

# Bone Lec 2



HUMAN HISTOLOGY

Semester 2, Year 1

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# Learning Objectives

**At the end , The student will be able to :-.**

- **Define and describe the types of bone.**
- **Describe the structure of the two basic types of bone (compact and spongy).**
- **Define ossification.**
- **Differentiate between different types of ossification.**



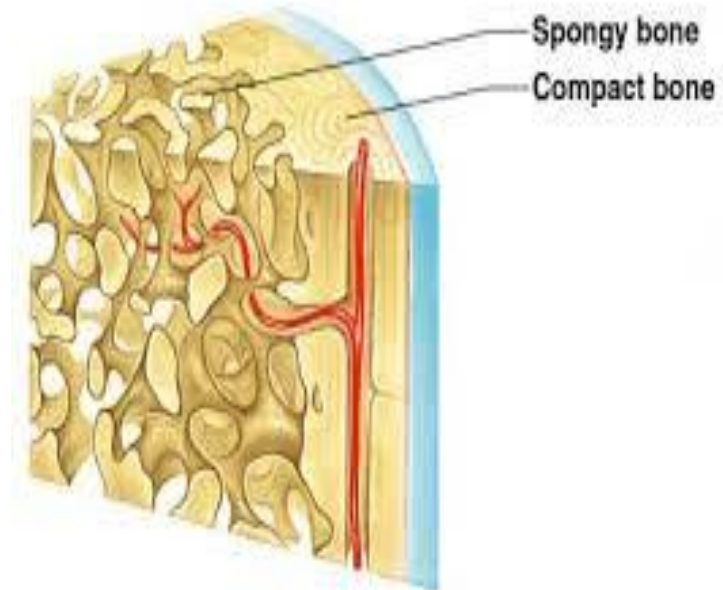
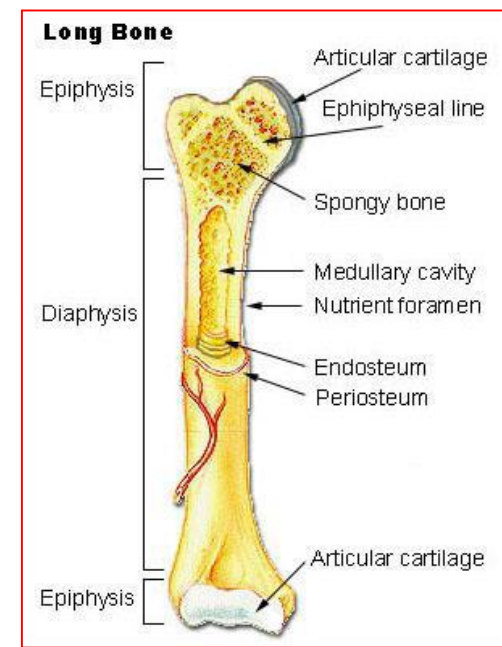
# Types of bone tissue

## 1-Macroscopic types:

**A. Spongy (cancellous) bone:** which consists of irregular bone **trabeculae** that branch and unit with one another enclosing spaces (numerous **cavities**) filled with **bone marrow**.

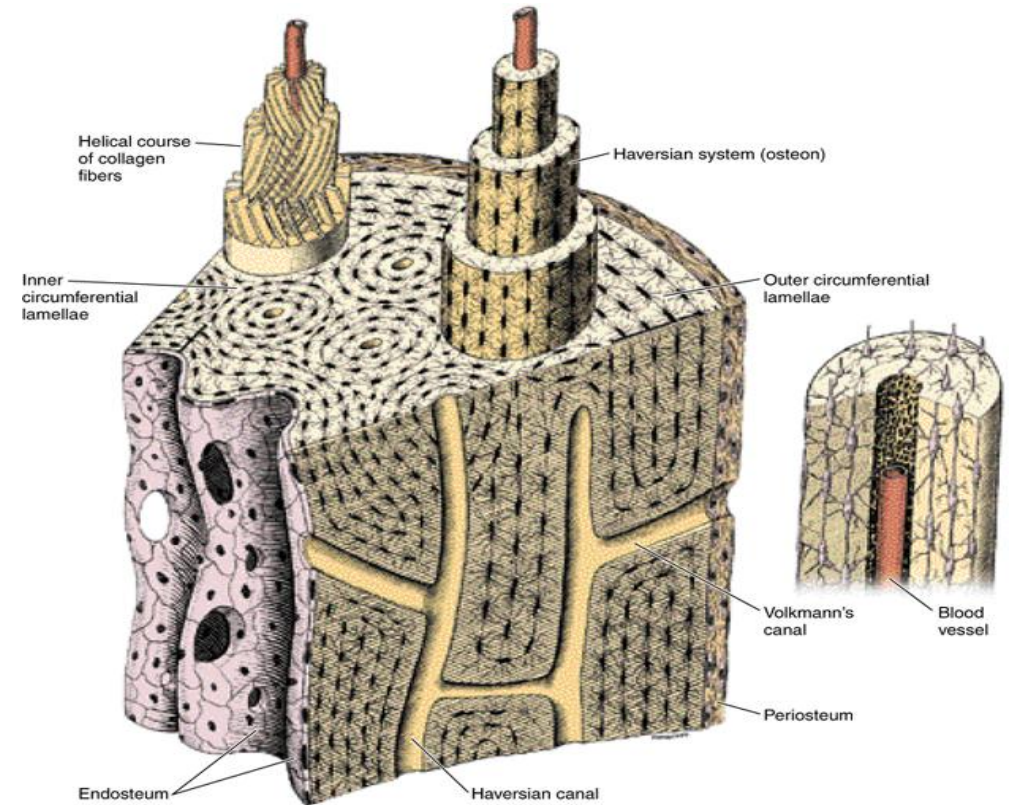
**B. Compact bone:** appears as solid very **dense mass** of bone tissue **without cavities**.

- **Both** types are present in every bone, but the amount and **distribution** of each **vary** considerably.
- **Cancellous bone is surrounded by Compact bone.**



# Compact bone

- **Sites:**
  - 1- Diaphysis of long bone.
  - 2- Covering any cancellous (spongy) bones, e.g. the outer and inner plates of the skull.
- **The bone lamellae are organized in the form of:**
  - a) Haversian systems.
  - b) Outer circumferential lamellae.
  - c) Inner circumferential lamellae.
  - d) Interstitial lamellae.



**a-Haversian System**

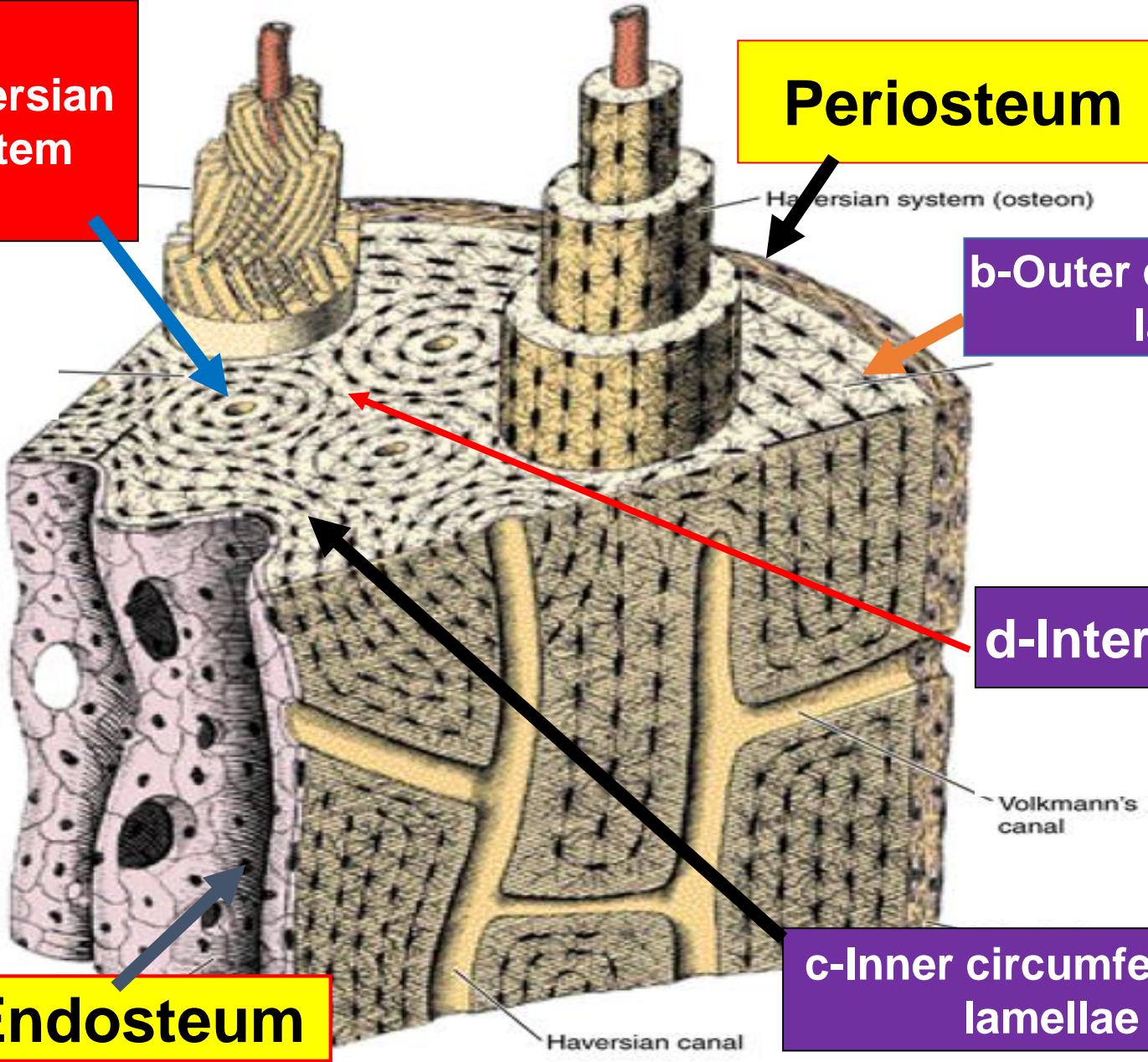
**Periosteum**

**b-Outer circumferential lamellae**

**d-Interstitial lamellae**

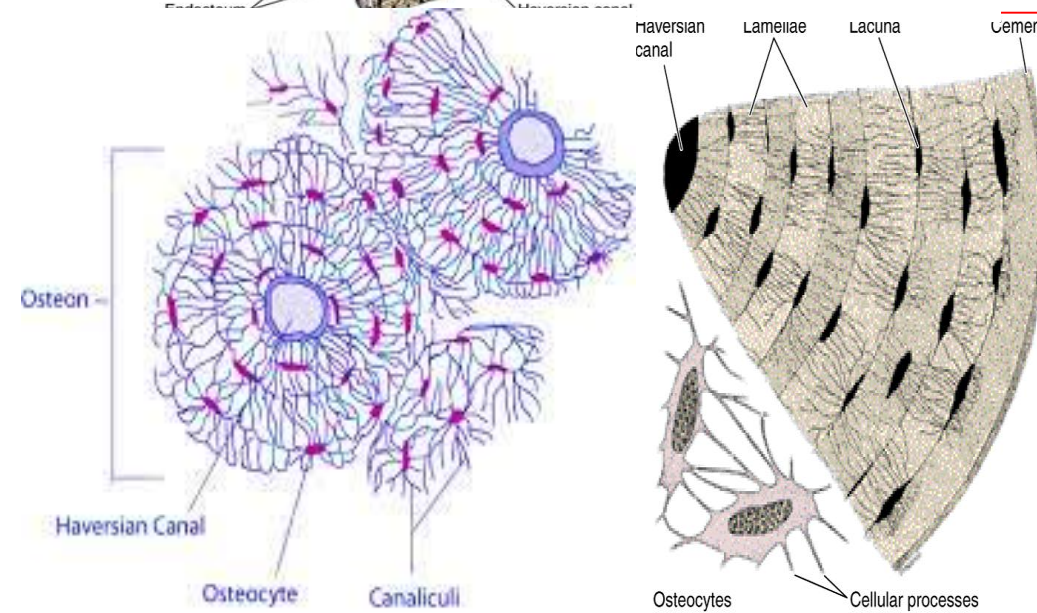
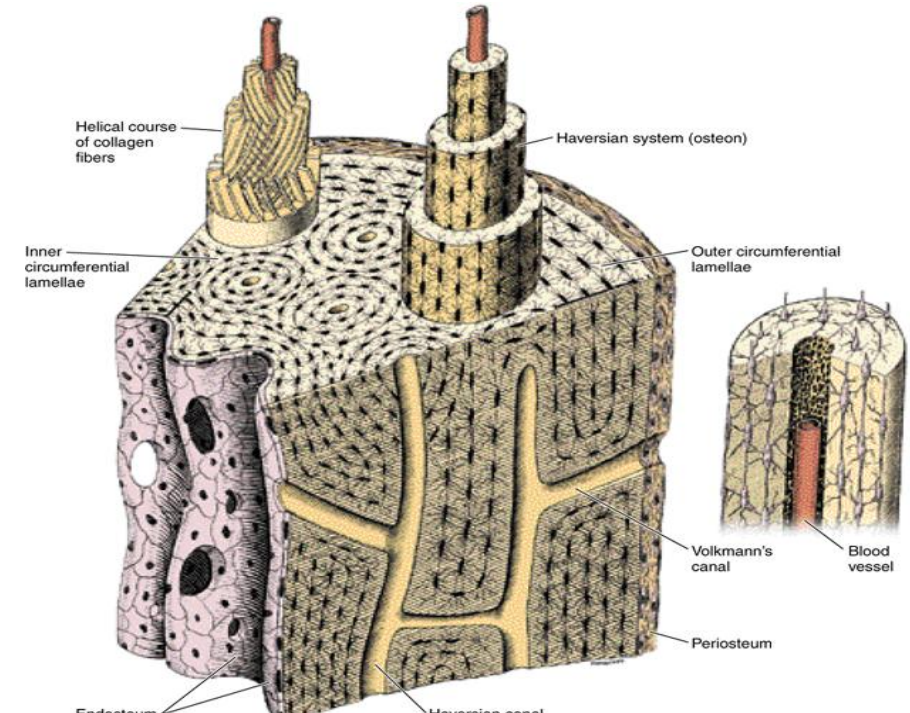
**Endosteum**

**c-Inner circumferential lamellae**



# (a) The Haversian system (osteon): Basic functional unit

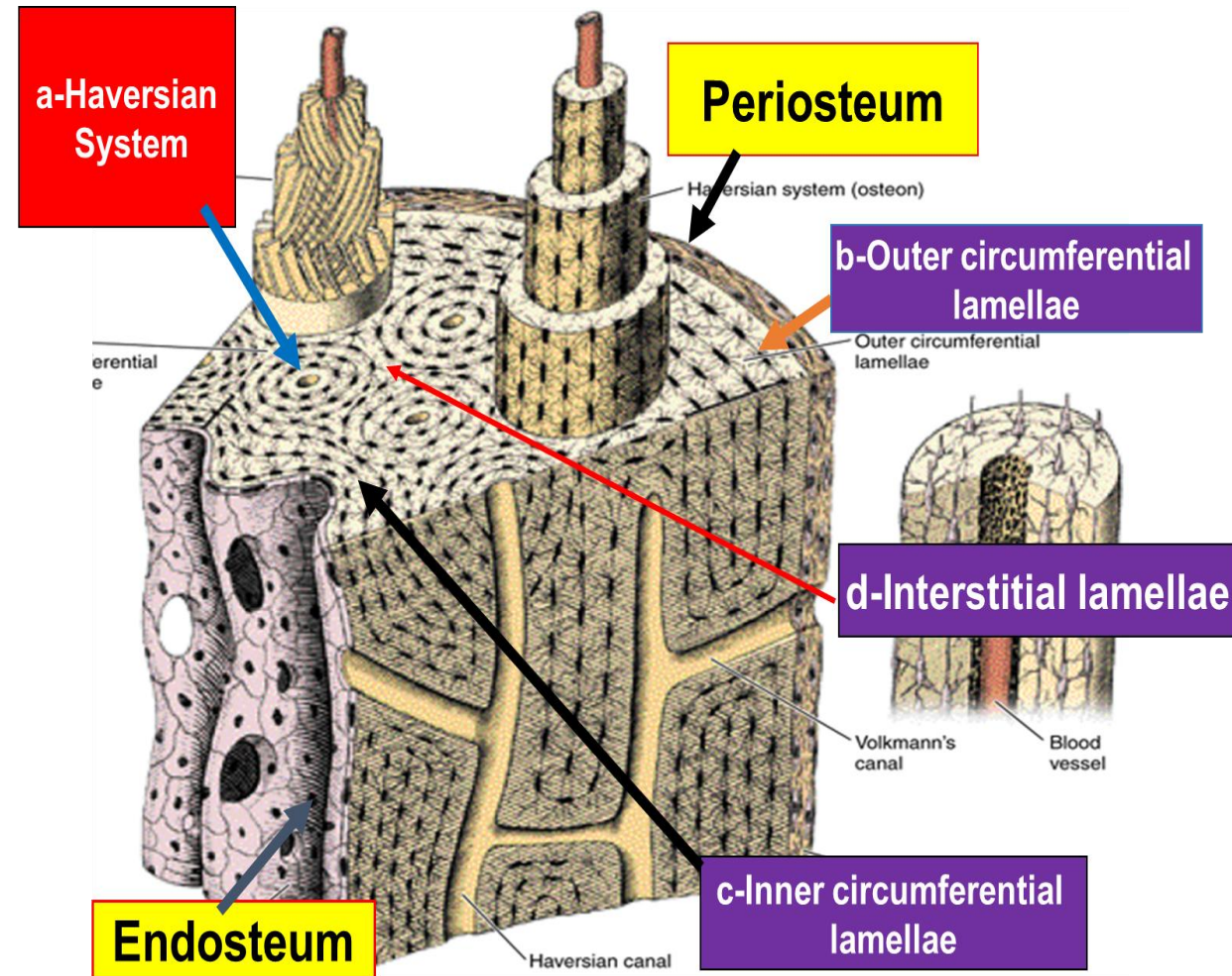
- 1- **Cylinder:** long & parallel to long axis of diaphysis.
- 2- **Central Haversian canal:** lined by endosteum & contains connective tissue, blood vessels and nerves.
- 3- **Canals of Volkmann's (perforating canals):** communicate Haversian canals with each other & with marrow cavity and periosteum.
- 4- **Concentric bone lamellae.**
- 5- **Cells:** osteocytes inside lacunae.



**(b) The outer circumferential lamellae:** lie immediately beneath the periosteum, parallel to it.

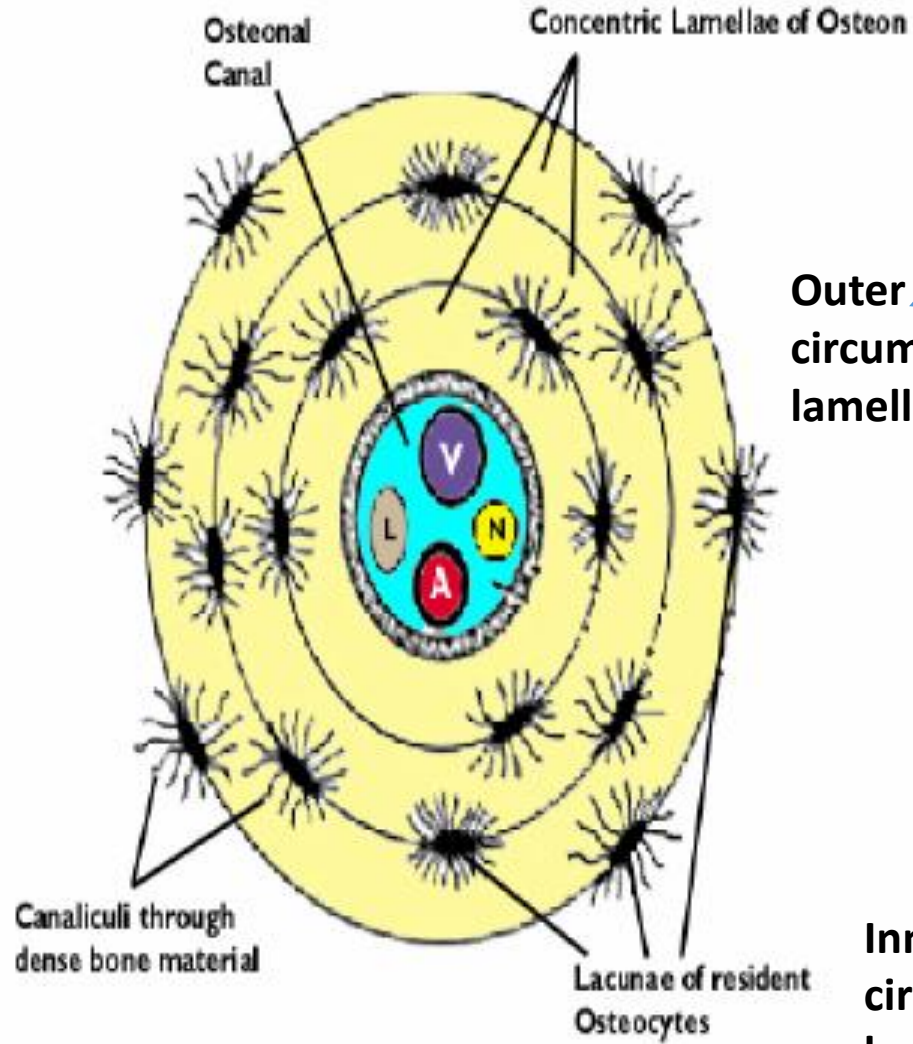
**(c) The inner circumferential lamellae:** Less in number and lie parallel to the endosteum around the marrow cavity.

**(d) The interstitial lamellae:** Irregularly shaped groups of parallel lamellae located in between the Haversian systems.



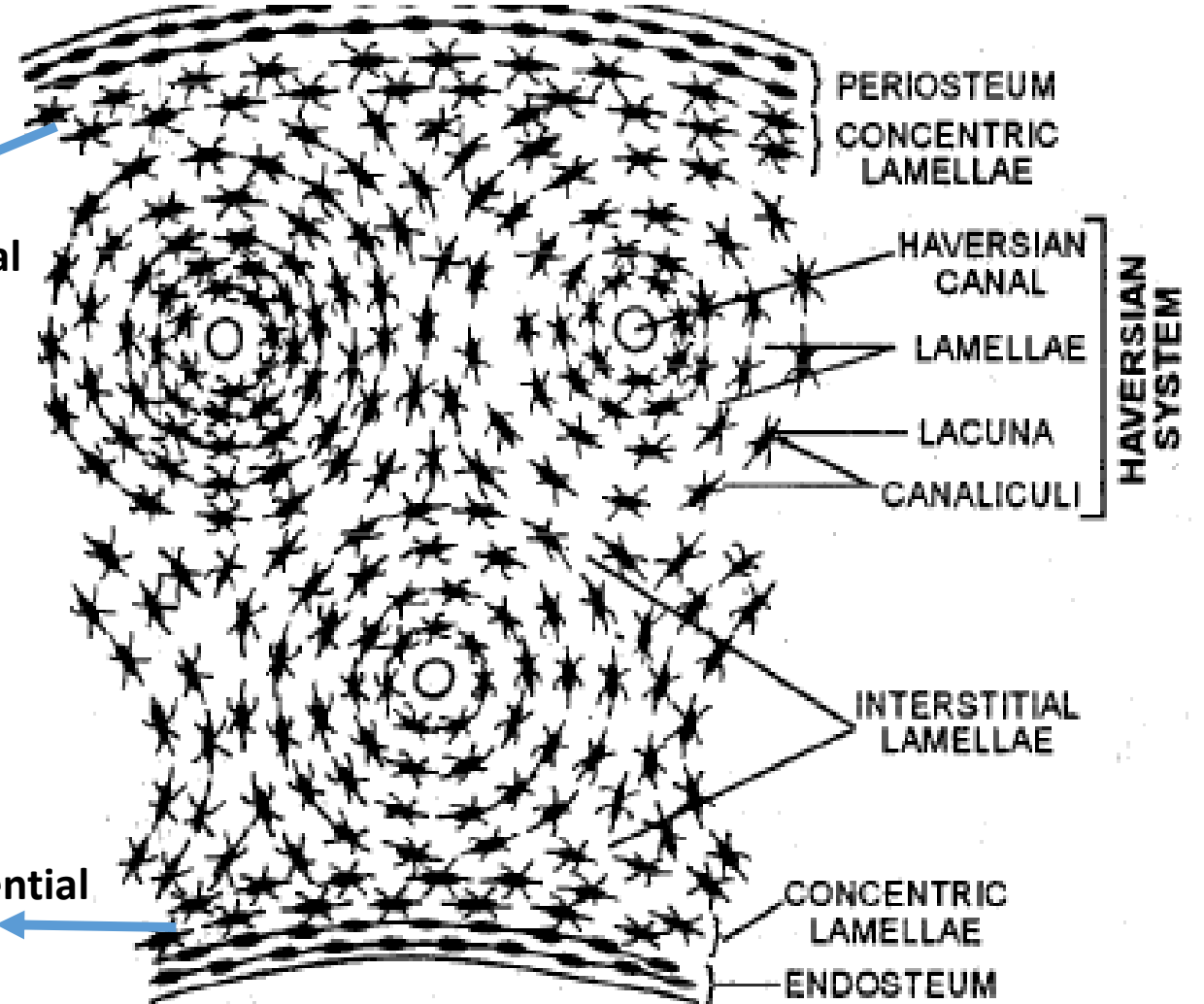
# Haversian system

# Compact bone T.S



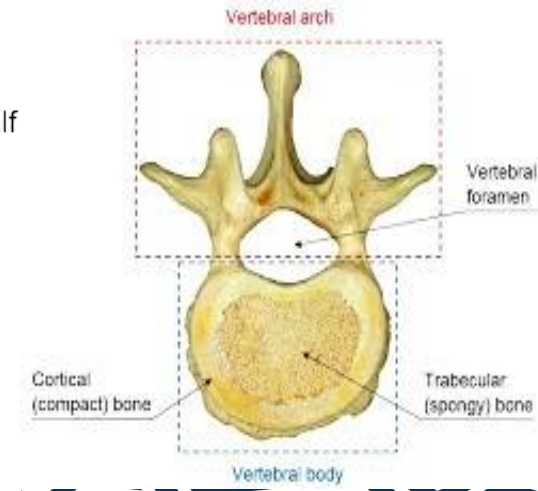
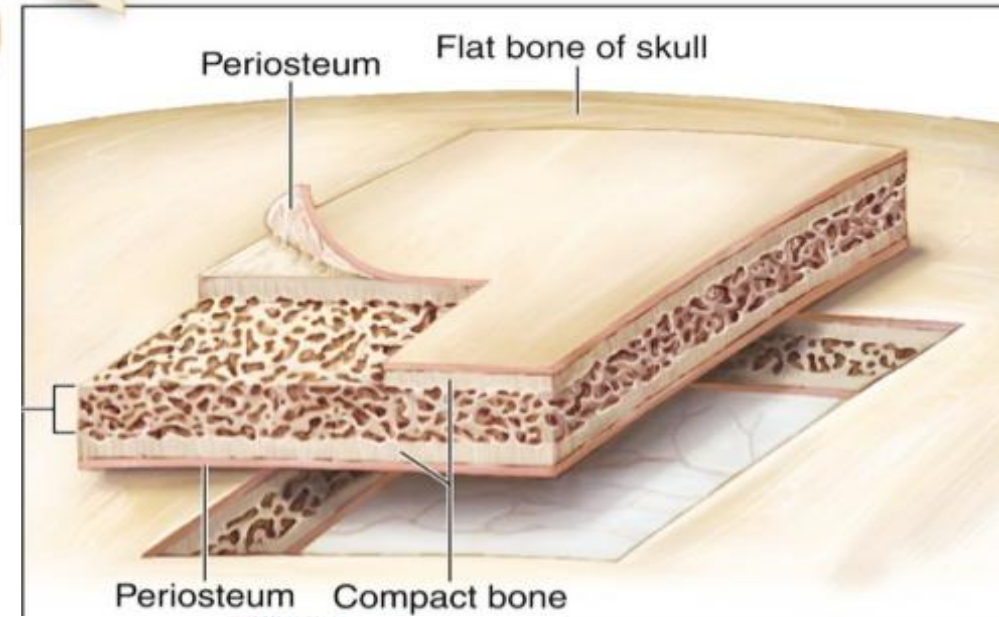
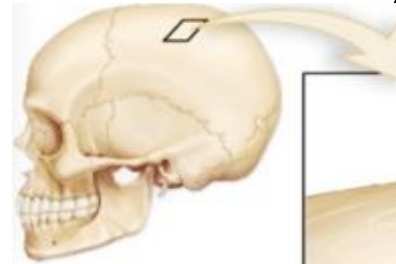
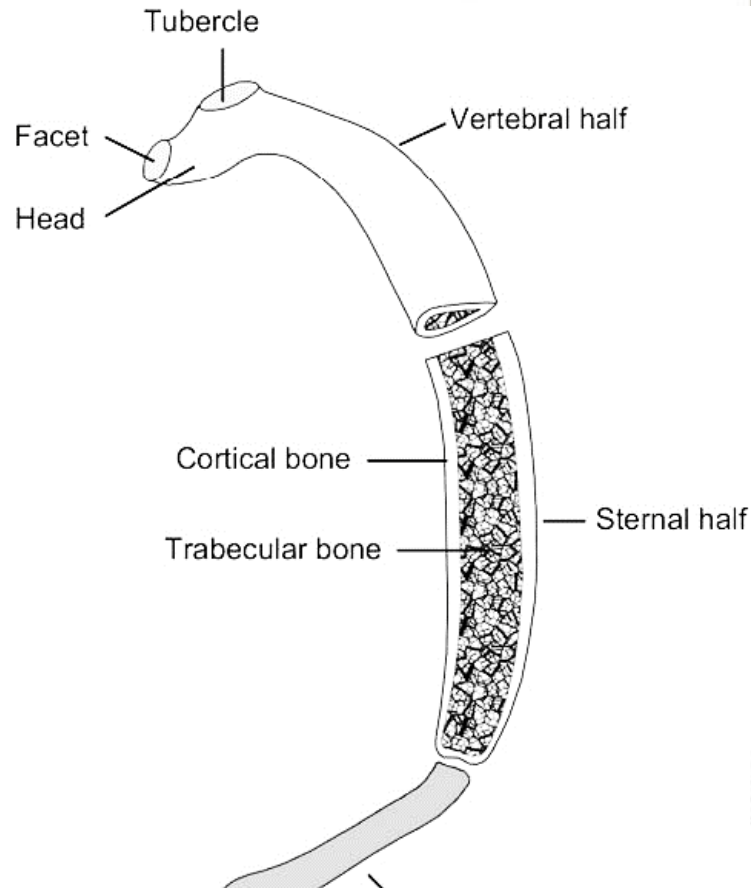
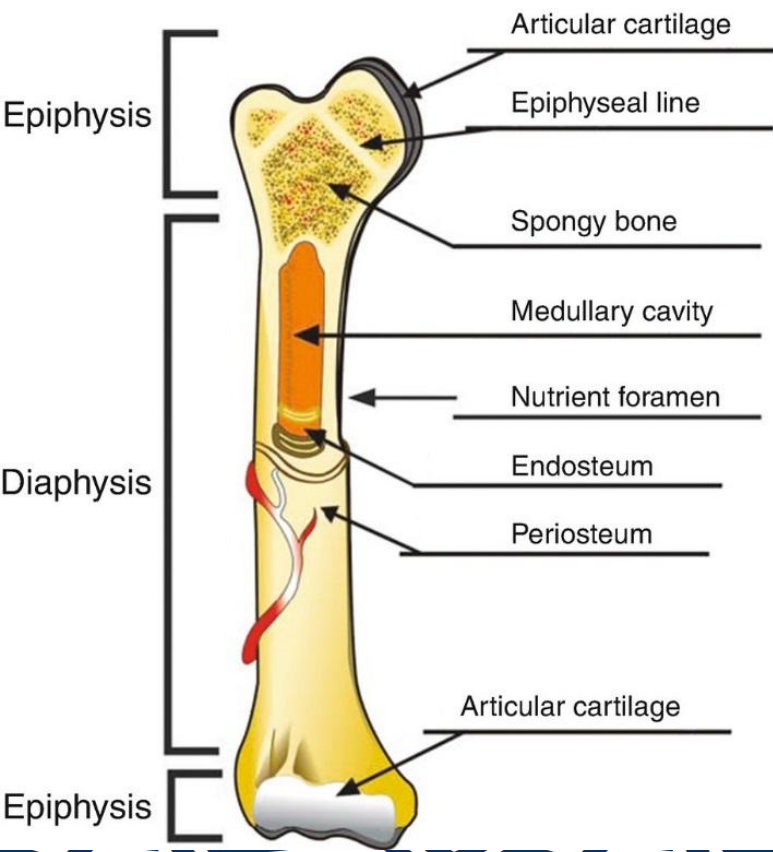
Outer circumferential lamellae

Inner circumferential lamellae



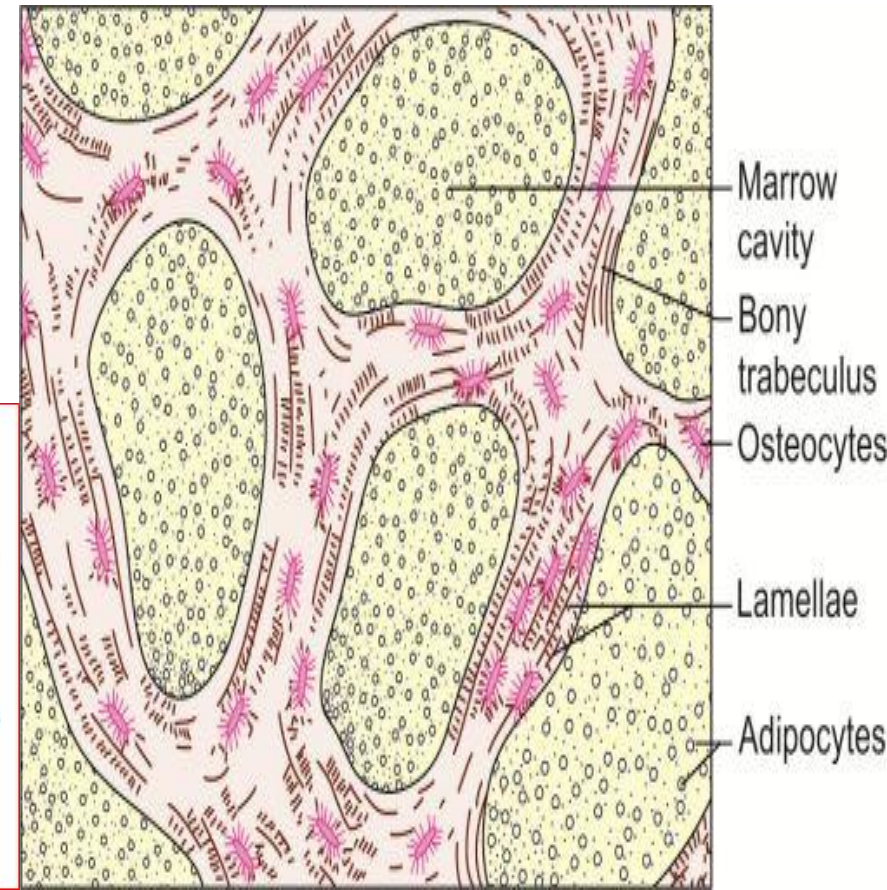
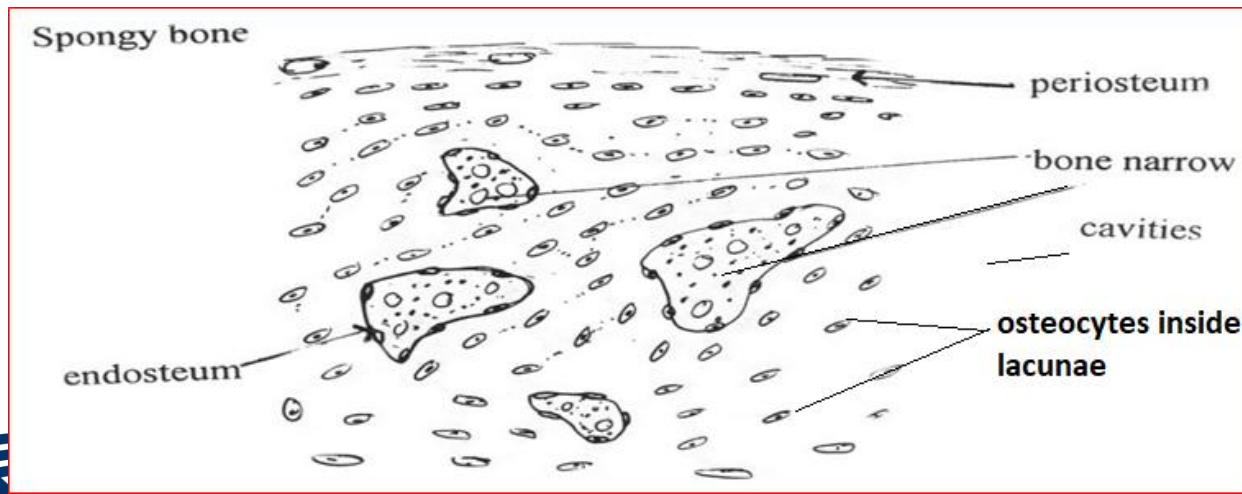
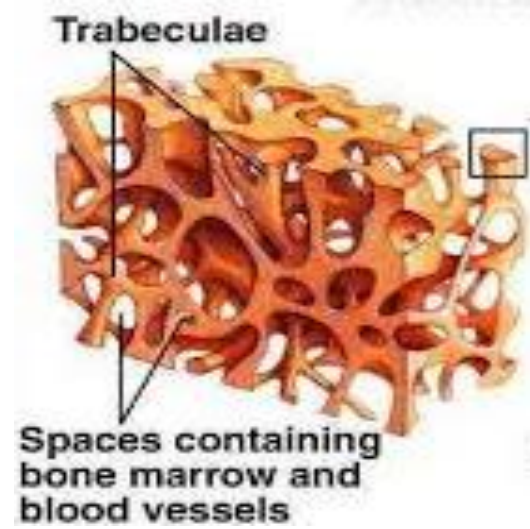
# Cancellous (spongy) bone

- **Sites:** 1- Flat bone (e.g. diploe of skull, scapulae and iliac bone).
- 2- Irregular bones (e.g. vertebrae).
- 3- Epiphysis of long bone.
- 4- Shaft of the ribs.



# Cancellous (spongy) bone

- It is composed of branching and anastomosing **bone trabeculae** formed of **irregularly arranged bone lamellae** with **osteocytes** inside lacunae **in between** the lamellae
- **Bone marrow cavities (spaces)** lined by endosteum in between them.
- **Haversian systems** are **absent**.
- **N.B.:** Cancellous bone is surrounded and protected by layer of compact bone covered by periosteum.



# **BONE FORMATION (OSSIFICATION)**

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# **BONE FORMATION (OSSIFICATION)**

Bone is formed from mesenchymal tissue in the embryo.

There are two methods of ossification:

- 1. Intramembranous:** bone develops within a mesenchymal membrane.
- 2. Intracartilagenous (endochondral):** bone develops by replacement of cartilage.



# INTRAMEMBRANOUS OSSIFICATION

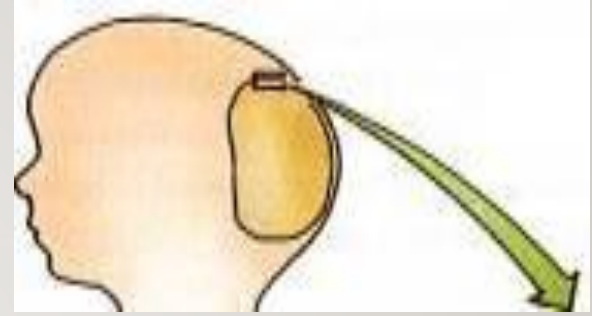
**Sites:** flat bones as skull, clavicle,...

## **Steps:**

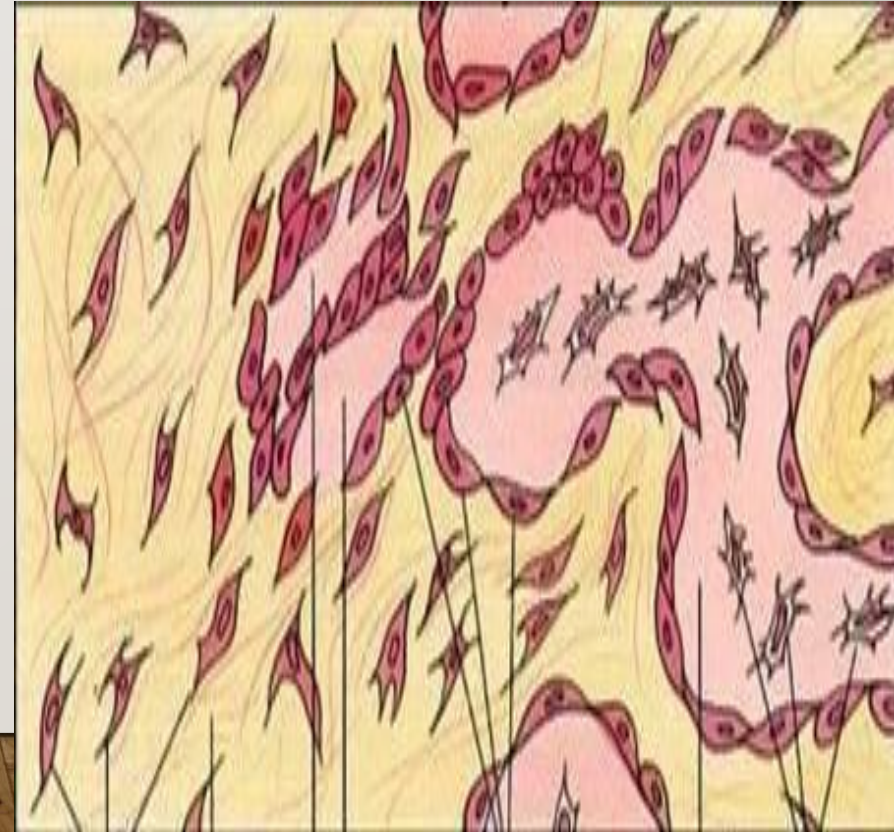
1. Future bone site is occupied with **mesenchymal membrane**.
2. **The primary ossification center** (starting point for ossification): a highly vascular area in the middle of the membrane. **UMCs** condense, proliferate and differentiate into **osteogenic cells**.



3. **Osteogenic cells** increase in size, number & differentiate to **osteoblasts**.

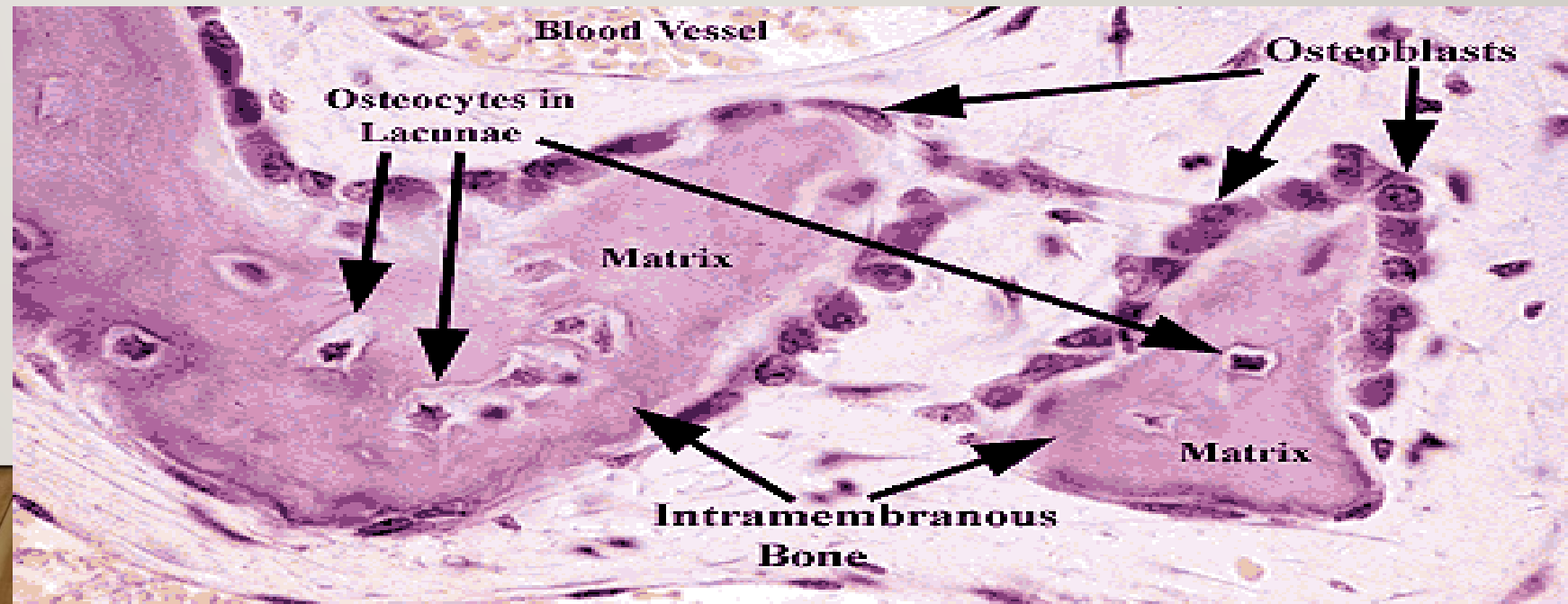


4. **Osteoblasts** divide & secrete **organic matrix** and alkaline phosphatase to stimulate **deposition of Ca salts** in matrix



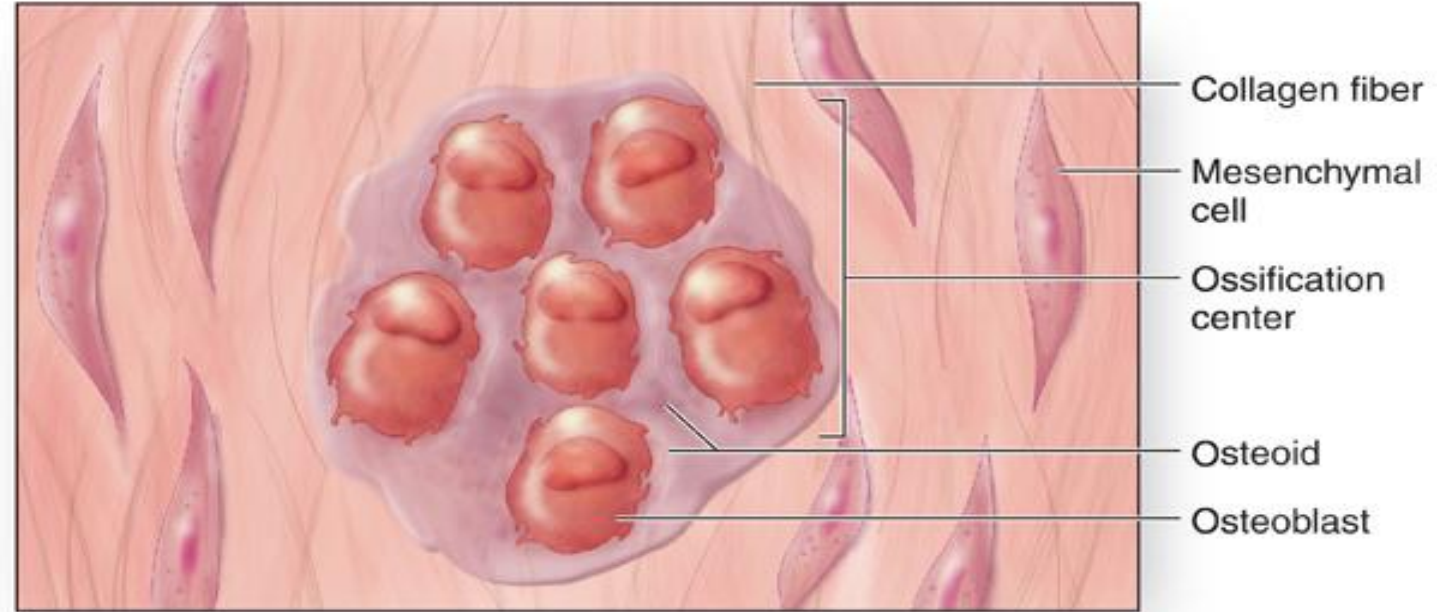
5. When **osteoblasts** are trapped inside **lacunae** surrounded with calcified matrix, called **osteocytes**.

6. Bone matrix extends in a **radial** manner in form of **trabeculae**, radiate from the starting point.

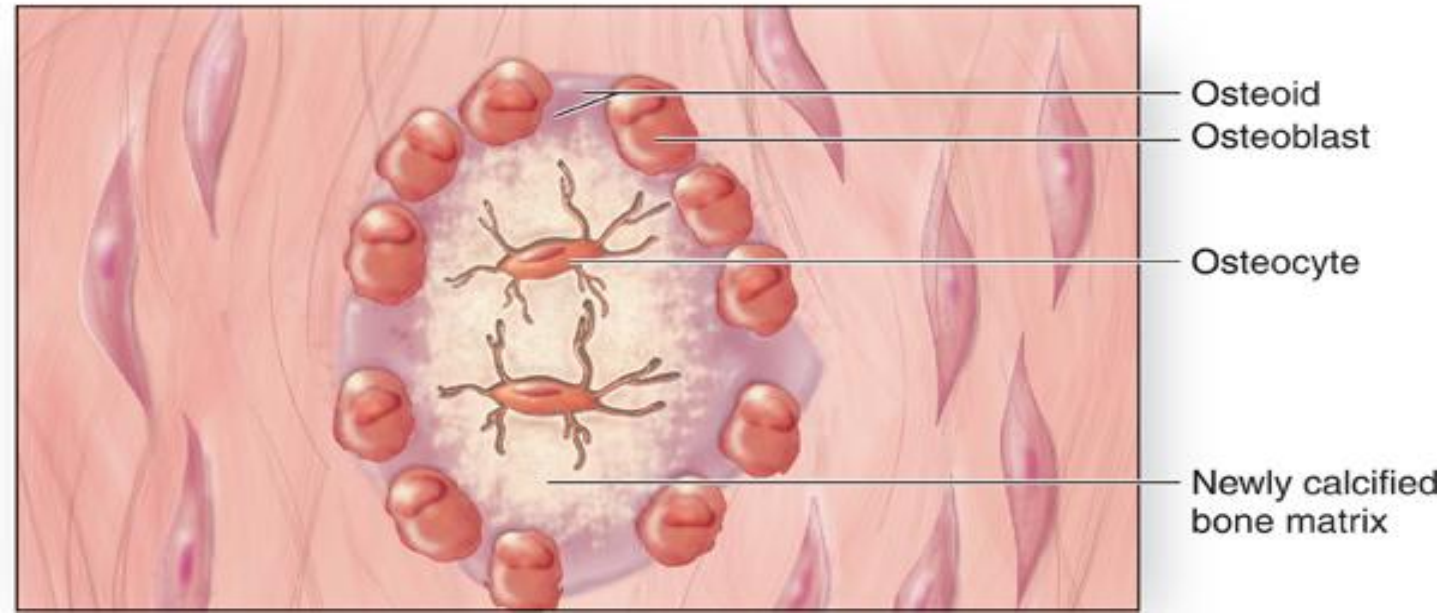


### Intramembranous Ossification

- ① Ossification centers form within thickened regions of mesenchyme



- ② Bone matrix (osteoid) undergoes calcification.



7. **Multiple ossification centers** appear in the mesenchymal membrane and the resulting bone trabeculae fuse together giving rise to **spongy bone**.
8. The vascular tissue that fills the spaces between trabeculae of spongy bones differentiate into **red bone marrow**.
9. **Growth & remodeling** of bone result by continuous deposition of new bone by osteoblasts & resorption by osteoclasts.



# INTRACARTILAGENOUS (ENDOCHONDRAL) OSSIFICATION

**Sites:** Long bones of limbs.

Takes place by replacement of a **cartilage model** which takes shape of future bone.

The cartilage model grows by **appositional** and **interstitial** methods.

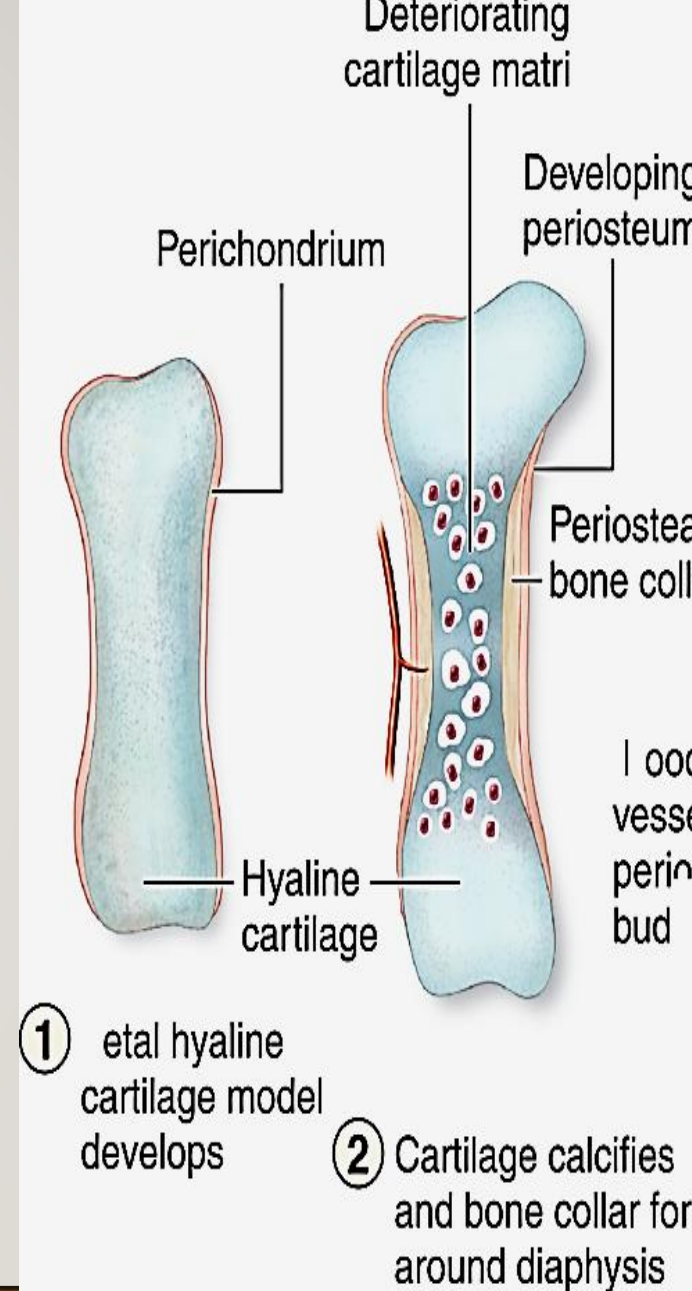


# Steps:

## A) Primary ossification center:

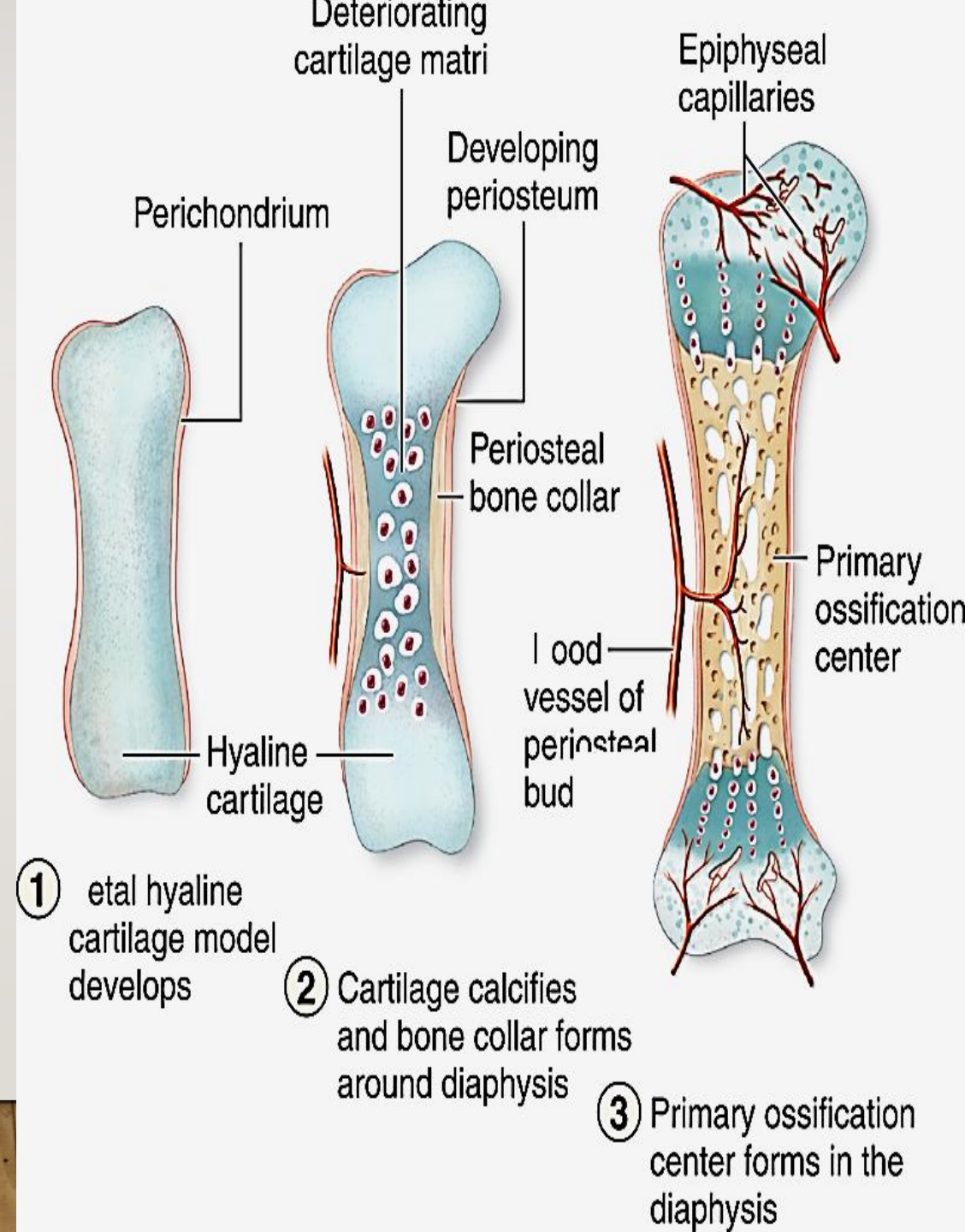
starts to appear at center of the model where following changes take place:

- Transformation of **chondrogenic** cells in perichondrium (future periosteum) to **osteogenic cells**, then **osteoblasts** which secrete **bone matrix** deep to the periosteum forming **subperiosteal bone collar**.
- Chondrocytes** within the center of the cartilaginous model undergo **hypertrophy** and initiate **matrix calcification** by releasing **alkaline phosphatase**.

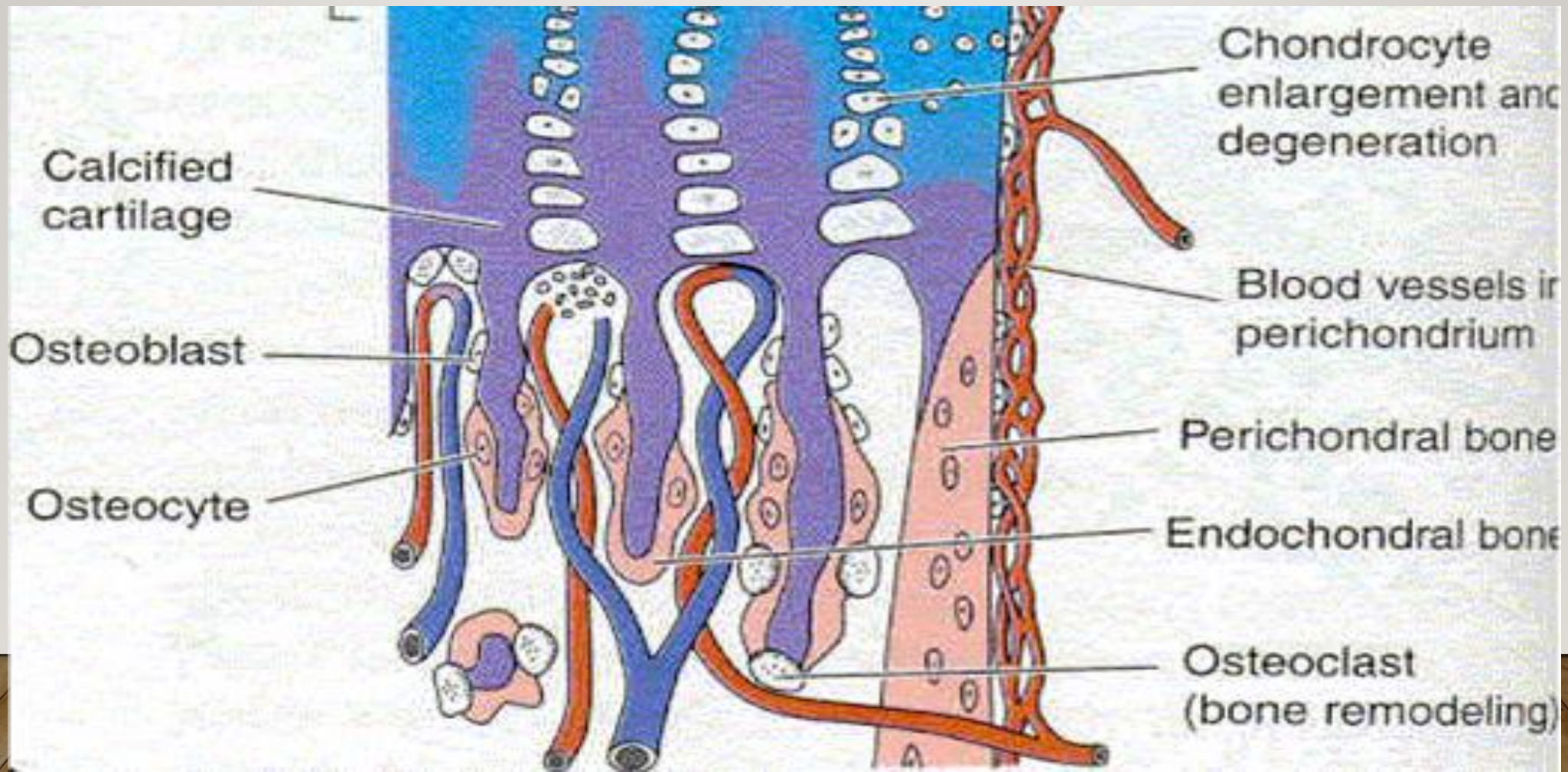


□ The **calcified cartilage matrix** prevents diffusion of nutrients, causing **death of the chondrocytes** with matrix break down, so neighboring lacunae become confluent, producing an increasingly **large cavity**.

□ **Osteoclasts** create **perforations** in the bone collar that let the **blood vessels, osteogenic cells, and UMCs** to enter the newly formed spaces in the cartilaginous model.



□ Newly developed **osteoblasts** secrete **bone matrix** on the surface of the calcified cartilage, forming basophilic calcified cartilage surrounded by acidophilic calcified bone.



□ Remodeling: **Osteoclasts** start to **resorb** the irregular trabeculae at the center, leading to formation of a **single bone marrow cavity** in which UMCs start to form bone marrow cells.

At same time, bone is remodeled into lamellar bone and mature **Haversian systems** are formed

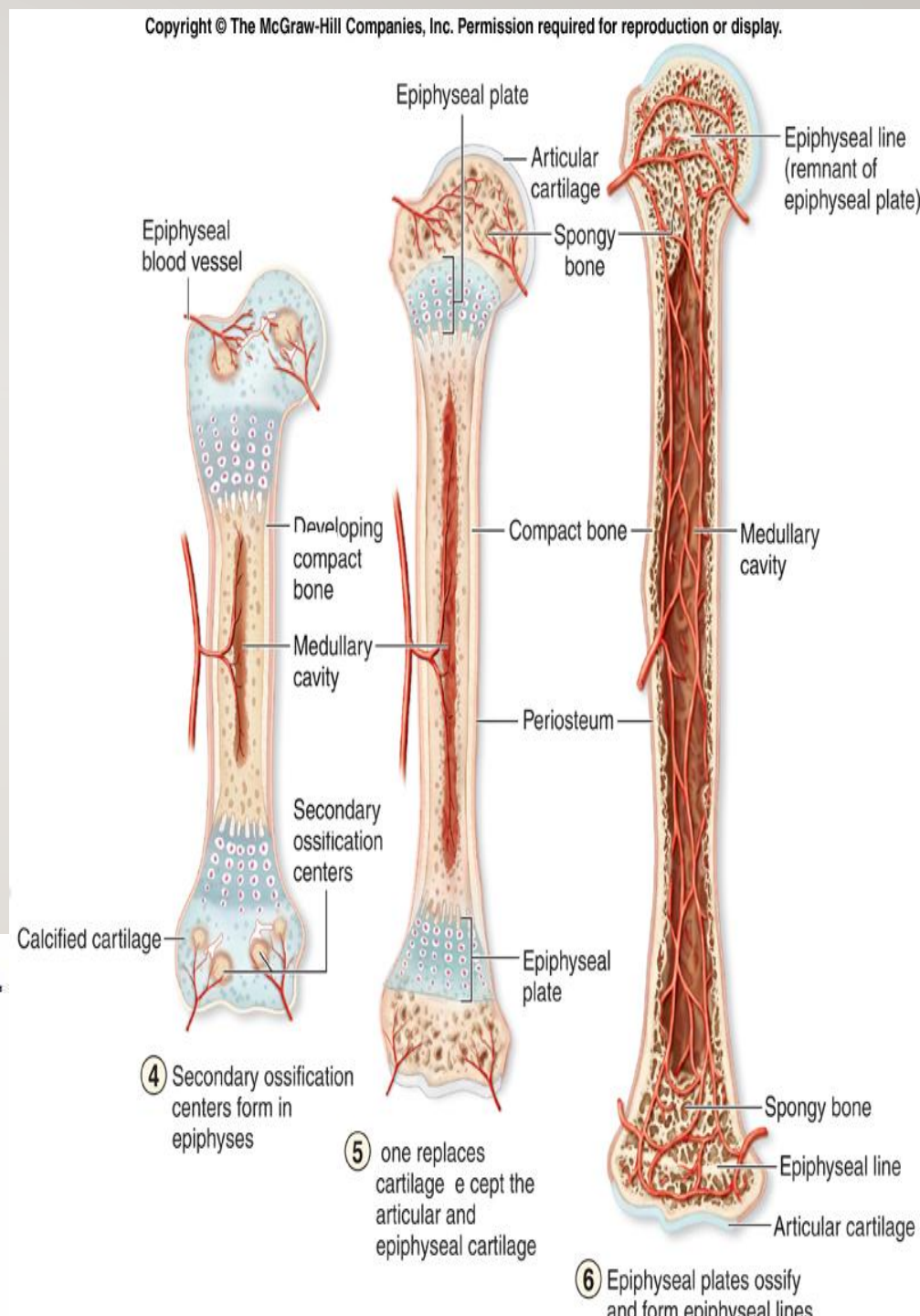
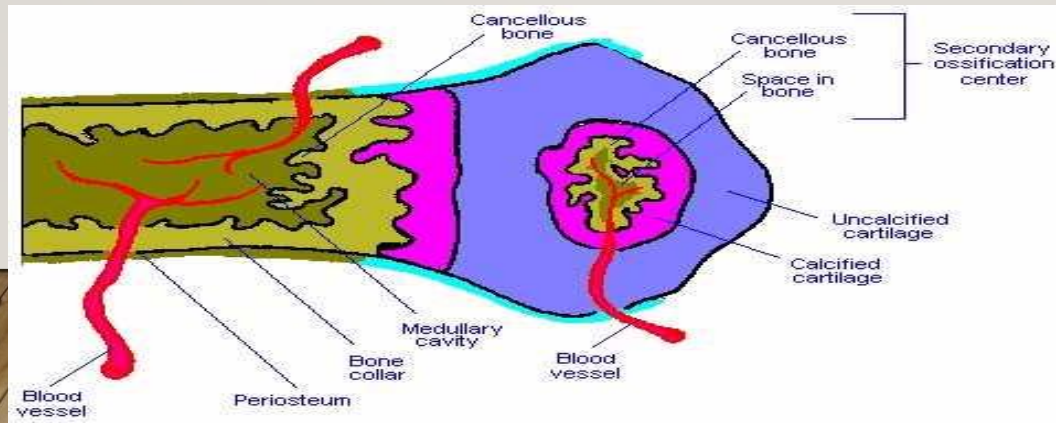


compact bone remodelling

## B) Secondary ossification center:

Appears after birth in the **two ends** of the developing bone (**epiphysis**) by increased vascularity.

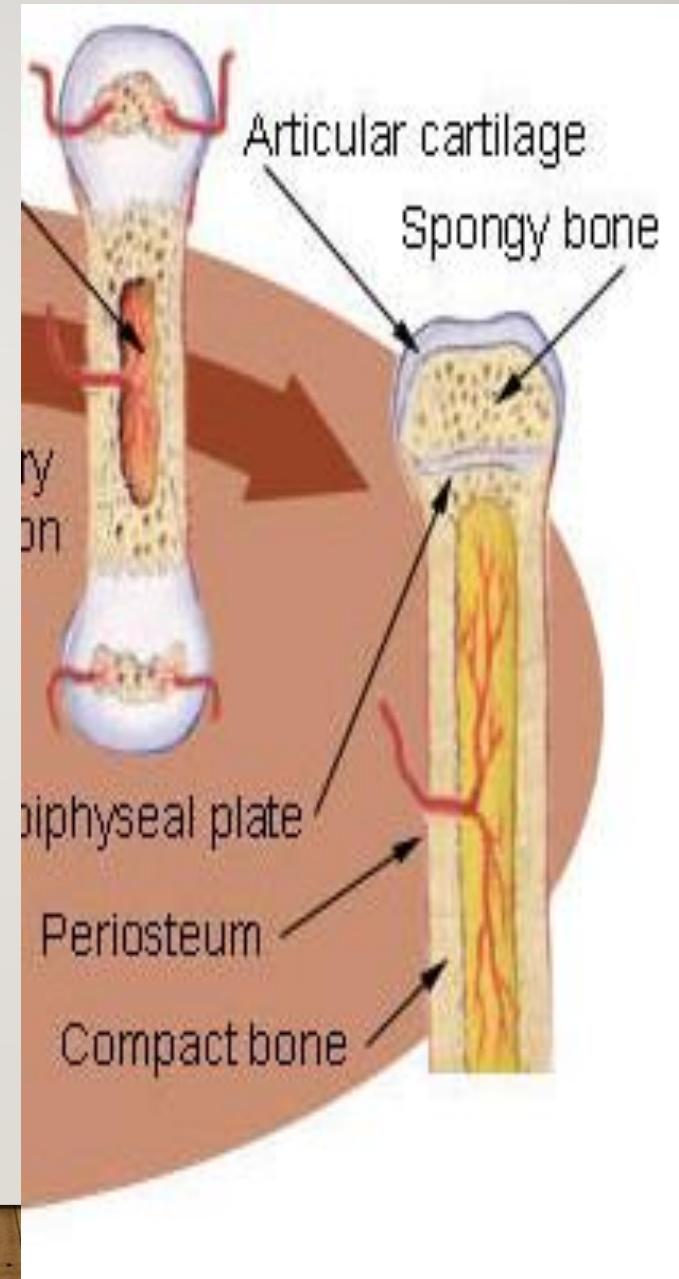
Ossification occurs by same steps as in primary center.

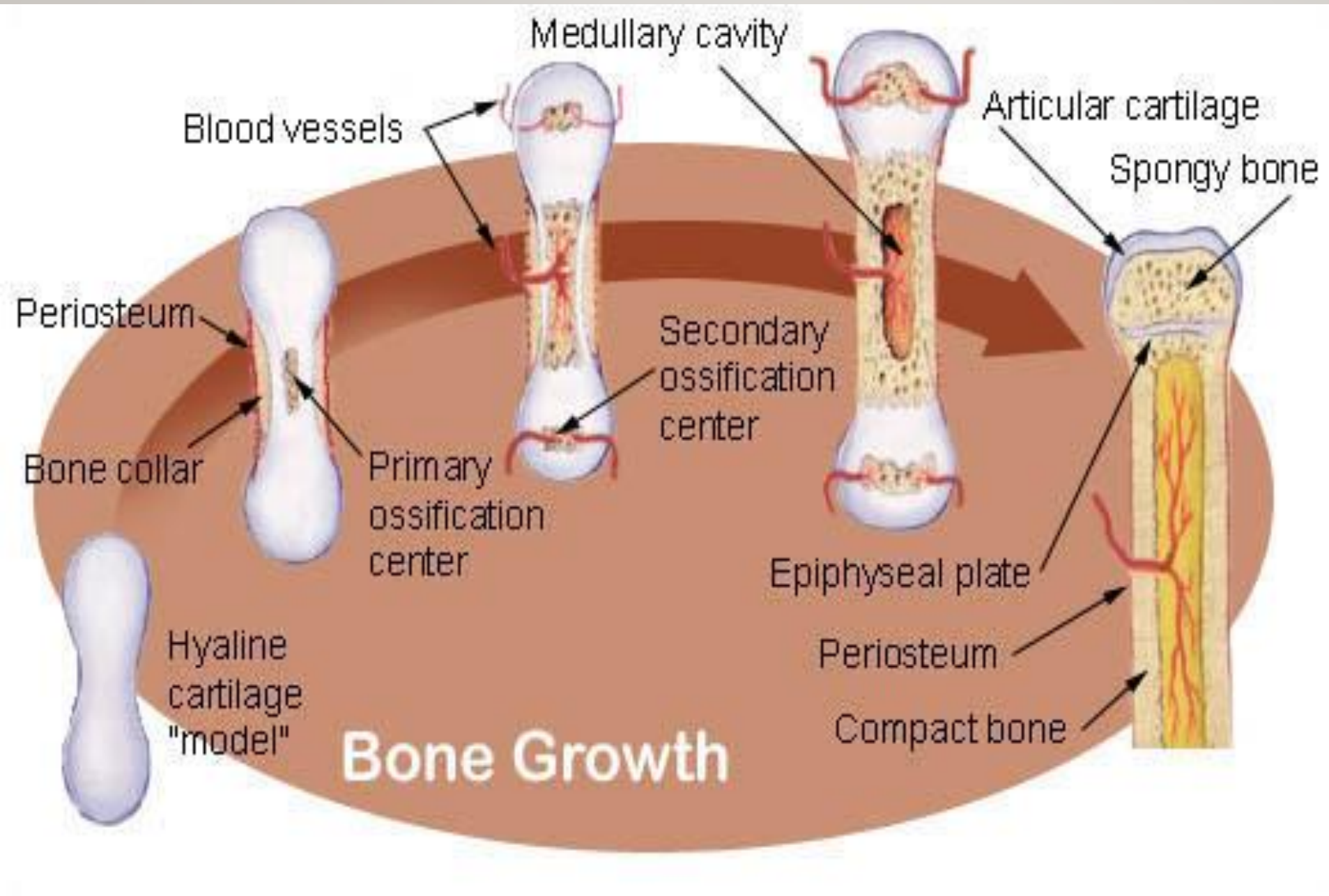


Thus the cartilage at the middle of the head is replaced by spongy bone except in:

**The epiphyseal plate** (left for growth until the age of closure).

**Articular cartilage** (will never ossify).





# POSTNATAL GROWTH OF BONE

## I) Growth in width (appositional):

by continuous **deposition of new compact bone on the outer surface** by **osteoblasts** and continuous bone **resorption of the old bone from the inner surface** by **osteoclasts**.

This leads to increase in the diameter of bone without **increase in the thickness**.



## 2) Growth in length (interstitial):

Occurs in the **epiphyseal plates** where proliferation of cartilage takes place.

At the age of 21-23 years, ossification of the epiphyseal plates is complete and the epiphyseal discs are **completely ossified** (closed).

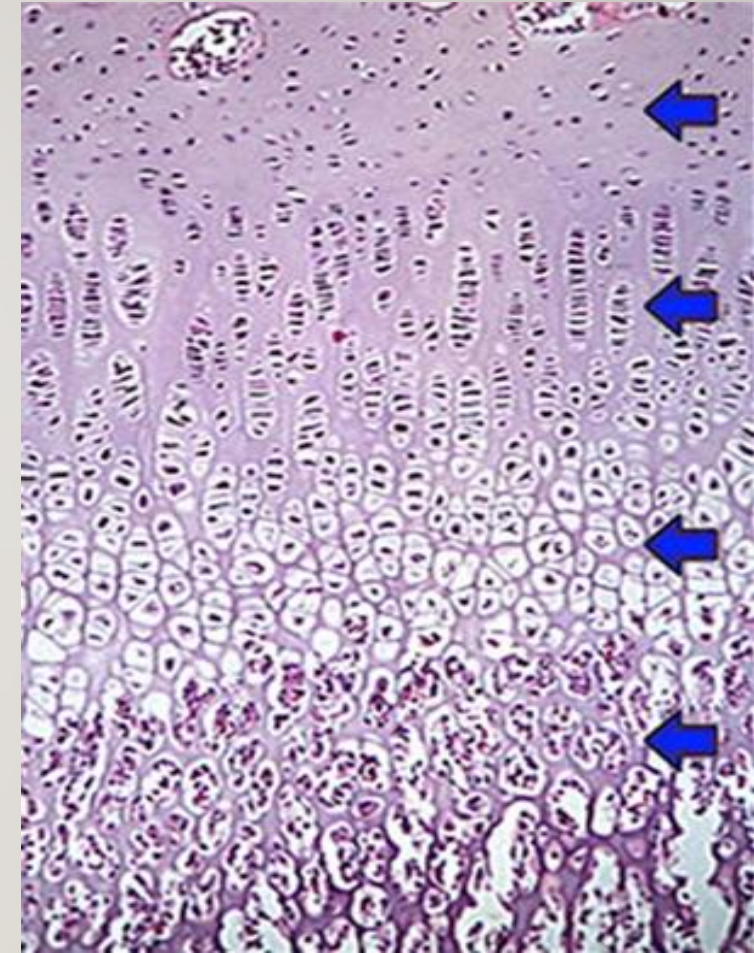


# EPIPHYSEAL PLATE MORPHOLOGY

Five zones, from epiphysis to diaphysis:

- Zone of **resting** cartilage
- Zone of **proliferating** cartilage
  - Rapid mitosis
  - Arranged as columns
- Zone of **hypertrophic** cartilage

Chondrocytes grow in size compressing the matrix into thin bars



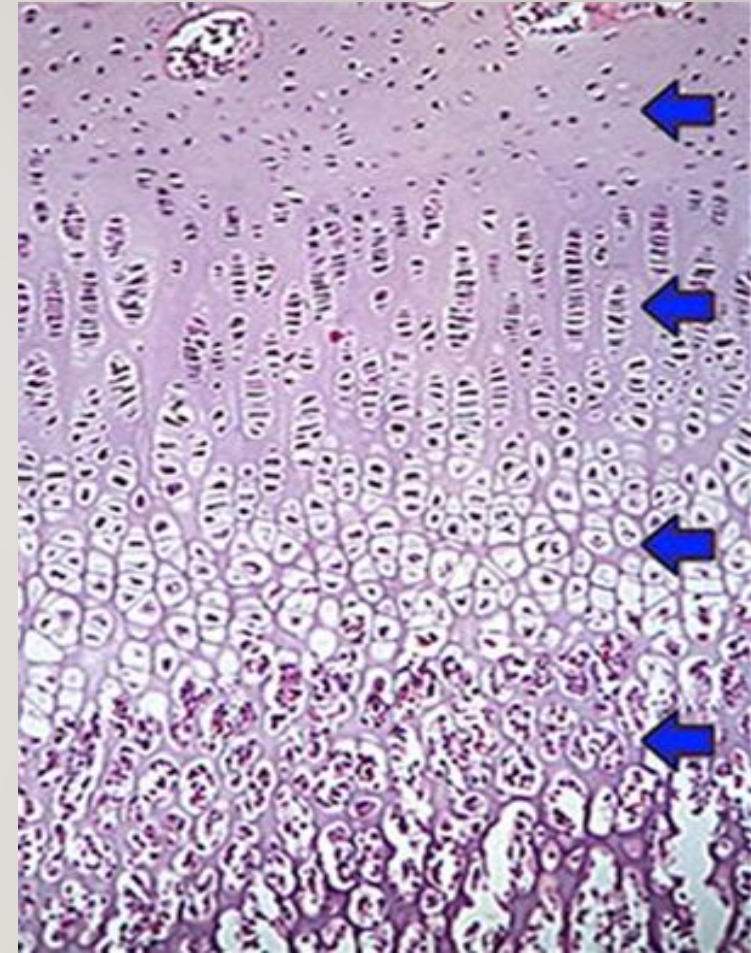
# EPIPHYSEAL PLATE MORPHOLOGY

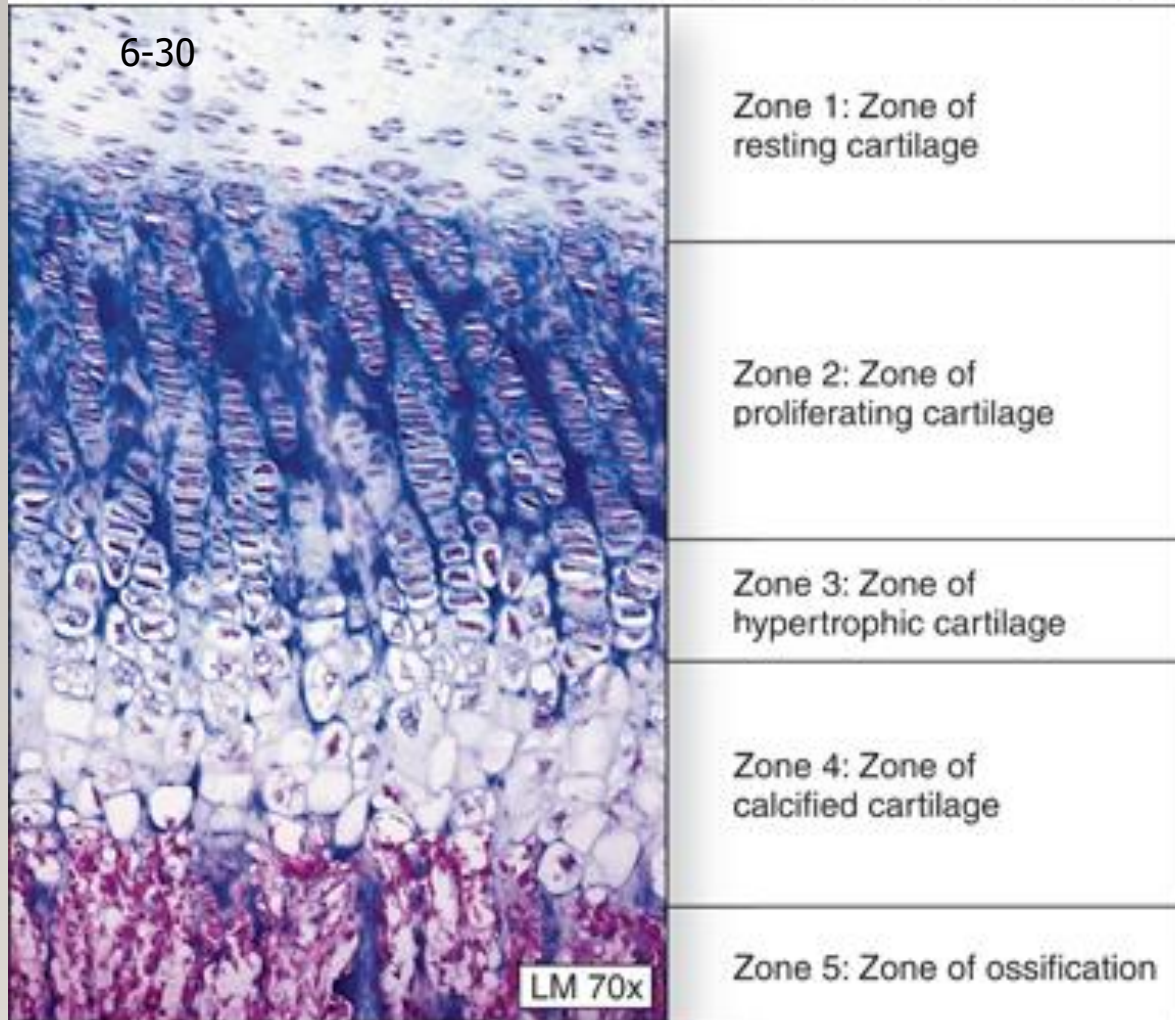
- Zone of **calcified** cartilage

Calcified matrix cut off nutrient to chondrocyte causing its death leaving empty lacunae

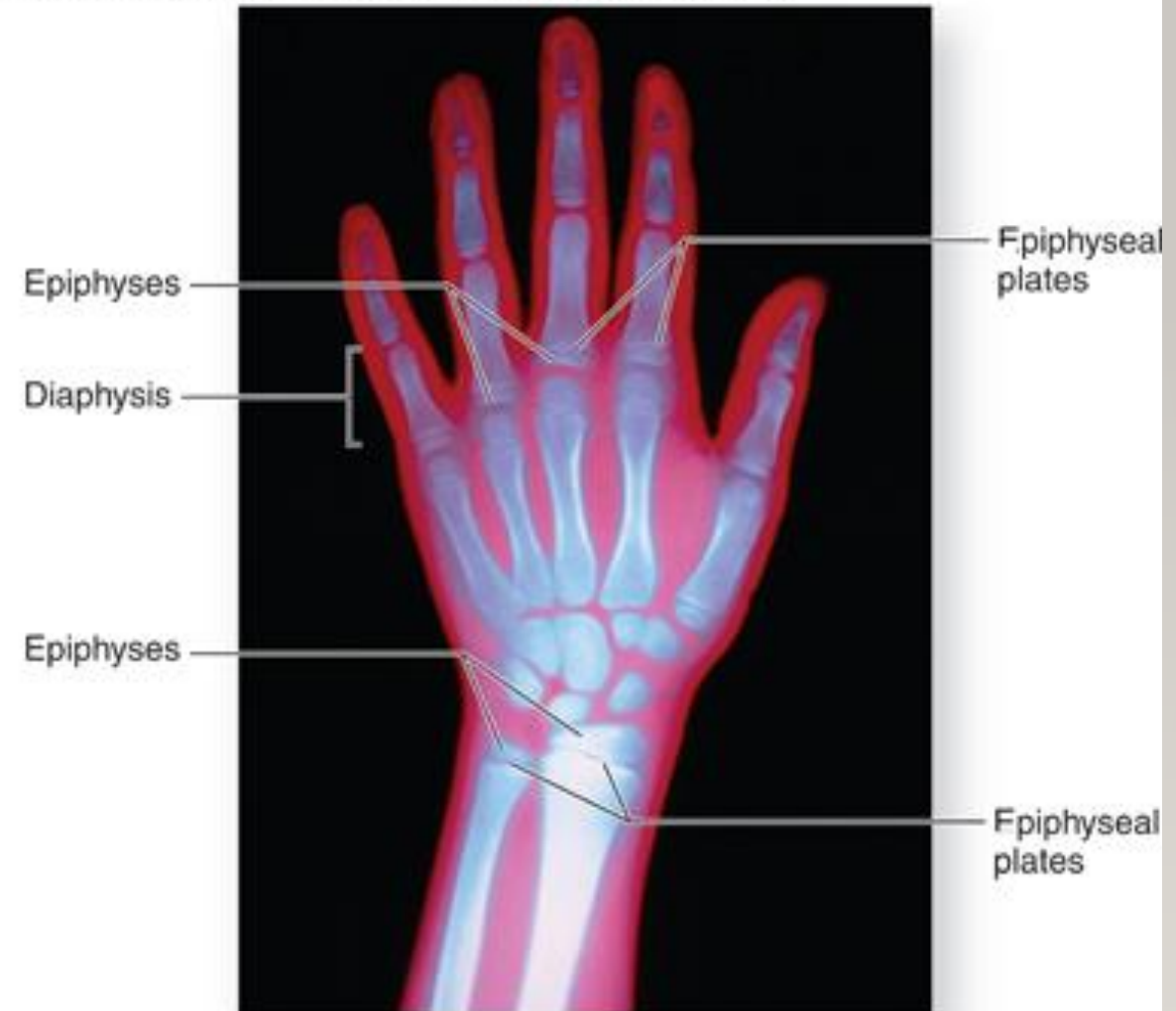
- Zone of **ossification**

Invasion by capillaries and osteoprogenitor cells





(a)



(b)

THANK YOU

