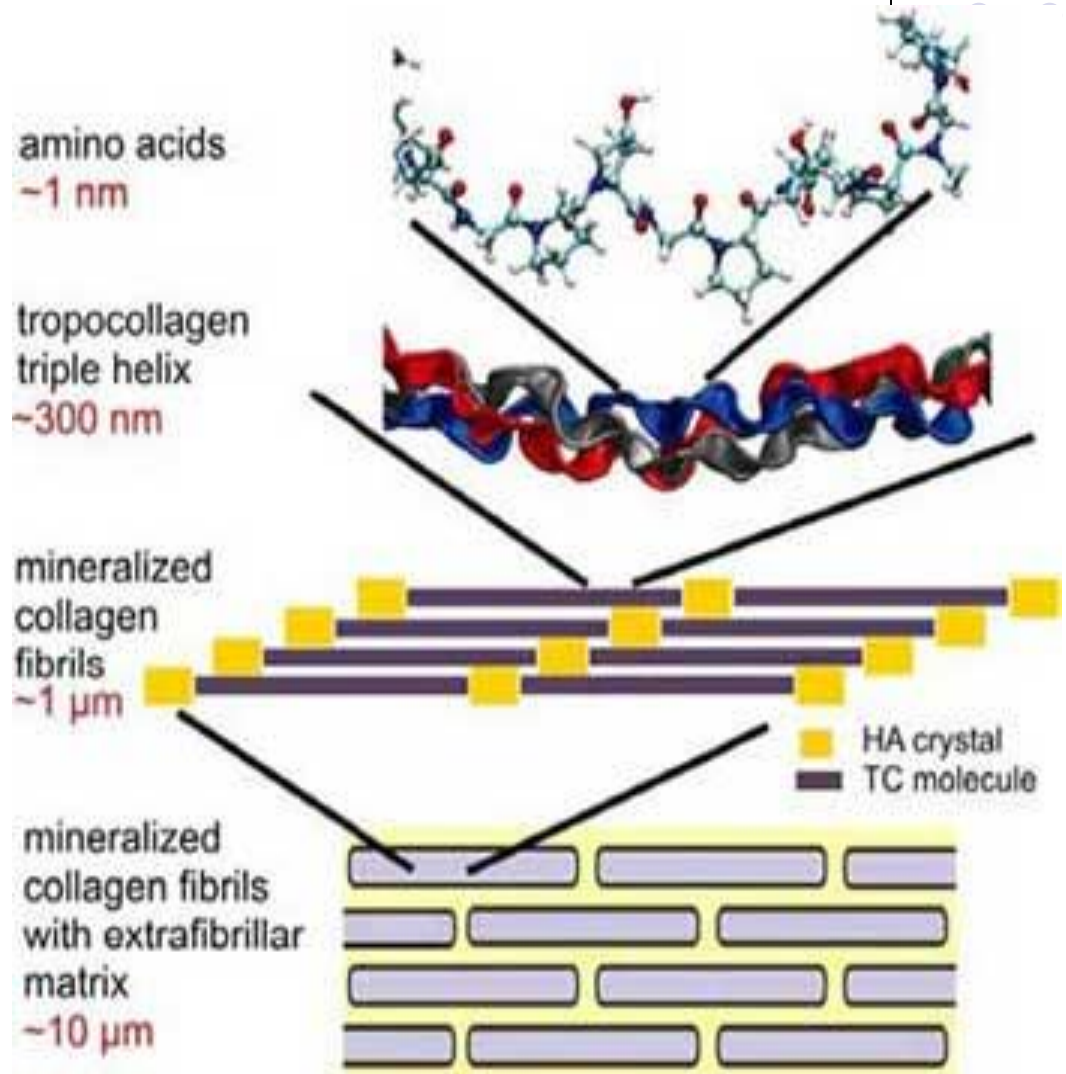
- large cells (up to 100  $\mu\text{m}$ ), polynucleated cells (up to 50 N), arise by fusion of monocytes
- in *Howship's lakune*
- lysosomal enzymes digest collagen fibers

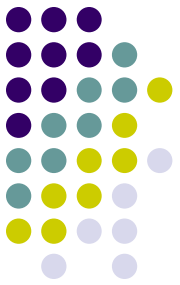


# Bone matrix



- collagen fibers – collagen I (cca 90 % of org. matter)
- amorphous matrix – osteoid.
- strength of matrix is caused by content of *inorganic salts* (hydroxylapatite).





# Types of bone tissue

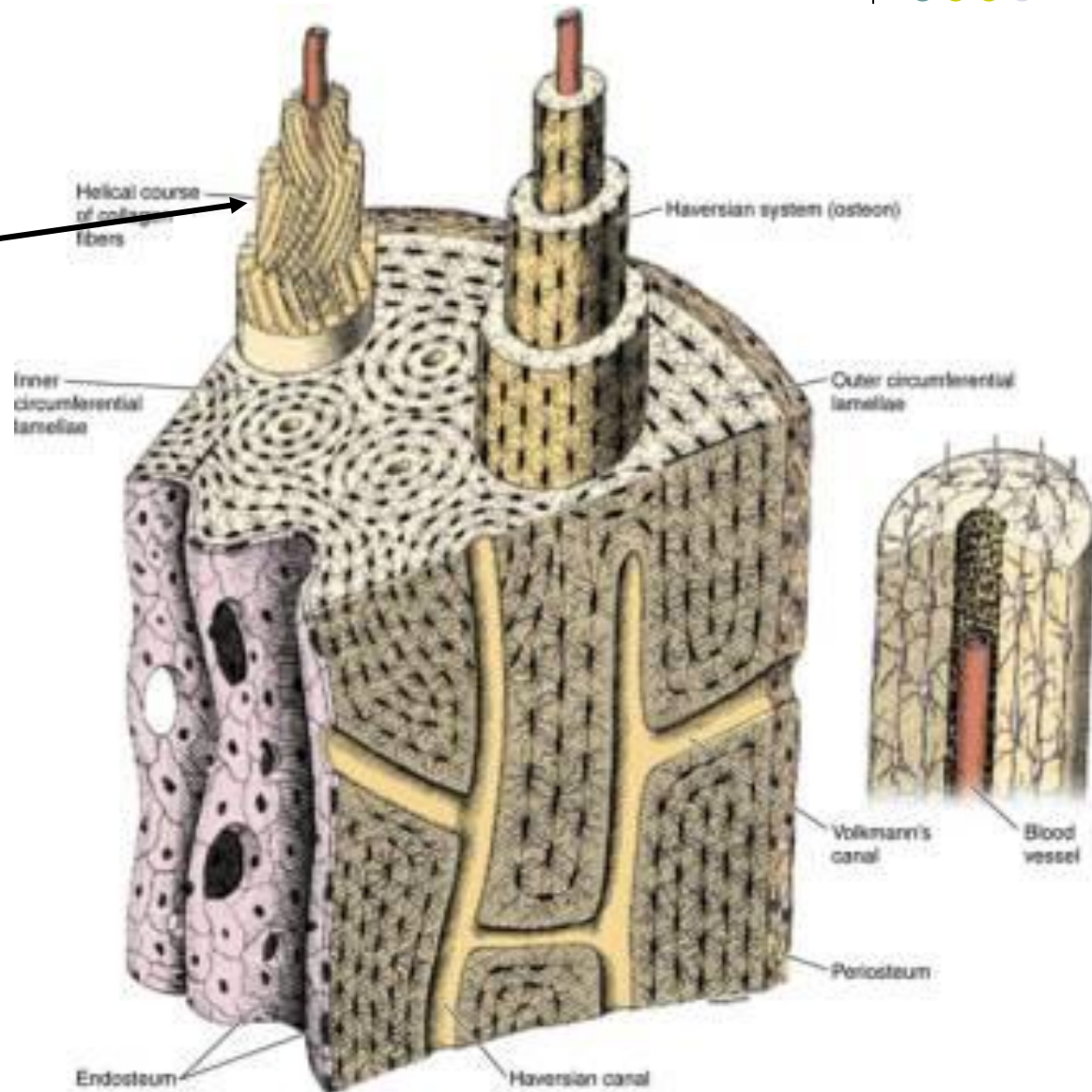
- **2 types:** /according to arrangement of collagen fibers/
  - **Fibrillar (woven) bone**
  - **Lamellar bone**
    - compact – wall of long bone diaphysis, surface layer of epiphysis
    - spongy /trabecular/ – inner part of epiphysis



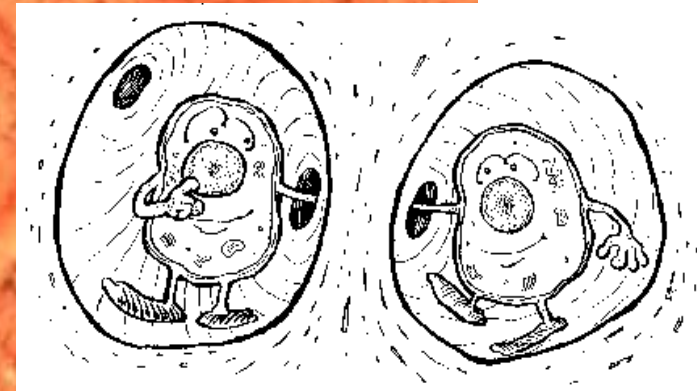
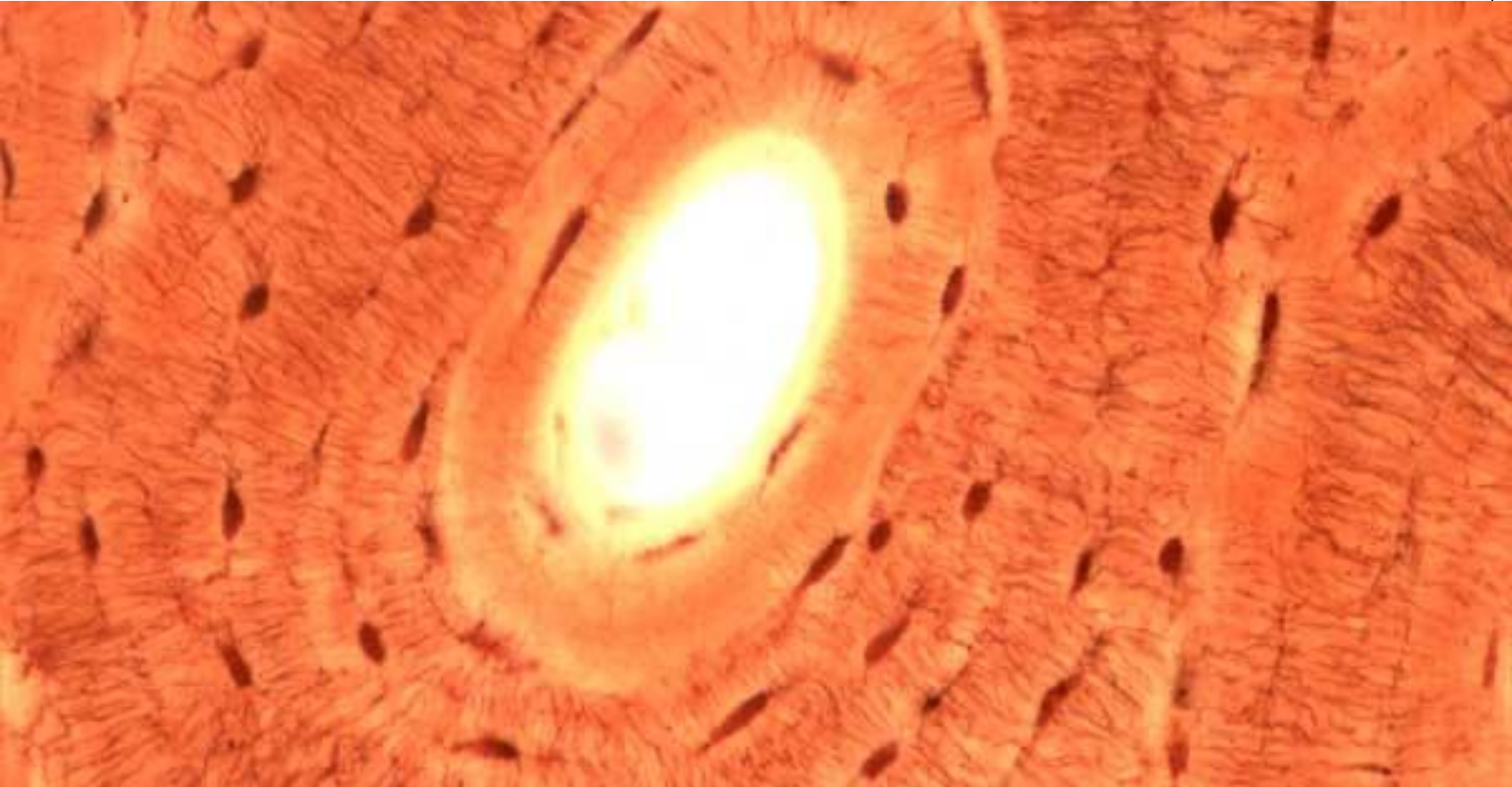
# Lamellar bone



- **Lamellae** – thin plates with regularly arranged **collagen fibers**
- **Haversian systems** - osteons
- **Circumferential lamellae**
  - outer
  - inner
- **Interstitial lamellae**



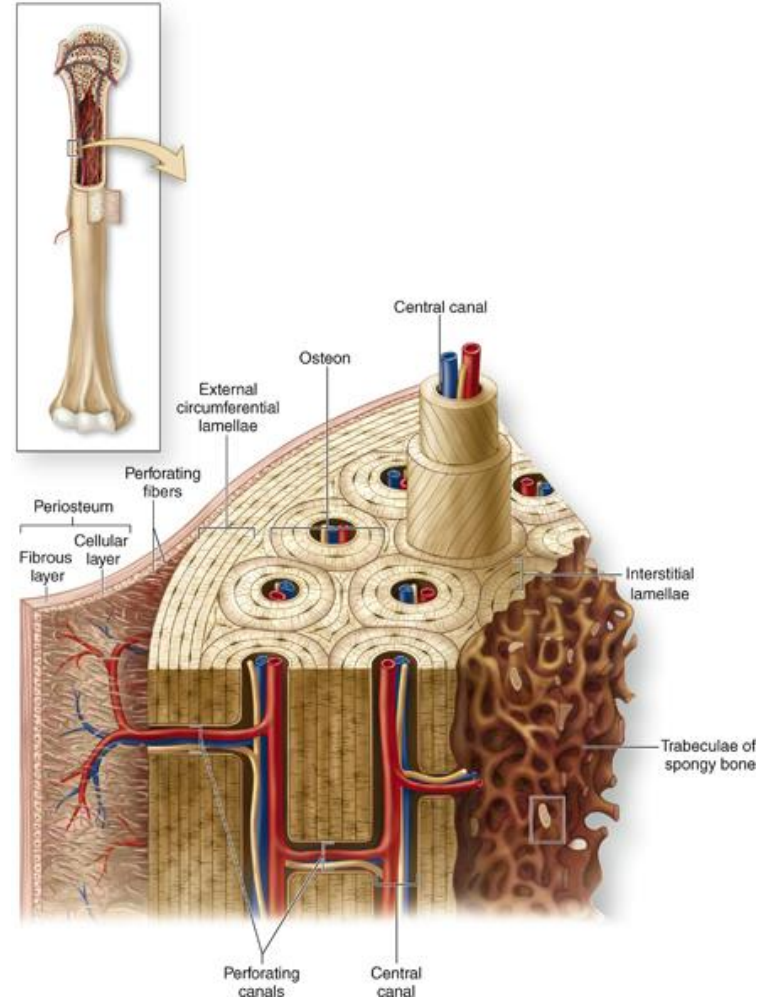
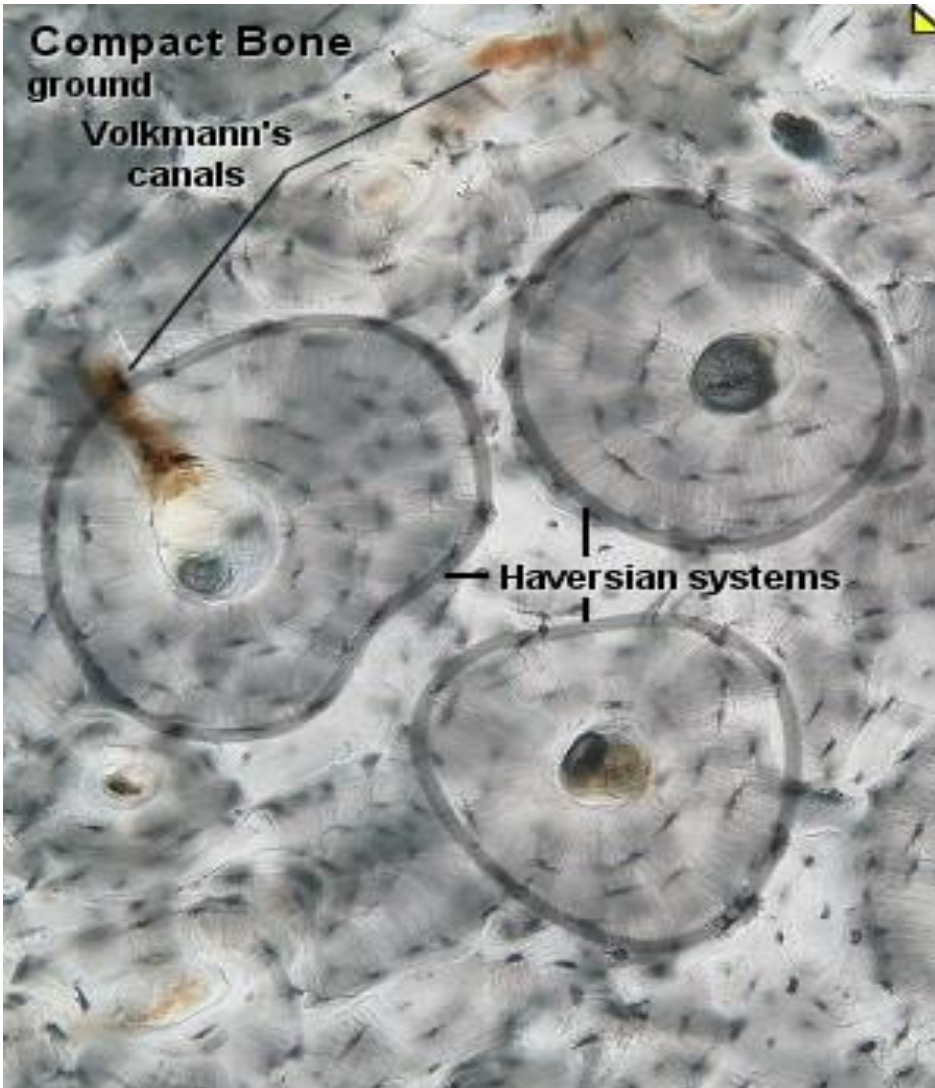
# Haversian system – osteon



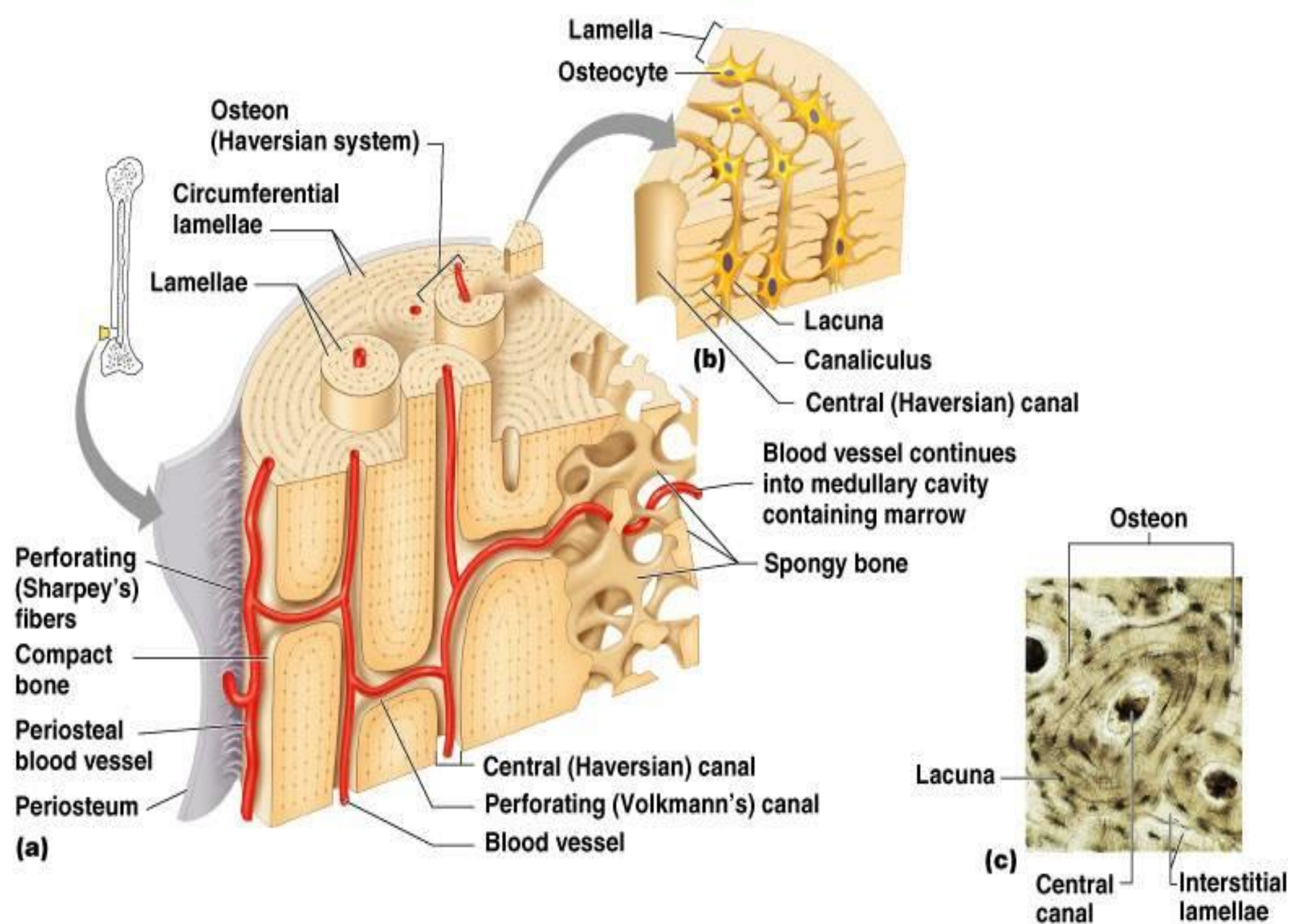
# Lamellar bone

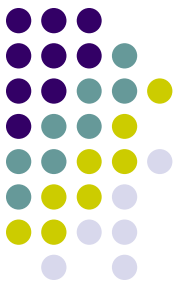


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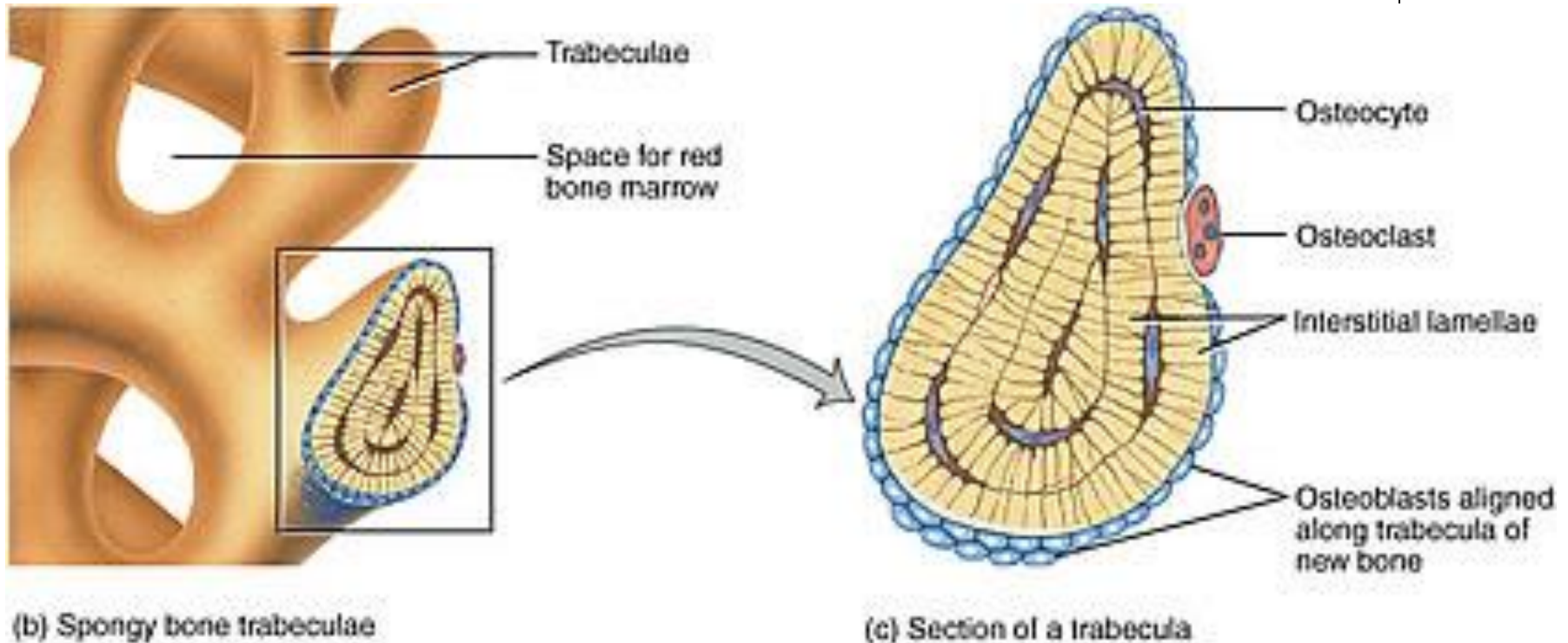


Haversian and Volkmann's canals





# Lamellar bone – spongy type



- Matrix is also organized into the ***lamellae***, but don't form Haversian systems.

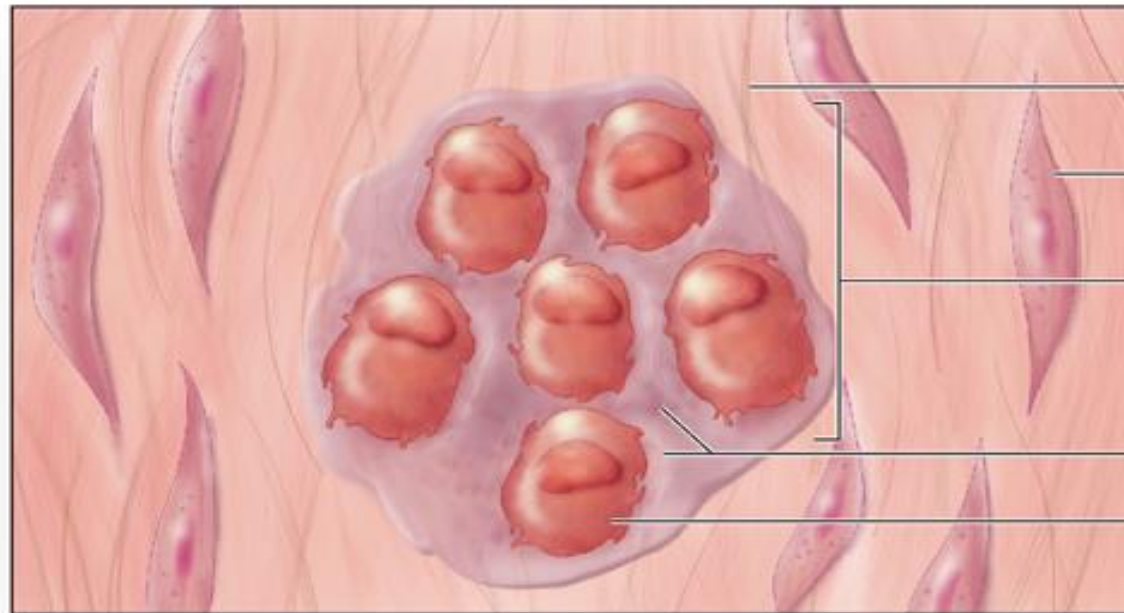
# Histogenesis of bone tissue



- **Endochondral ossification** – hyaline cartilage is model for bone  
(long bones)
  
- **Intramembranous ossification** – mesenchyme membrane is model, mesenchymocytes differentiate into osteoblasts  
(skull bone, part of mandibule and clavícula)

# Intramembranous ossification

- ① Ossification centers form within thickened regions of mesenchyme



Collagen fiber

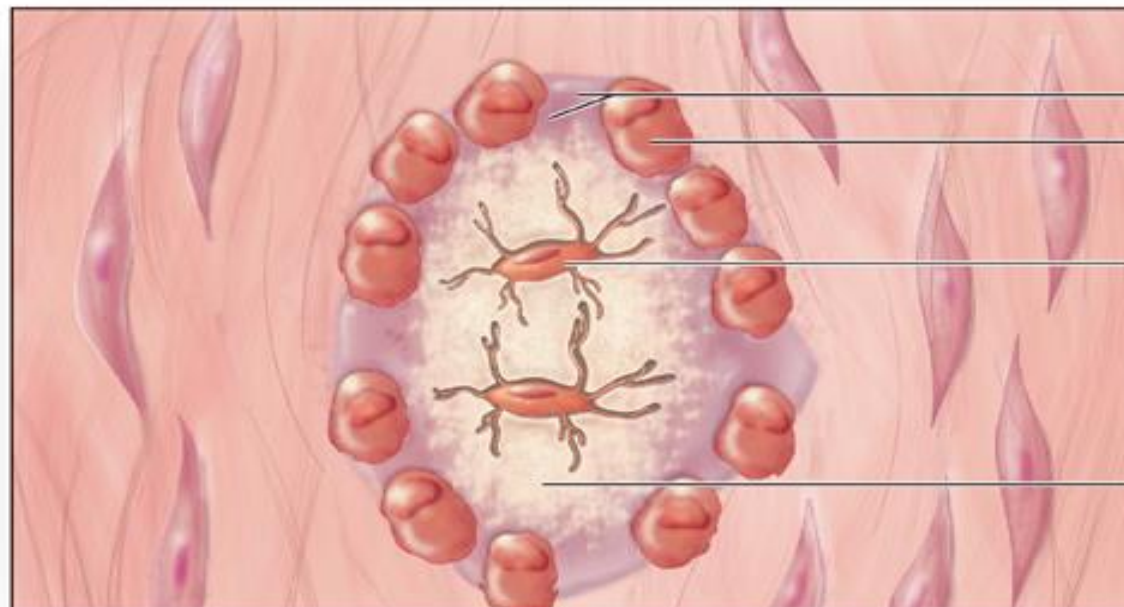
Mesenchymal cell

Ossification center

Osteoid

Osteoblast

- ② Bone matrix (osteoid) undergoes calcification.



Osteoid

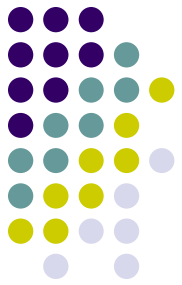
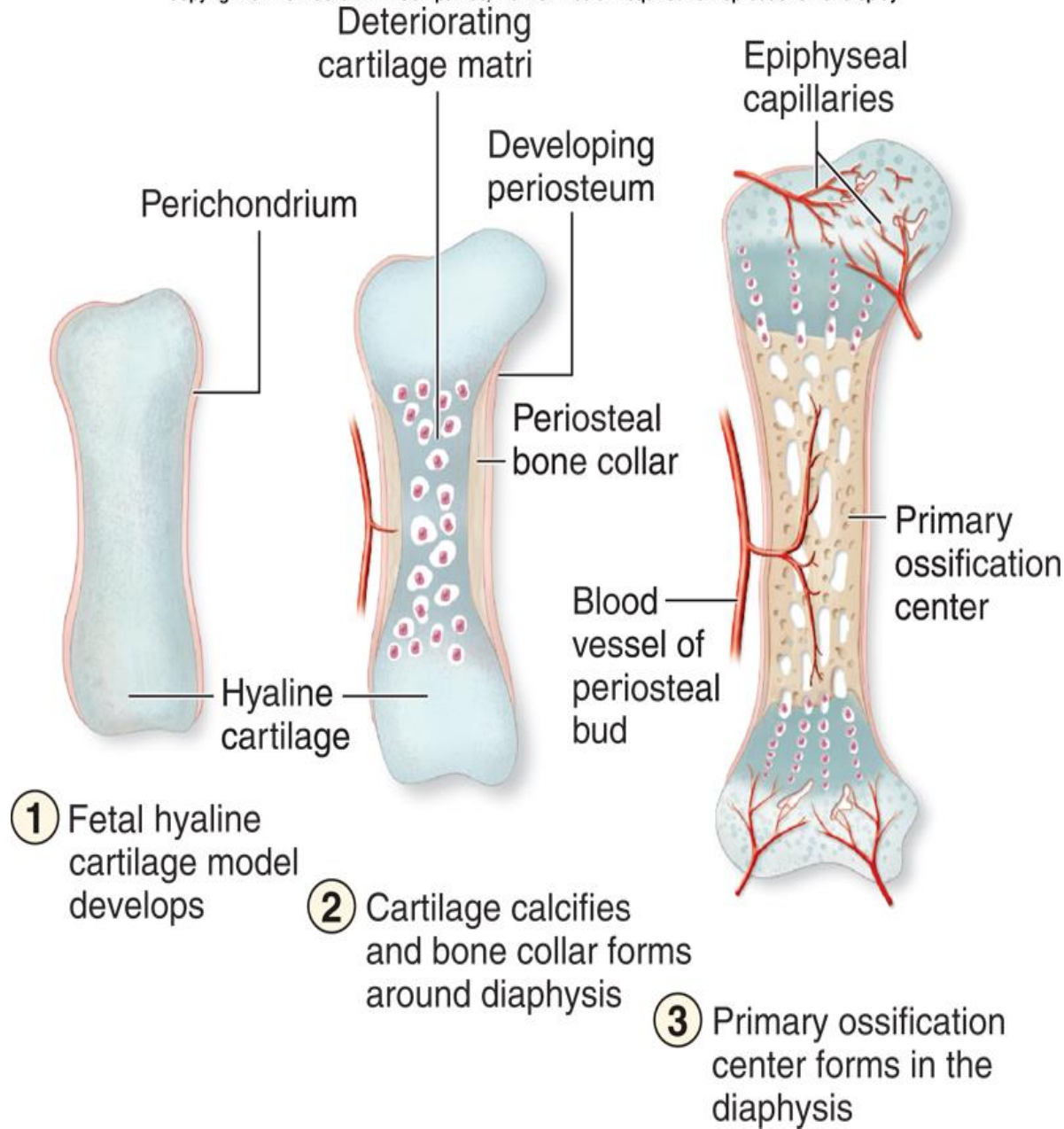
Osteoblast

Osteocyte

Newly calcified bone matrix

# Endochondral ossification

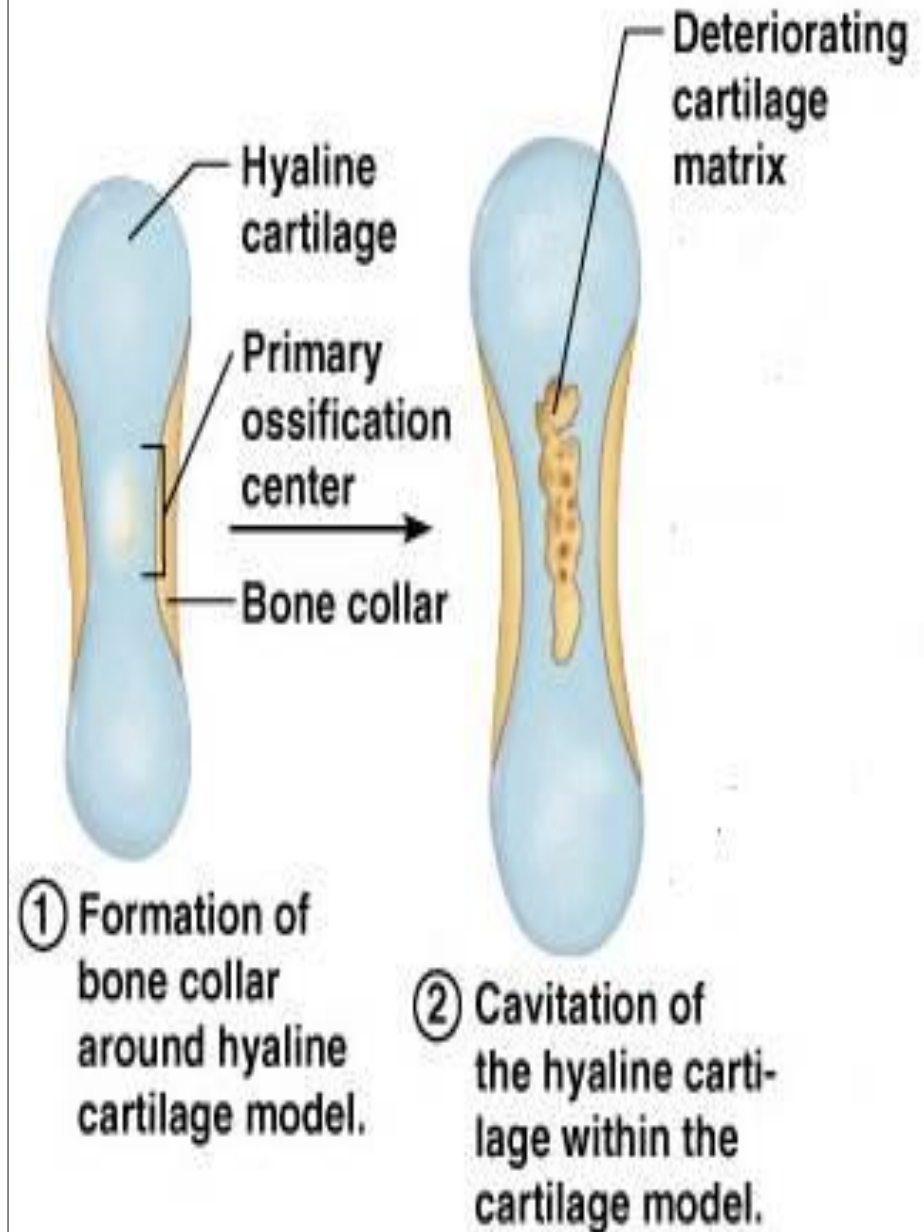
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## Periosteal bone collar

Undifferentiated cells in the perichondrium become osteoblasts, and the perichondrium is now the periosteum.

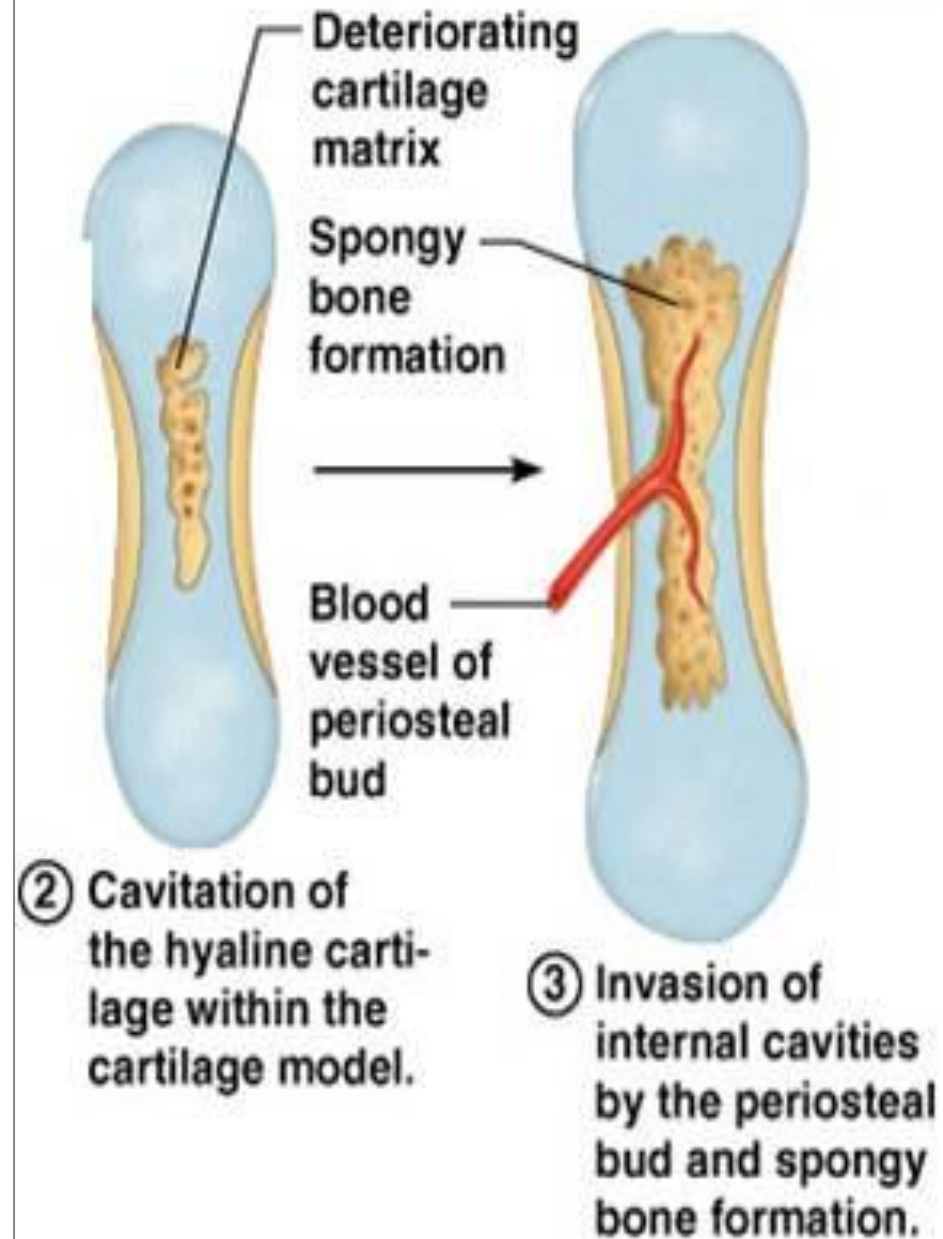


Chondrocytes at the center of the growing (**proliferating zone**) cartilage model enlarge (**zone of hypertrophy**).

The matrix calcifies (**zone of calcification**) and chondrocytes die. The rest of matrix form trabecular processes – spicules.

Blood vessels penetrate cartilage and carry the osteoblasts from periosteum. Osteoblasts cover the spicules and produce osteoid (**ossification zone**).

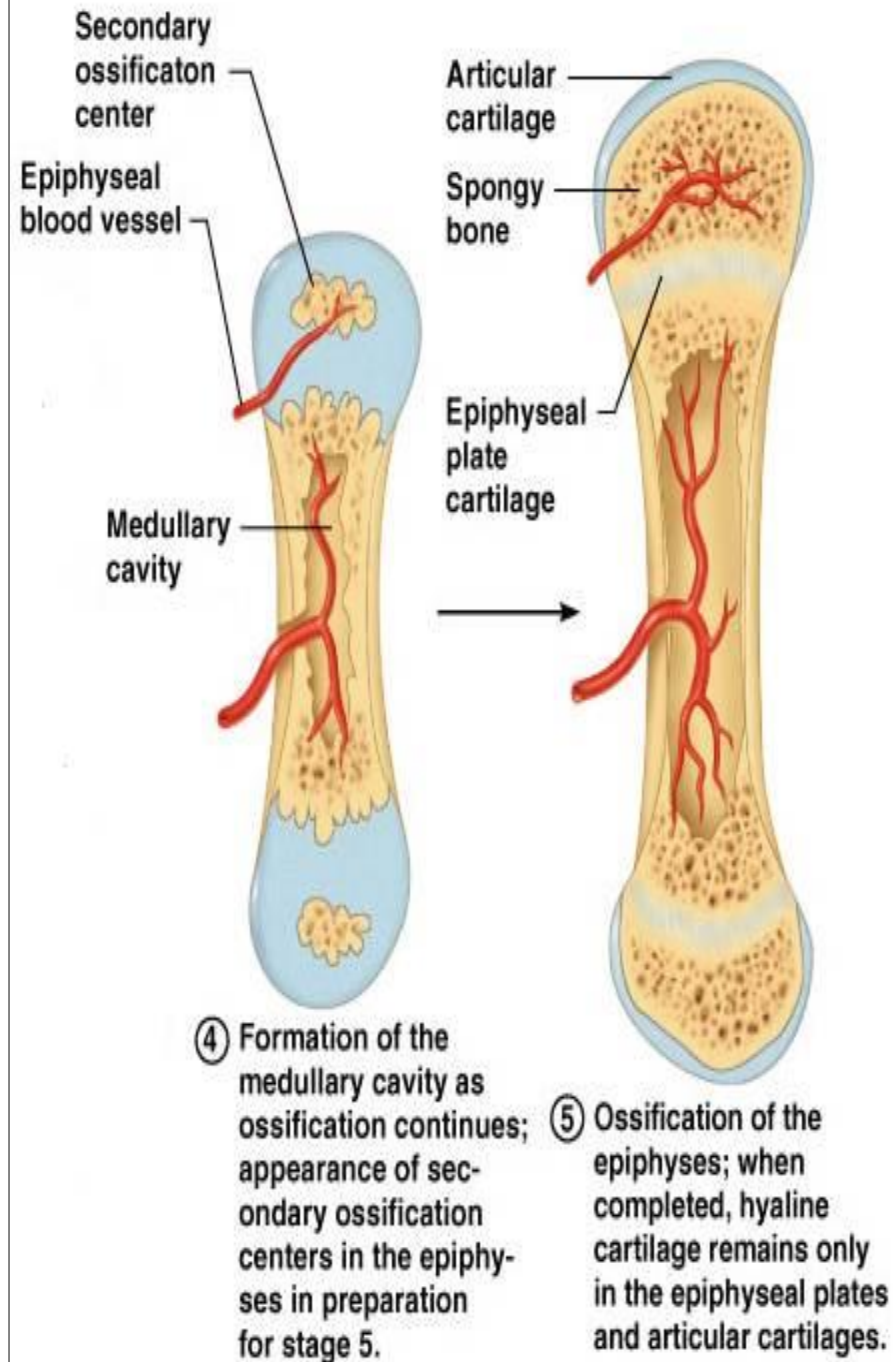
Ossification spreads in long axis of bone.



Osteoclasts resorb primitive bone (**zone of resorption**) and medullary cavity is formed.

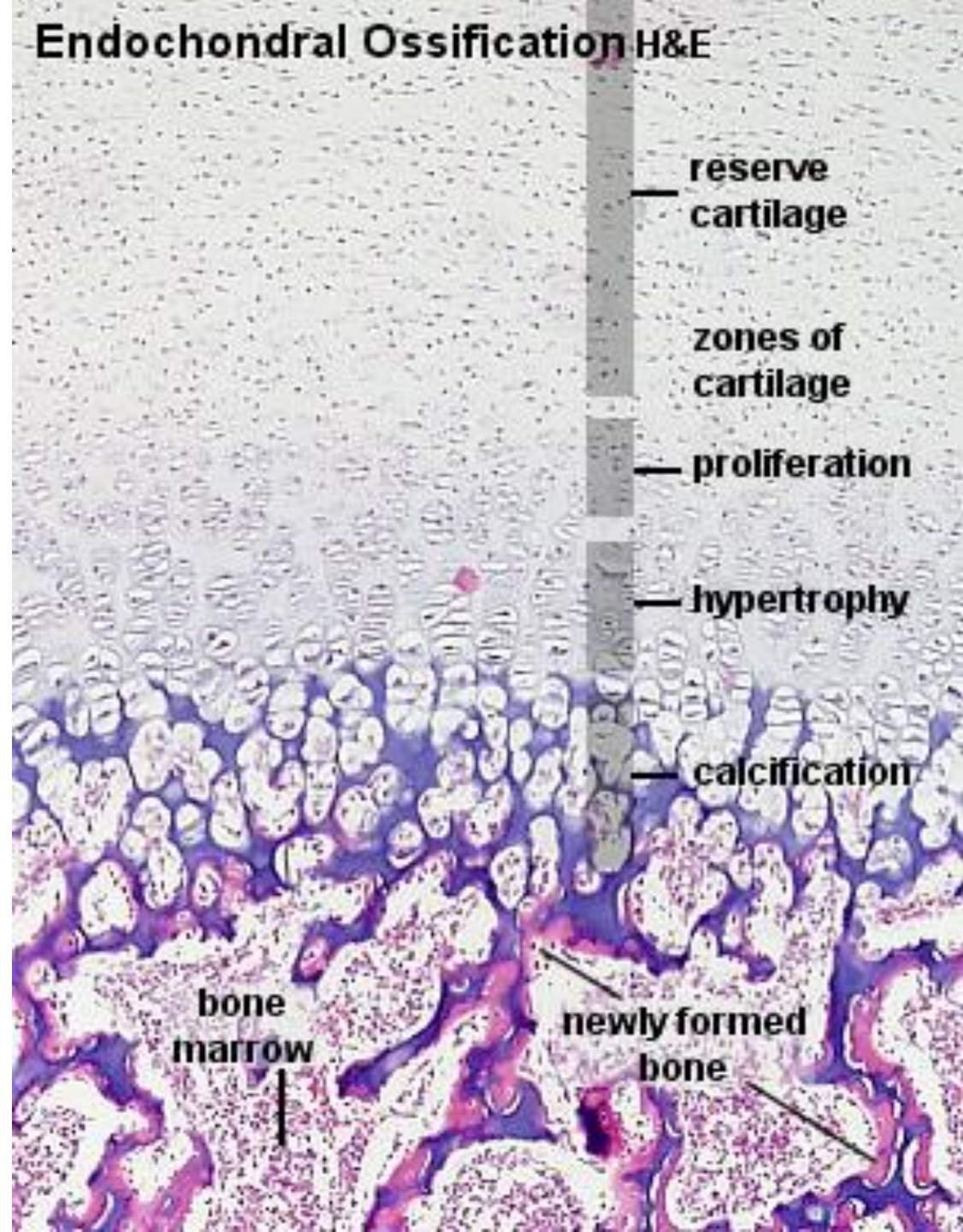
Similar process begins in epiphyses. Ossification spread radially.

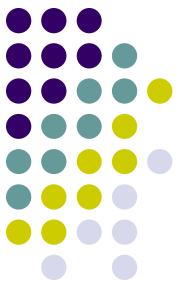
Also epiphyseal plates ossify at the end of body growth (cca 18 years).



# Endochondral ossification

- Zone of normal cartilage
- Zone of proliferated cartilage
- Zone of hypertrophic cartilage
- Zone of calcification
- Line of erosion
- Zone of ossification
- Zone of resorption

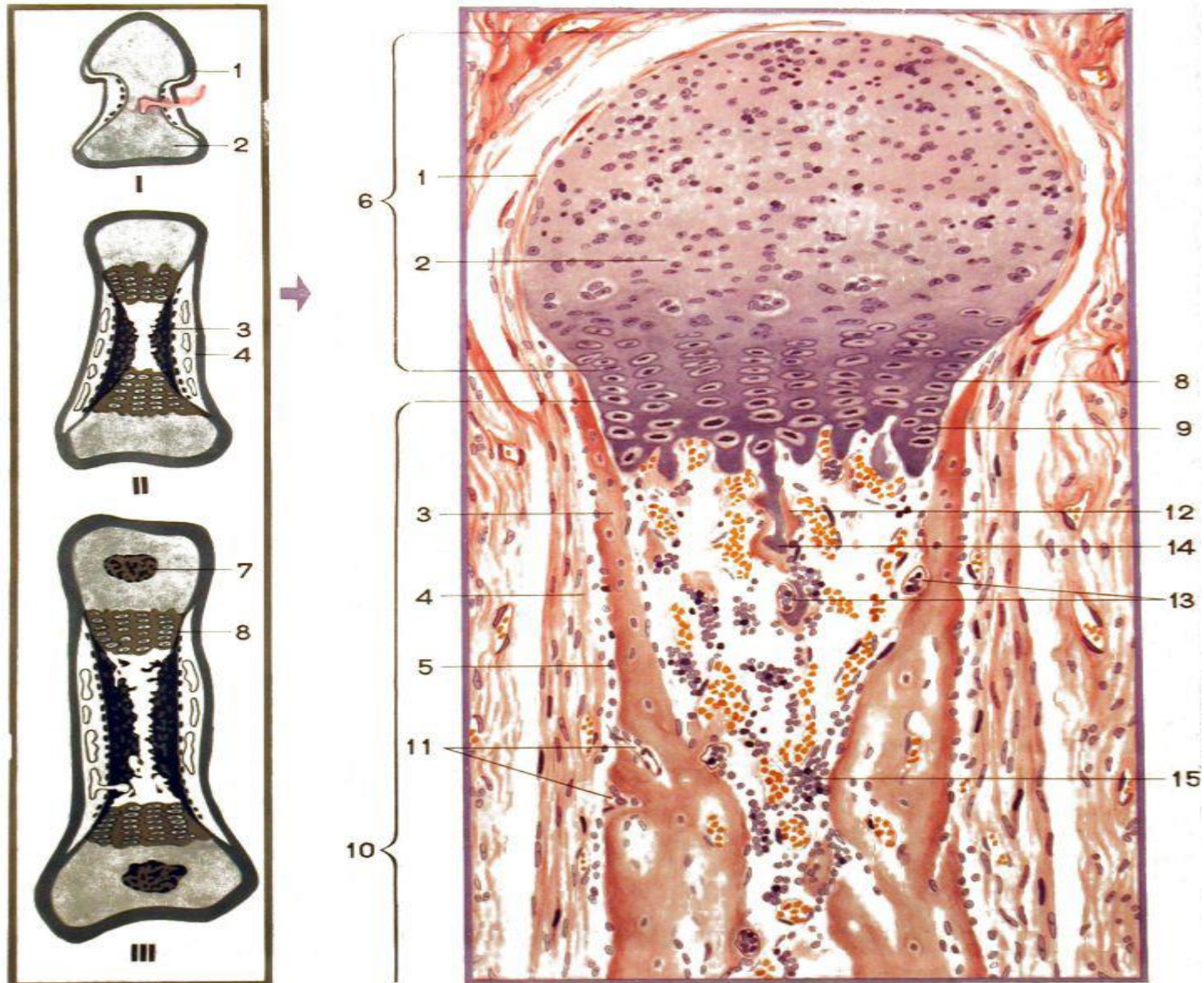




# Bone growth

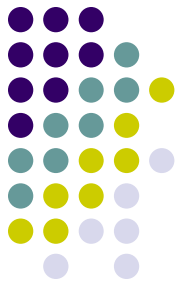
- cannot occur interstitially as cartilage growth does, because its rigid, mineralized matrix traps osteocytes and prevents them from dividing mitotically. Growth occurs in two directions:
- in length, by maintenance and growth of epiphyseal plate of cartilage. These plates allow a bone to expand lengthwise.
- in diameter, by continuous formation of bone around the periphery of the diaphysis.

# ENDOCHONDRAL OSSIFICATION



I, II, III- STAGES OF OSTEOGENESIS

1-PERICHONDRIUM; 2-EMBRYONIC CARTILAGE; 3-BONE CUFF; 4-PERIOSTEUM;  
 5-OSTEOBLASTS; 6-EPIPHYSIS; 7-SECONDARY OSSIFICATION CENTRE; 8-EPIPHYSEAL PLATE;  
 9-CHONDROCYTIC DEATH; 10-DIAPHYSIS; 11-BLOOD VESSELS; 12-ENDOCHONDRAL BONE;  
 13-OSTEOCLASTS; 14-CALCIFYING CARTILAGE; 15-MARROW



Normal hyaline cartilage

# Endochondral ossification

Proliferating cartilage  
(growth)

Hypertrophic cartilage

Calcified cartilage  
\* - calcified matrix

LINE of EROSION

B  
O  
N  
E

spicules

blood vessels

osteoid

osteoblasts

