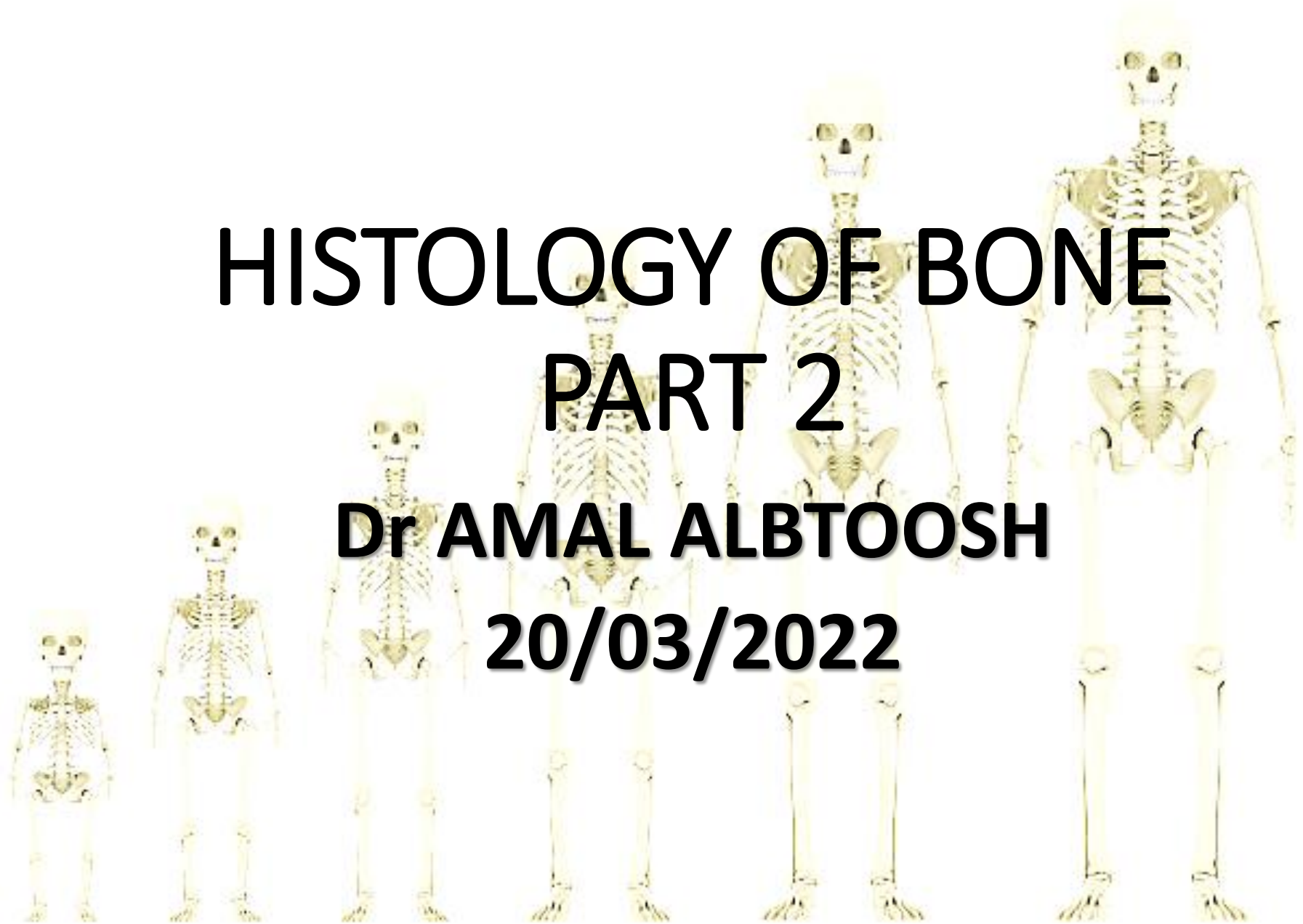


HISTOLOGY OF BONE
PART 2

Dr AMAL ALBTOOSH

20/03/2022

LEARNING OBJECTIVE

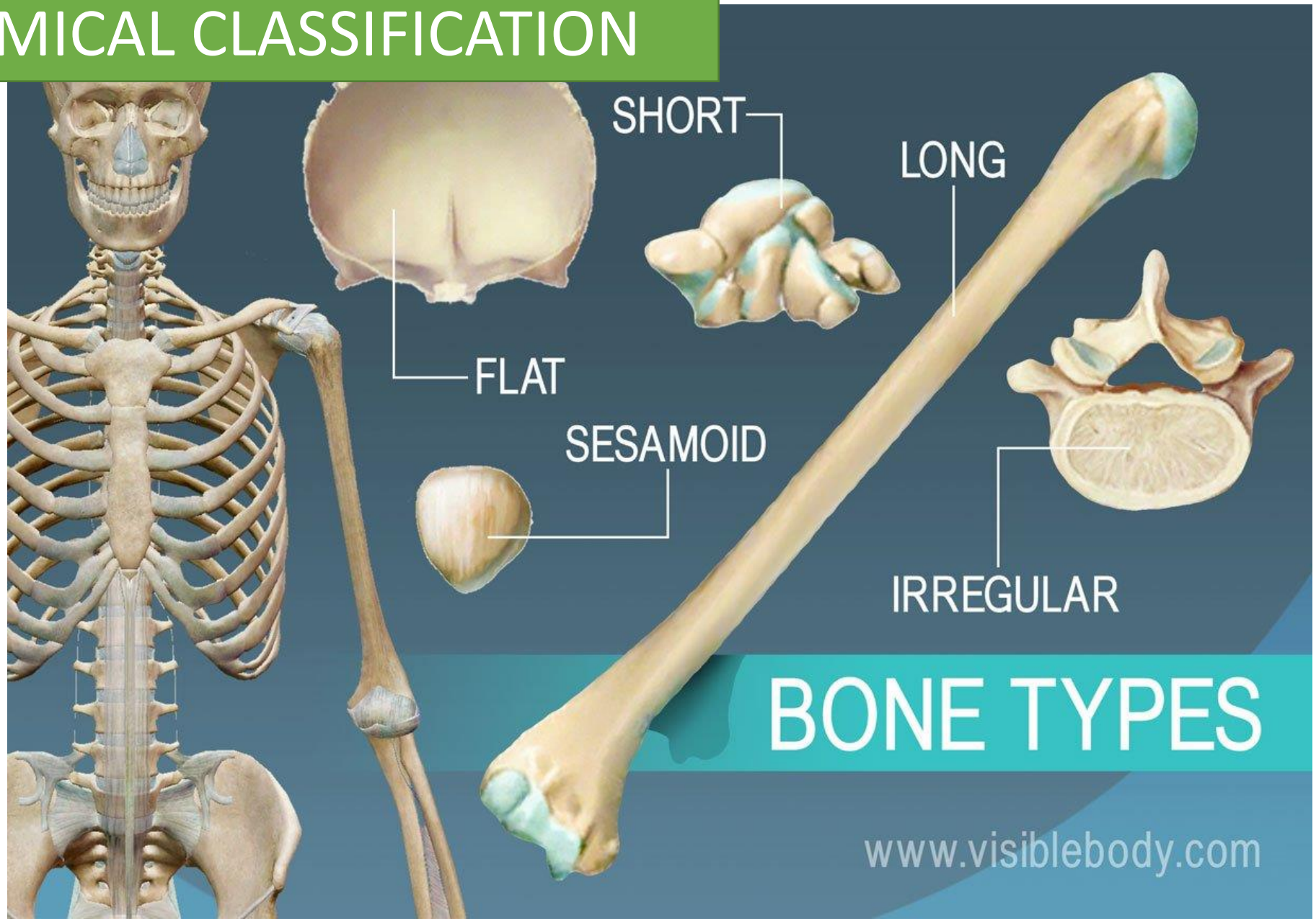
1. Outline the different types classification of bone.
2. Outline the two distinct ways of bone ossifications.
3. Outline the way in which bones continue to grow throughout early life to maturity and correlate this with the histological appearance of an epiphyseal growth plate

Characteristic	Cartilage	Bone
Ground substance	Chondroitin sulfate, keratan sulfate Chondronectin, chondrocalcin No mineralization High degree of hydration (75%)	Chondroitin sulfate, keratan sulfate Osteonectin, osteocalcin, osteoporin Hydroxyapatite, citrate, bicarbonate Low degree of hydration (7%)
Fibers	Type I collagen (fibrocartilage) Type II collagen (hyaline and elastic)	Type I collagen (provides tensile strength)
Vascularity	Avascular; nutrients received via diffusion	Highly vascular
Nerves	Absent	Present
Growth	Interstitial and appositional	Appositional only
Repair	Low	High
Mitosis	Chondrogenic—yes Chondroblasts—yes Chondrocytes—yes	Osteoprogenitor—yes Osteoblasts—no Osteocytes—no Osteoclasts—no
Communication	No junctions between chondrocytes	Gap junctions between osteocytes
Hormonal influence	T_3, T_4, testosterone, GH, cortisone, hydrocortisone, estradiol	PTH; 1,25-$(OH)_2$ vitamin D; calcitonin; GH; estrogens; androgens; T_3; T_4; cortisol
Vitamin influence	N/A	Vitamins D, C, and A

Classification of bone

MACROSCOPICALLY		MICROSCOPICALLY		ANATOMICALLY
CORTICAL 80% of skeleton	CANCELLOUS	PRIMARY [WOVEN]	SECONDARY [LAMELLAR]	LONG BONE SHORT BONE FLAT BONE… ETC

ANATOMICAL CLASSIFICATION



ANATOMICAL CLASSIFICATION

Long bones

- E.G. Femur, humerus, tibia, forearm bones
- **Three anatomic regions in long bones**

❖ **Diaphysis**

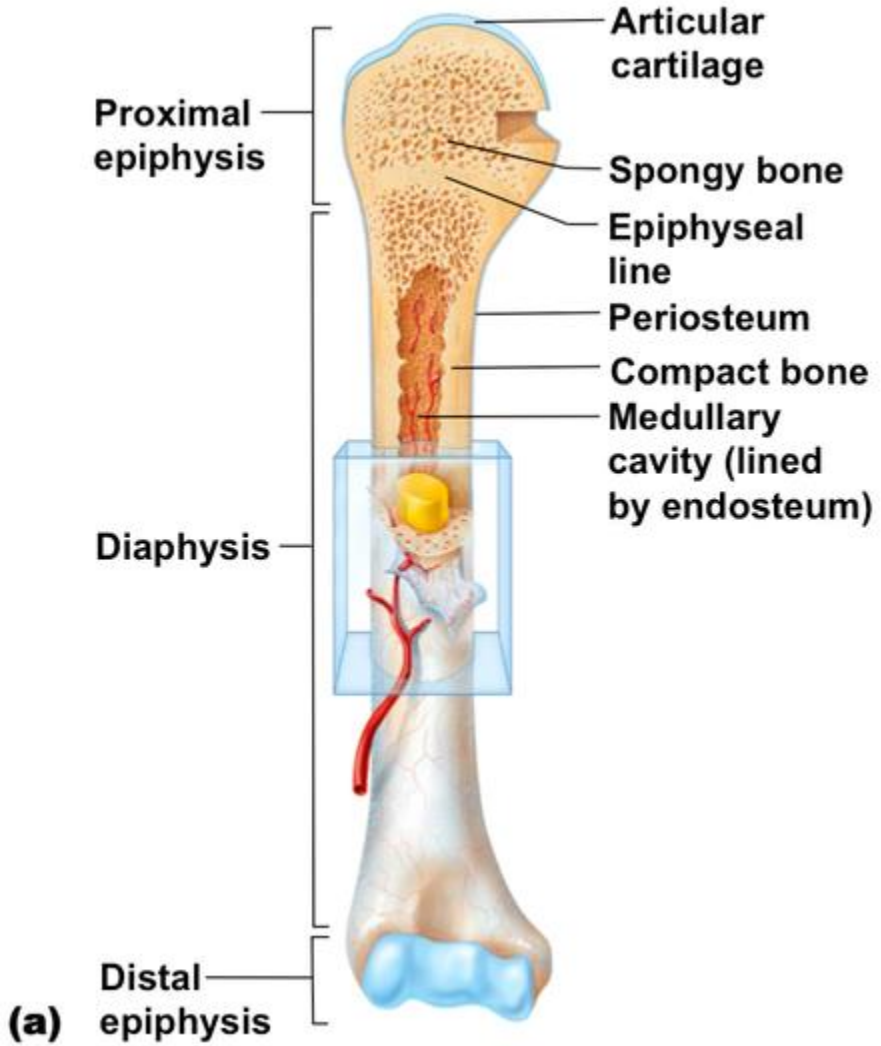
- Thick cortical bone surrounding a central canal of cancellous bone
- Outer region covered by periosteum

❖ Metaphysis

- Thin cortical bone surrounding loose trabecular bone

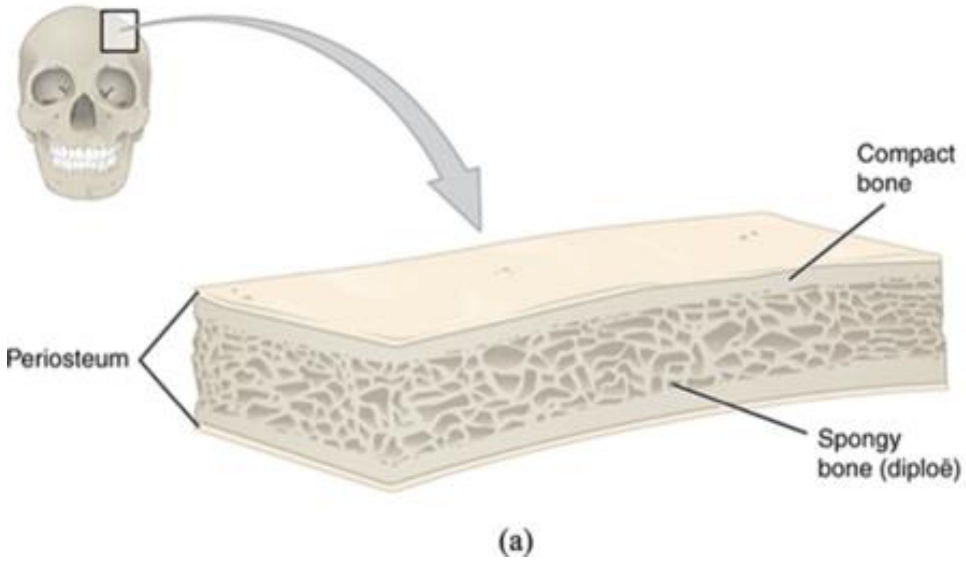
❖ **Epiphysis**

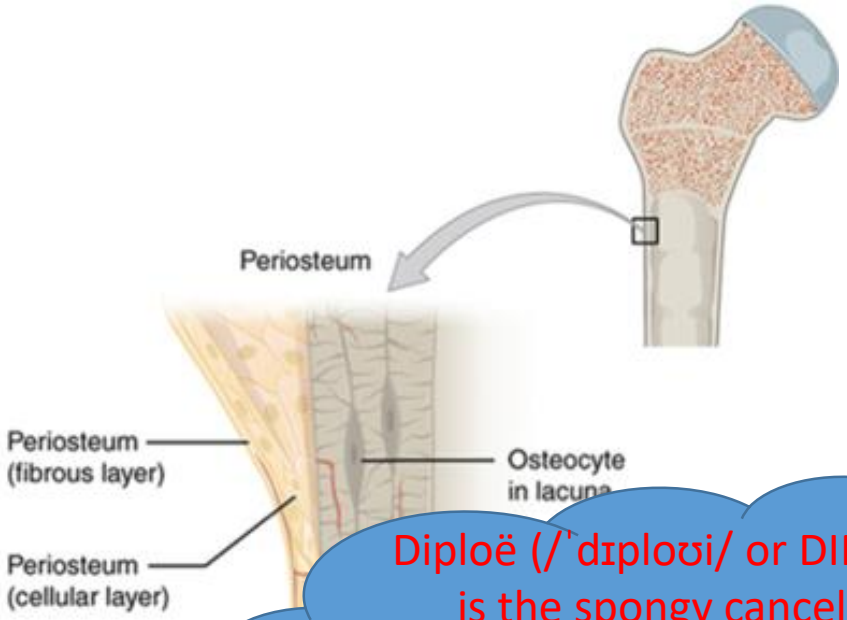
- End of bone that forms the articular surface



ANATOMICAL CLASSIFICATION

- Flat bones
- Examples: Skull, pelvis, scapula
- Varied structure of either purely cortical bone or cortical bone with a thin central trabecular region





Diploë (/ˈdɪploʊi/ or DIP-lo-ee) is the spongy cancellous bone **separating the inner and outer layers of the cortical bone of the skull**.

Classification of bone

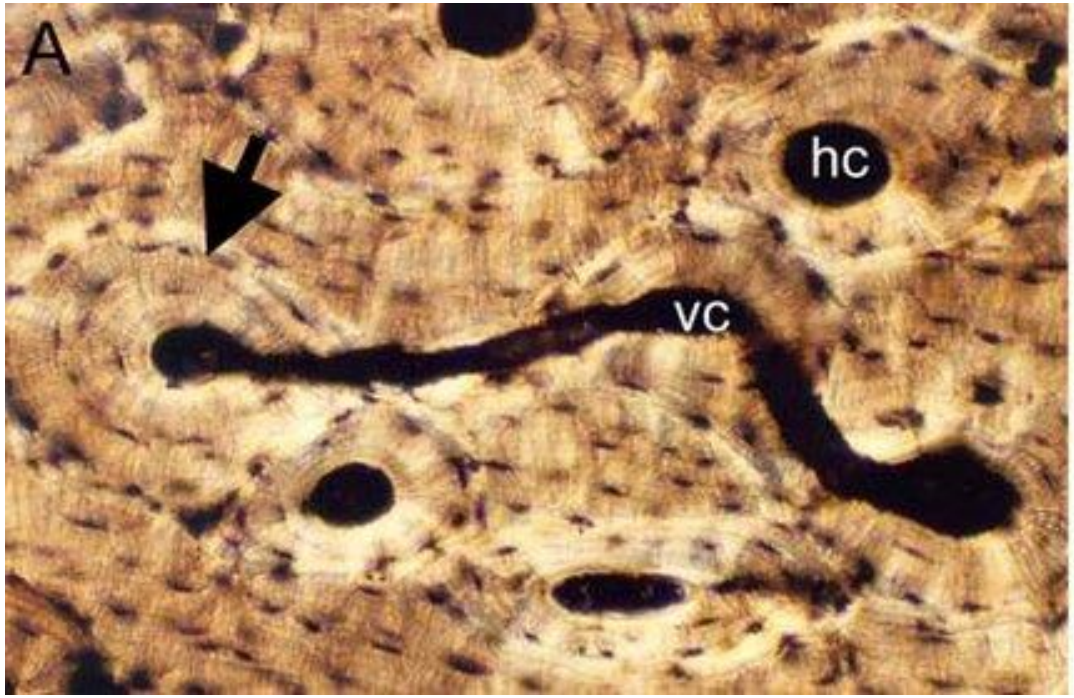
Microscopic observation of bone reveals two types

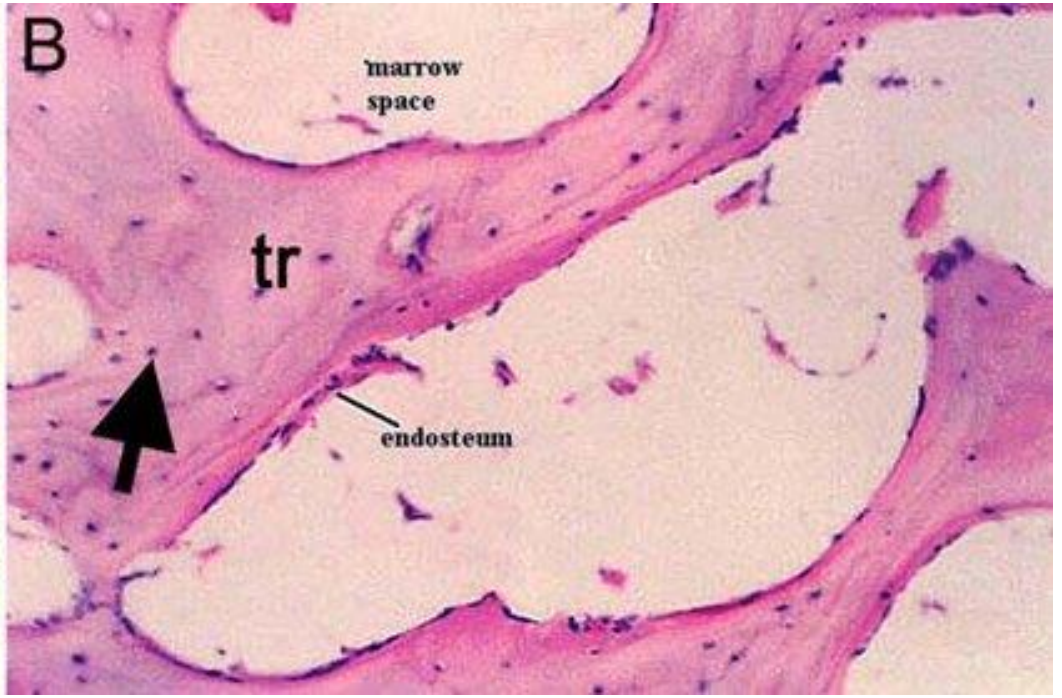
Primary bone (immature bone; woven bone)

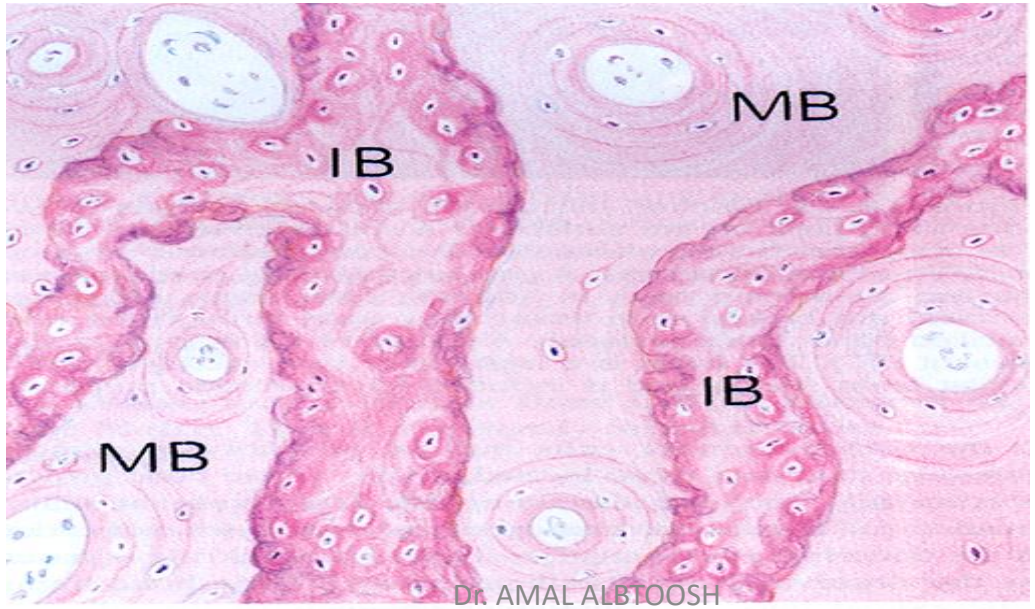
- Immature bone is a temporary type of bone found in developing bone, growing bone, remodeling and repairing bone.
- It is rapidly replaced by stronger mature bone.
- Immature bone has a number of names: primary, woven, immature.
- compared to lamellar bone, woven bone has more osteocytes per unit of volume
- Examples: Tooth sockets, near suture lines in skull bones, and at insertion sites of tendons

Secondary bone (mature or lamellar bone)

- Mature bone is the strong, highly organized type of bone found in bone.
- Its organization makes it very strong and perfect for resisting tensile (particularly torsion) forces and compressive forces.
- Mature bone also has a number of names: mature, secondary, lamellar.
- Example: cortical and cancellous bone


A
hc
vc


B
marrow space
tr
endosteum


MB
IB
IB
MB

Histogenesis of bone/ ossification

Histogenesis: **Origin of a tissue; formation and development of tissues of the body.**
So in bone it is: ossification

Medically speaking, ossify refers to **the process by which bone forms, or by which tissue (usually cartilage) changes into bone**.

occurs by two processes

✓ Both processes produce bone that appears histologically identical.

I. INTRAMEMBRANOUS

- ✓ Involves the replacement of sheet-like connective tissue membranes with bony tissue.
- ✓ Is the process by which most of the **flat bones** are formed.

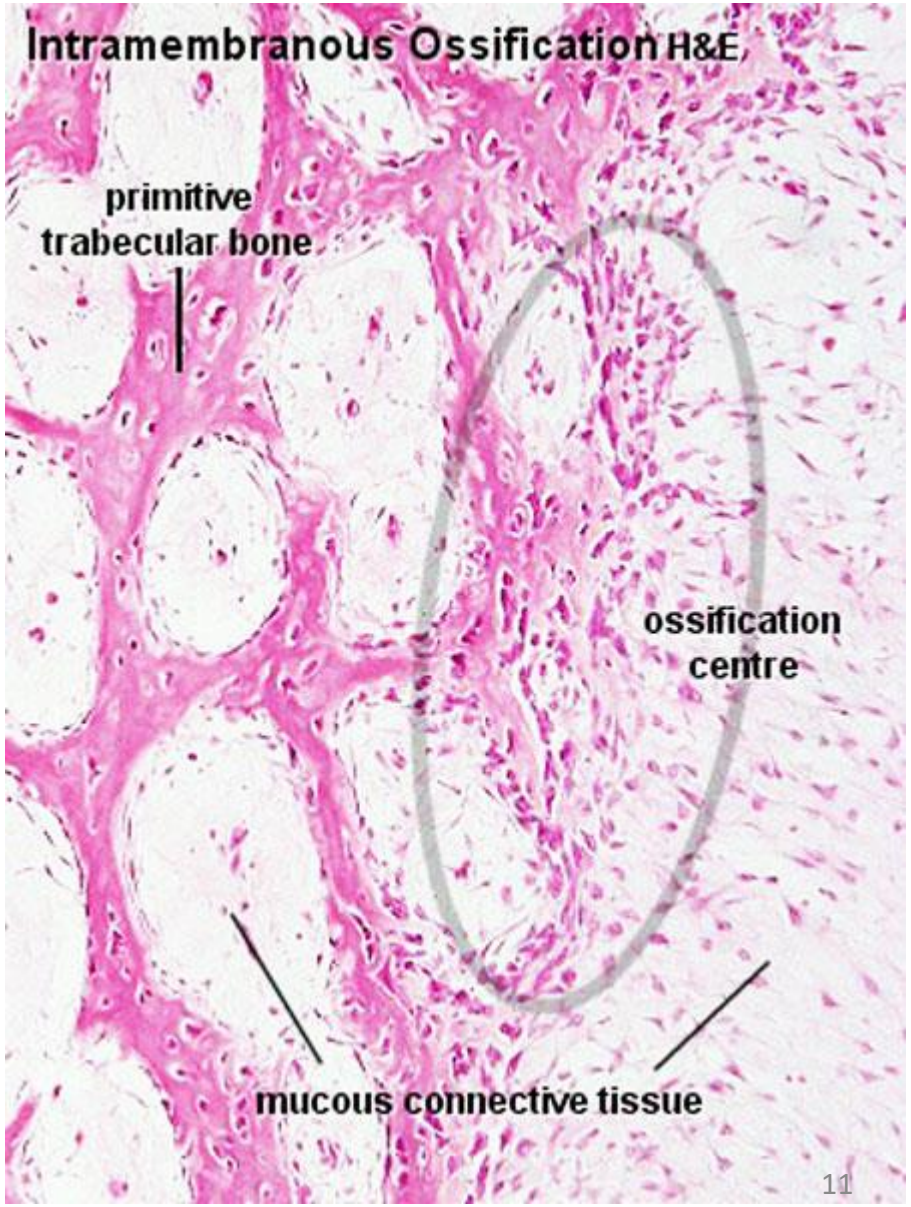
II. ENDOCHONDRAL

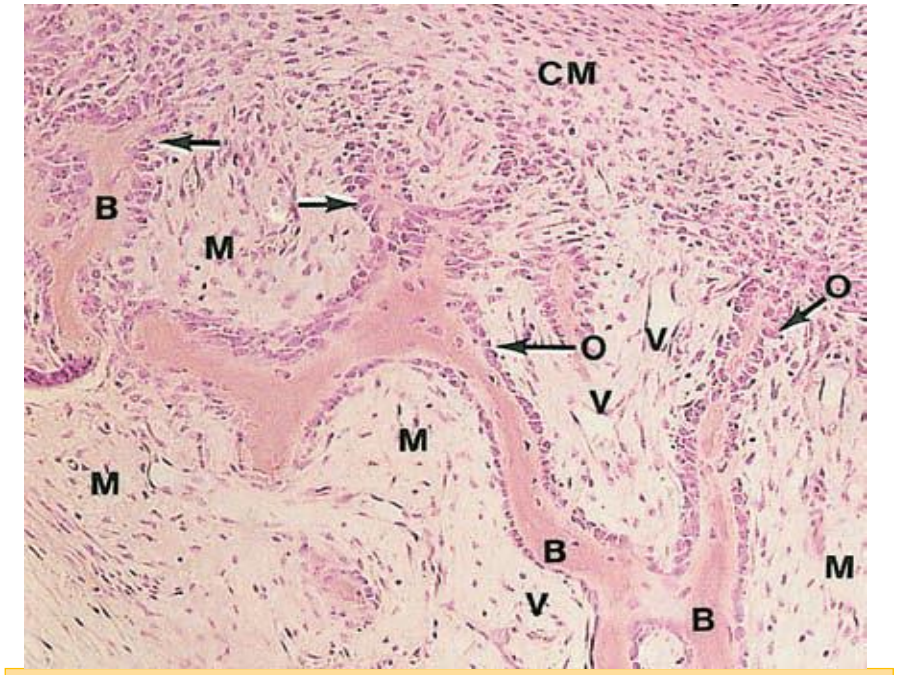
- ✓ Involves the replacement of **hyaline cartilage** with bony tissue.
- ✓ Most of the bones of the skeleton are formed in this manner.

Histogenesis of bone/ ossification

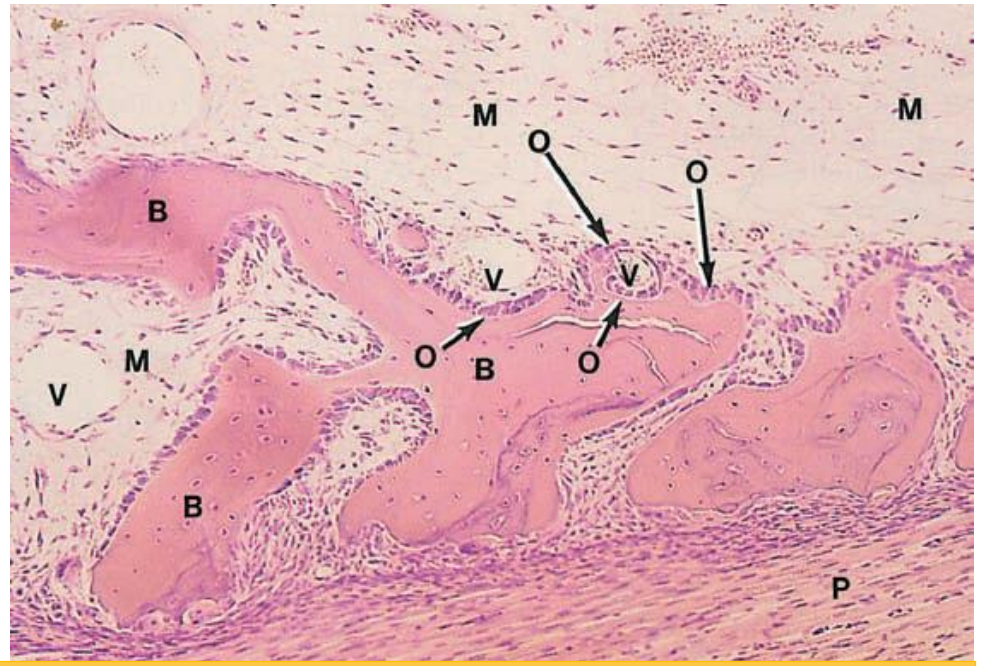
I. INTRAMEMBRANOUS

- ✓ involves the replacement of sheet-like connective tissue membranes with bony tissue.
- ✓ They include certain flat bones of the skull and some of the irregular bones. [clavicle?!]
- ✓ Osteoblasts migrate to the membranes and deposit bony matrix around themselves.
- ✓ When the osteoblasts are surrounded by matrix they are called osteocytes.





- Areas of typical mesenchyme (M) and condensed mesenchyme (CM) are adjacent to layers of new osteoblasts (O).
- Some osteoblasts have secreted matrices of bone (B), the surfaces of which remain covered by steoblasts.
- Between these trabeculae of new woven bone are areas with small blood vessels (V).
- X40. H&E.



- At higher magnification another section shows these same structures.
- The developing periosteum (P) adjacent to masses of woven bone that will soon merge to form a continuous plate of bone.
- The larger mesenchyme-filled region

at the top is part of the developing marrow cavity.

- Osteocytes in lacunae can be seen within the eosinophilic bony matrix.

- X100. H&E.

Histogenesis of bone/ ossification

II. ENDOCHONDRAL

- ✓ Endochondral ossification involves the replacement of hyaline cartilage skeleton model with bony tissue.
- ✓ Most of the bones of the skeleton are formed in this manner → These bones are called endochondral bones.
- ✓ During the third month after conception, the perichondrium that surrounds the hyaline cartilage "models" becomes infiltrated with blood vessels and osteoblasts and changes into a periosteum.
- ✓ The osteoblasts form a collar of compact bone around the diaphysis.
- ✓ At the same time, the cartilage in the center of the diaphysis begins to disintegrate.
- ✓ Osteoblasts penetrate the disintegrating cartilage and replace it with spongy bone. This forms a primary ossification center.
- ✓ Ossification continues from this center toward the ends of the bones.
- ✓ After spongy bone is formed in the diaphysis, osteoclasts break down the newly formed bone to open up the medullary cavity.

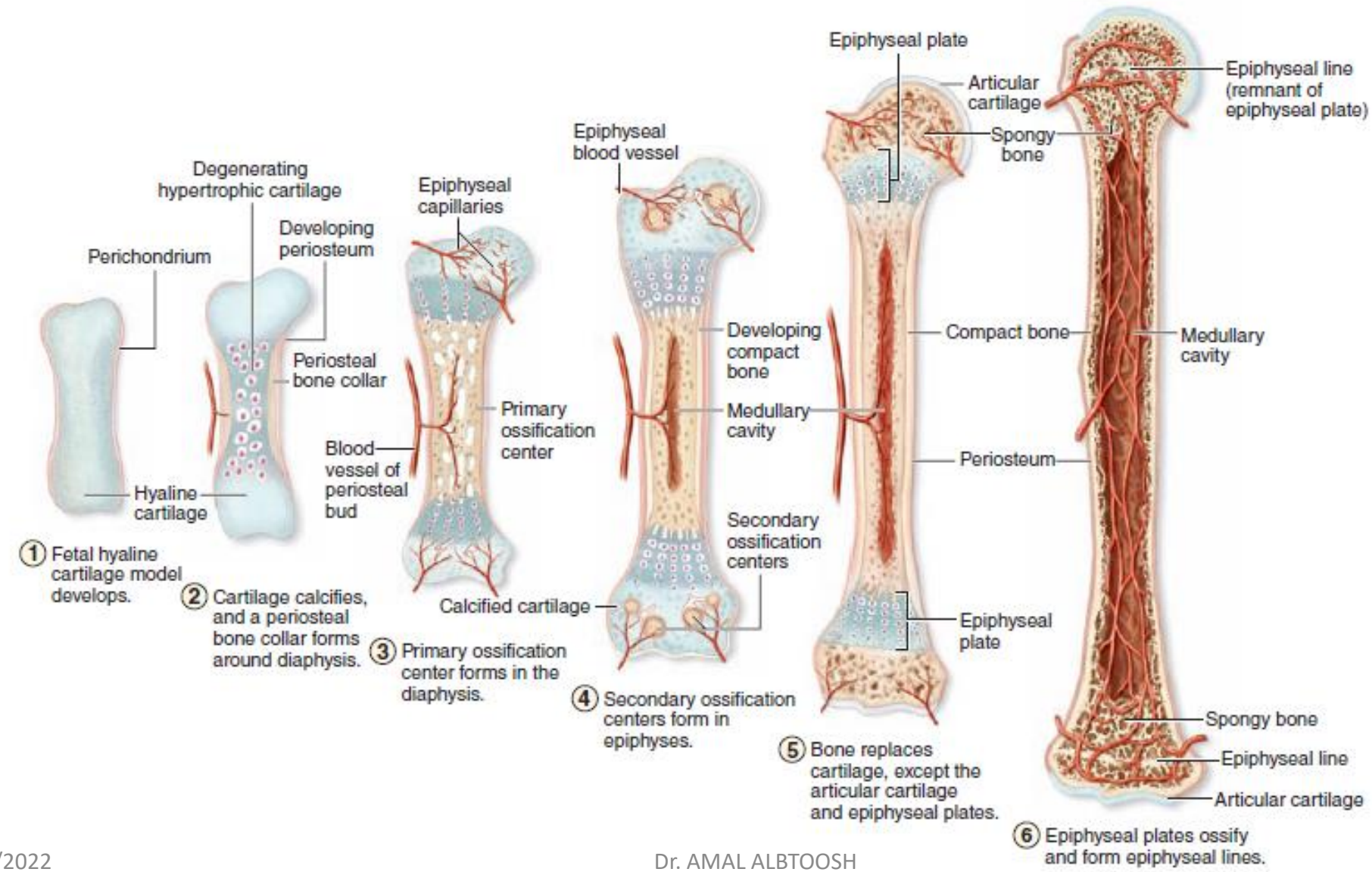
Histogenesis of bone/ ossification

II. ENDOCHONDRAL

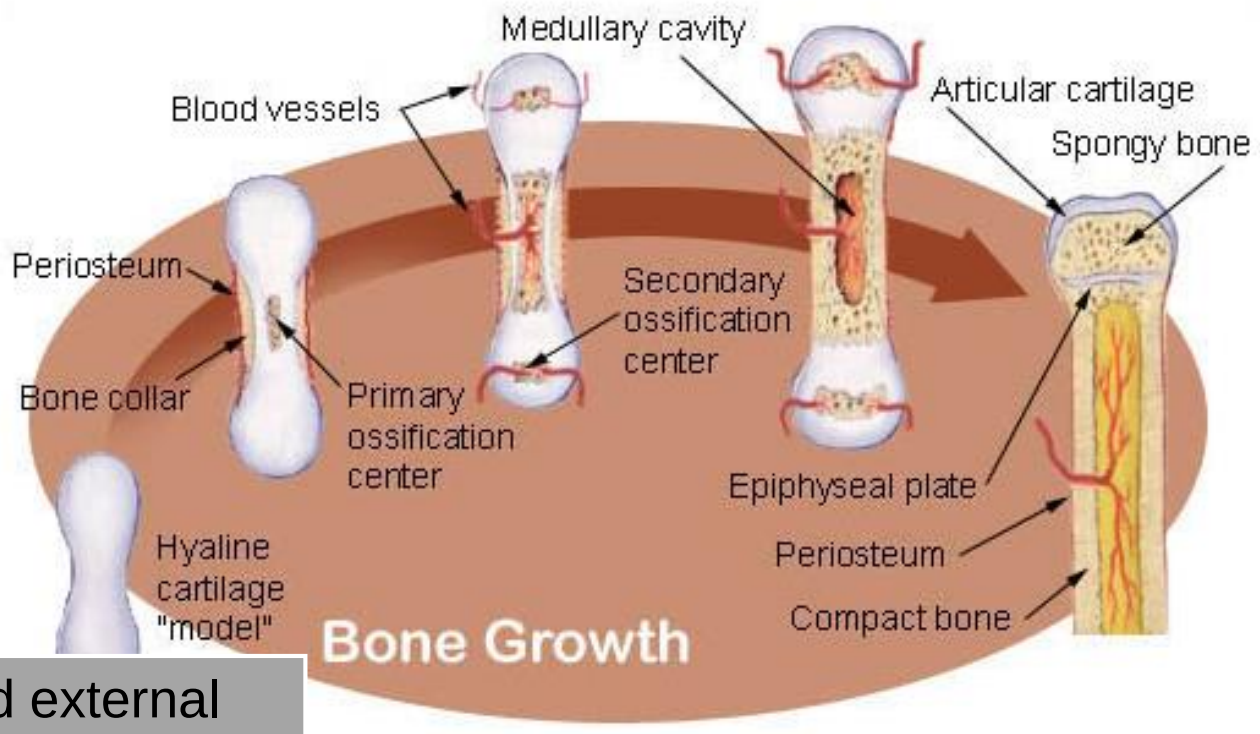
- ✓ The cartilage in the epiphyses continues to grow so the developing bone increases in length.
- ✓ Later, usually after birth, secondary ossification centers form in the epiphyses.
- ✓ Ossification in the epiphyses is similar to that in the diaphysis except that the spongy bone is retained instead of being broken down to form a medullary cavity.
- ✓ When secondary ossification is complete, the hyaline cartilage is totally replaced by bone except in two areas.
- ✓ The two areas:

1) A region of hyaline cartilage remains over the surface of the epiphysis as the articular cartilages
2) Another area of cartilage remains between the epiphysis and diaphysis. This is the epiphyseal plate or growth region..

FIGURE 8–14 Osteogenesis of long bones by endochondral ossification.

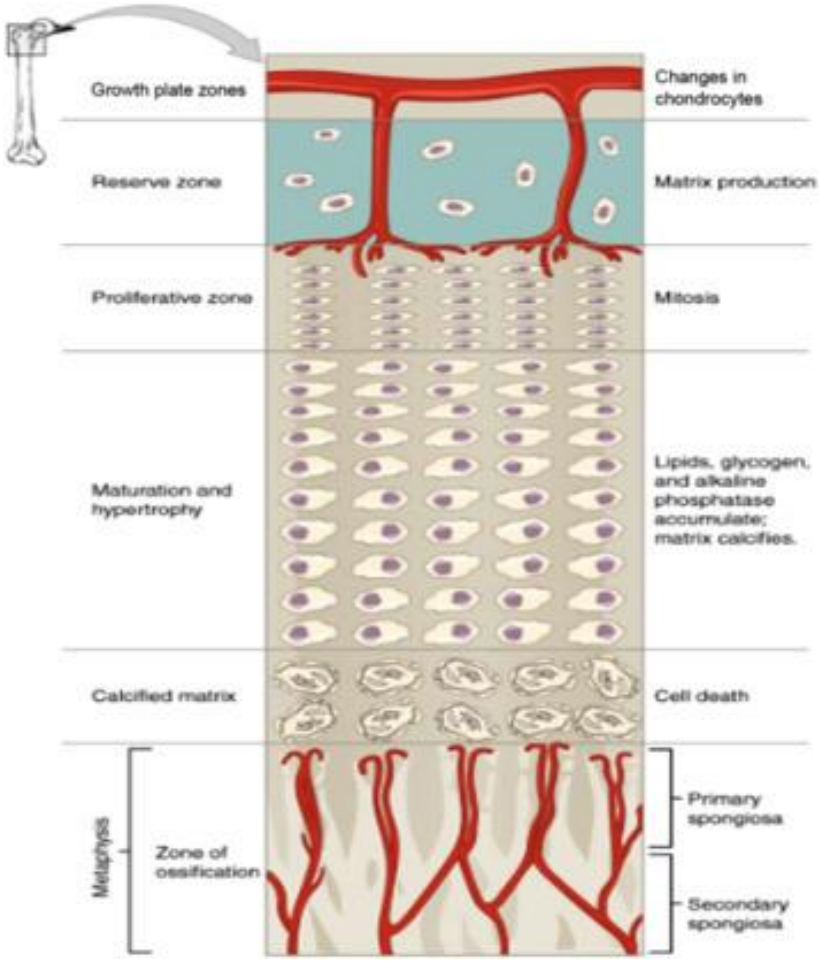


BONE GROWTH



- Bone grows in width at its internal and external surfaces, and in length at its epiphyses.
- Growth which involves the deposition of bone at the bone surface by cells in the endosteum and periosteum is known as appositional growth while growth at the epiphyseal growth plate is endochondral ossification.

Zones of the epiphyseal plates



❖ Are histologically distinctive and arranged in the following order:

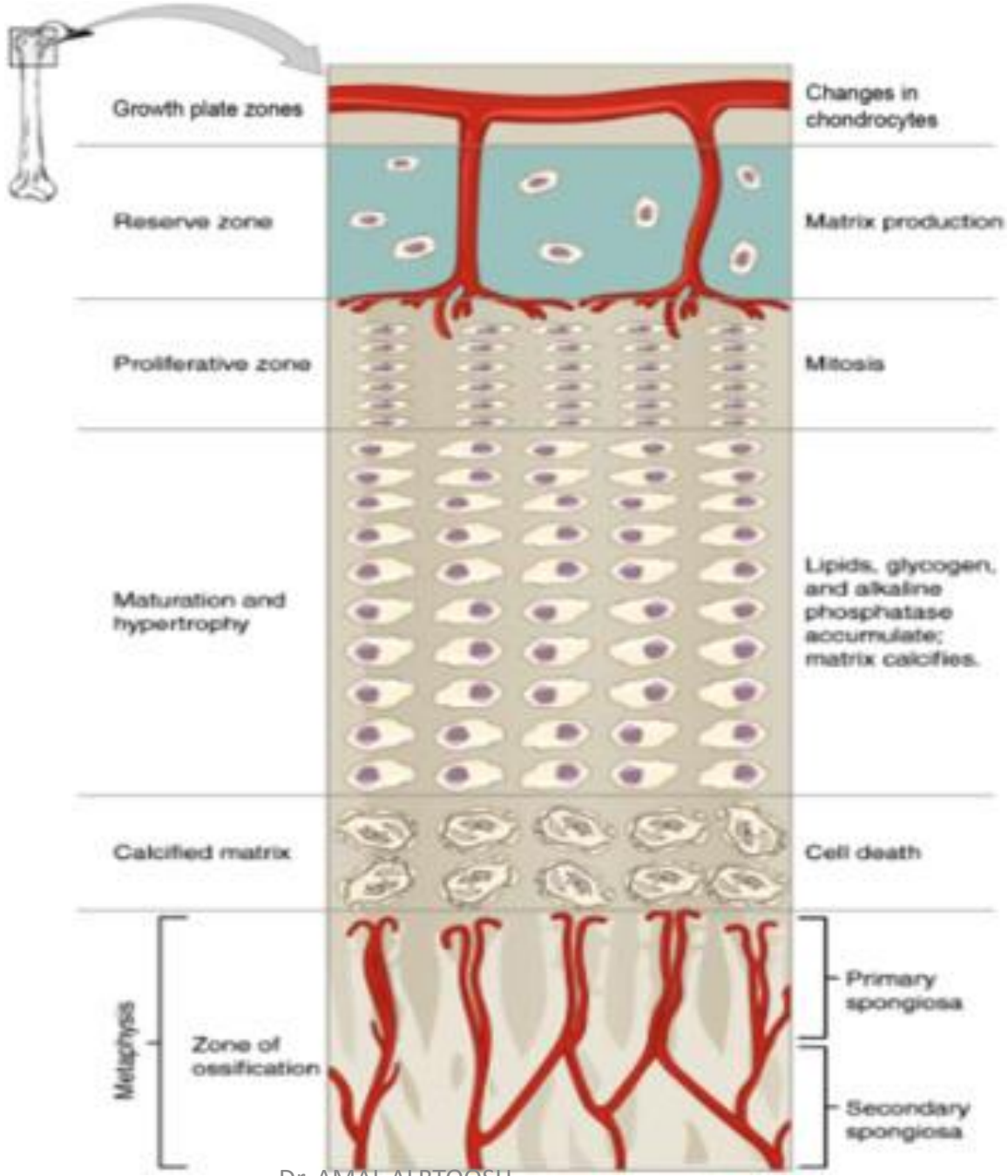
a. The **zone of reserve/ resting** cartilage is at the epiphyseal side of the plate. It possesses small, randomly arranged inactive chondrocytes.

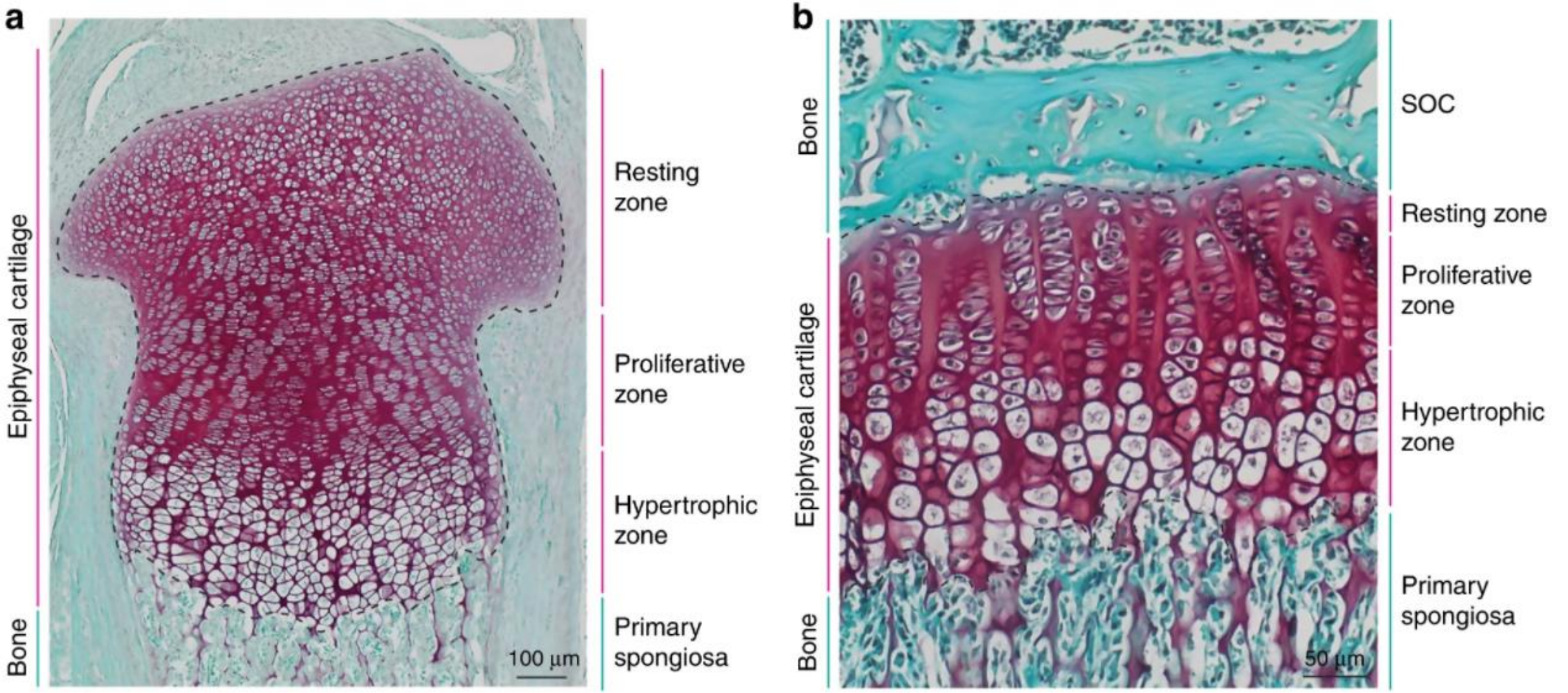
b. The **zone of proliferation** (of chondrocytes) is a region of rapid mitotic divisions giving rise to rows of isogenous cell groups.

c. The **zone of cell hypertrophy and maturation** is the region where the chondrocytes are greatly enlarged.

d. The **zone of calcification** is the region where hypertrophied chondrocytes die and the cartilage becomes calcified.

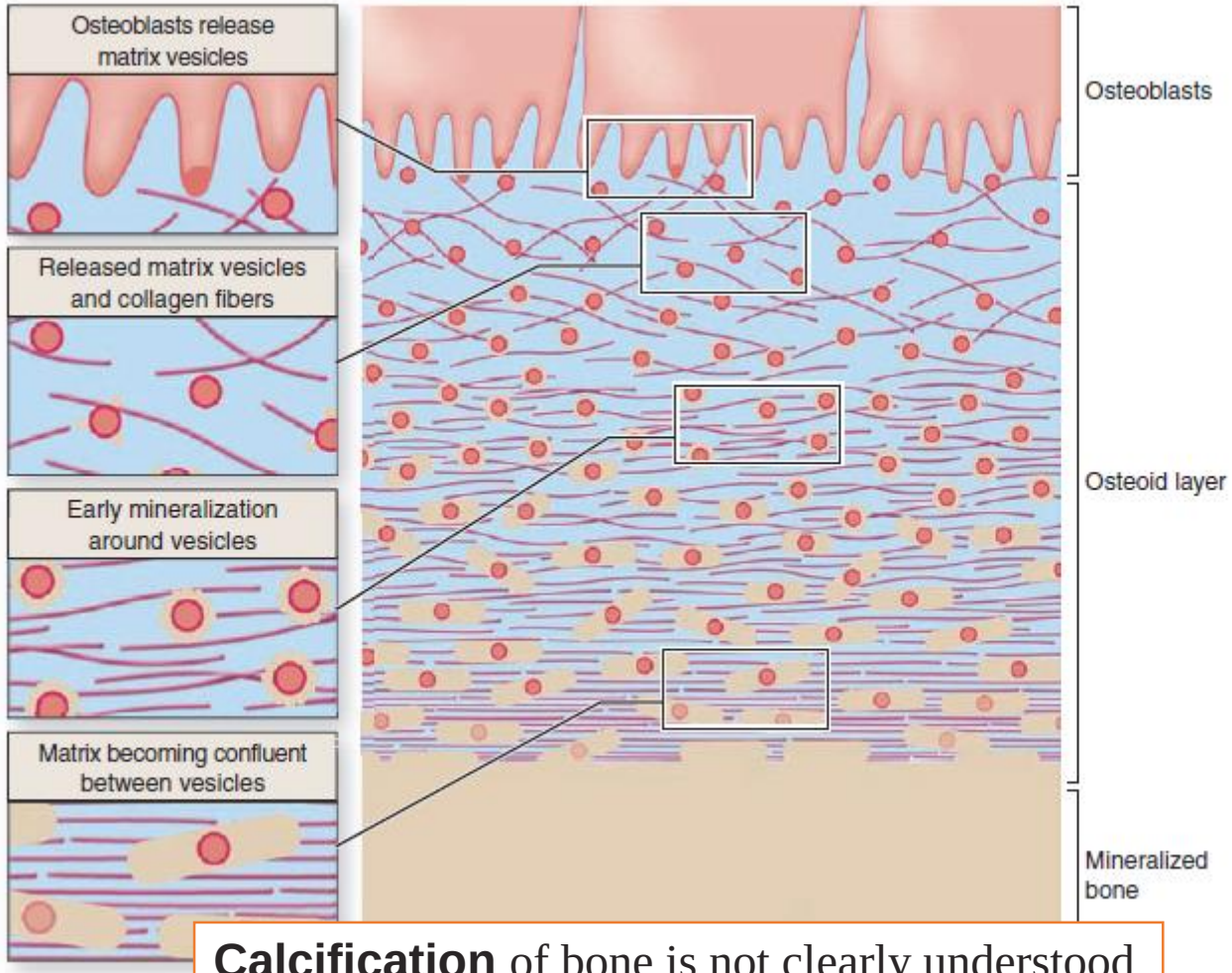
e. The **zone of ossification** is the area where newly formed osteoblasts elaborate bone matrix on the calcified cartilage, forming a calcified cartilage-calcified bone complex, which is resorbed and replaced by bone.


Growth plate zones
Changes in chondrocytes
Reserve zone
Matrix production
Proliferative zone
Mitosis
Maturation and hypertrophy
Lipids, glycogen, and alkaline phosphatase accumulate; matrix calcifies.
Calcified matrix
Cell death
Metaphysis
Zone of ossification
Primary spongiosa
Secondary spongiosa


a
Epiphyseal cartilage
Bone
Resting zone
Proliferative zone
Hypertrophic zone
Primary spongiosa
100 µm
b
Bone
Epiphyseal cartilage
Bone
SOC
Resting zone
Proliferative zone
Hypertrophic zone
Primary spongiosa
50 µm

OSTEOBLASTS

Osteoid is mineralized under the influence of an **osteoprotegerin (OPG), osteocalcin** (for bone mineralization), **osteopontin** formation of sealing zone between osteoclasts
and the subosteoclastic compartmen **osteonectin** (related to bone mineralization),
and **bone sialoprotein** (binding osteoblasts to ECM). They also poss PTH receptors on their cell membra



Calcification of bone is not clearly understood

BONE REMODELING

Bones are constantly remodeling due to stress or damage.

There are two main types of remodeling that take place:

- surface remodeling
- internal remodeling

Surface remodeling occurs when osteoblasts in the periosteum or endosteum are activated to commence appositional growth

Surface remodeling is usually balanced by osteoclast activity elsewhere in the bone, especially in adult who are no longer growing

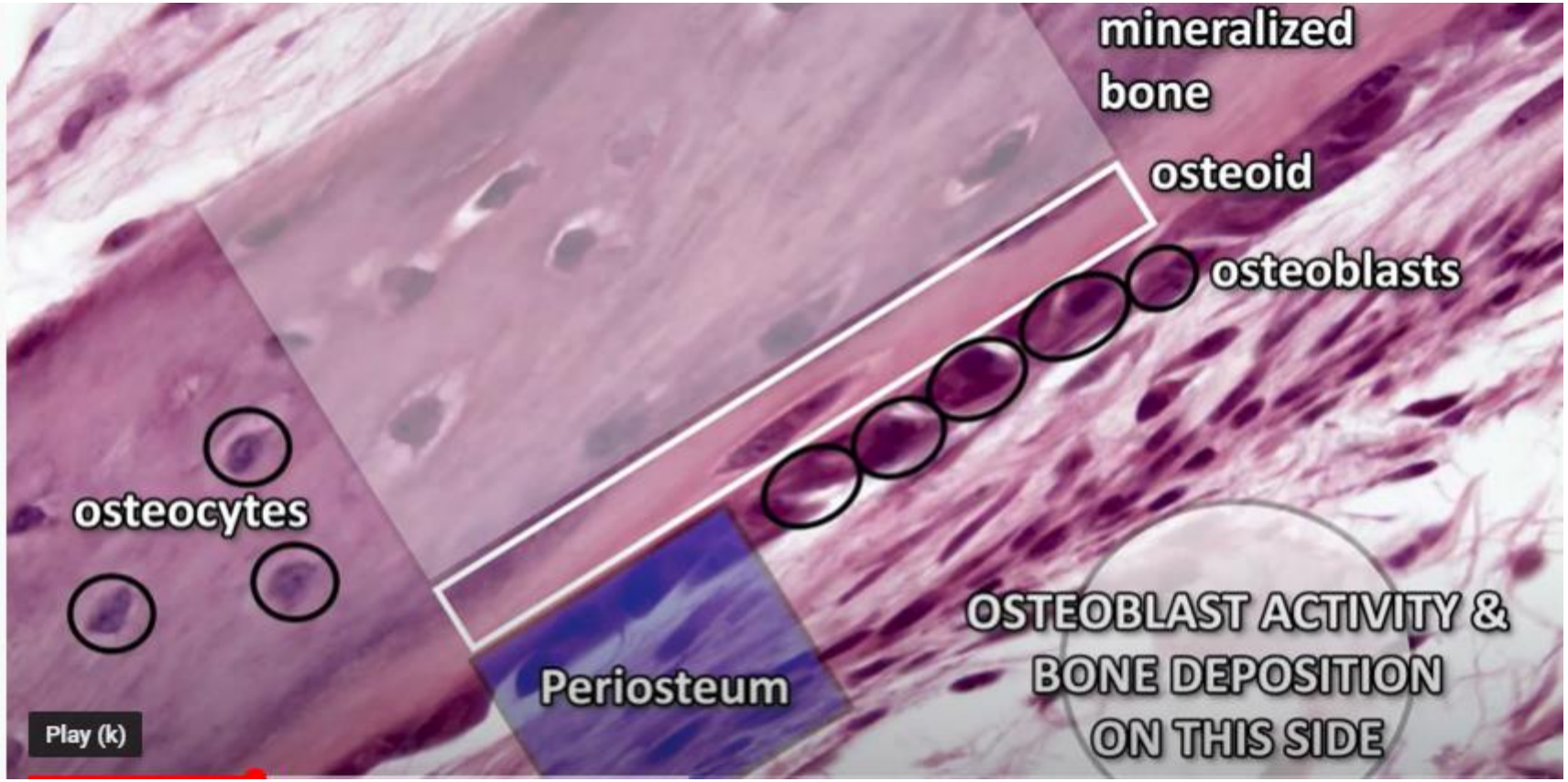
•Internal remodeling is the physical removal of mature bone by osteoclasts in a cutting cone and deposition of new bone in a wave called a closing cone to fill the hole.

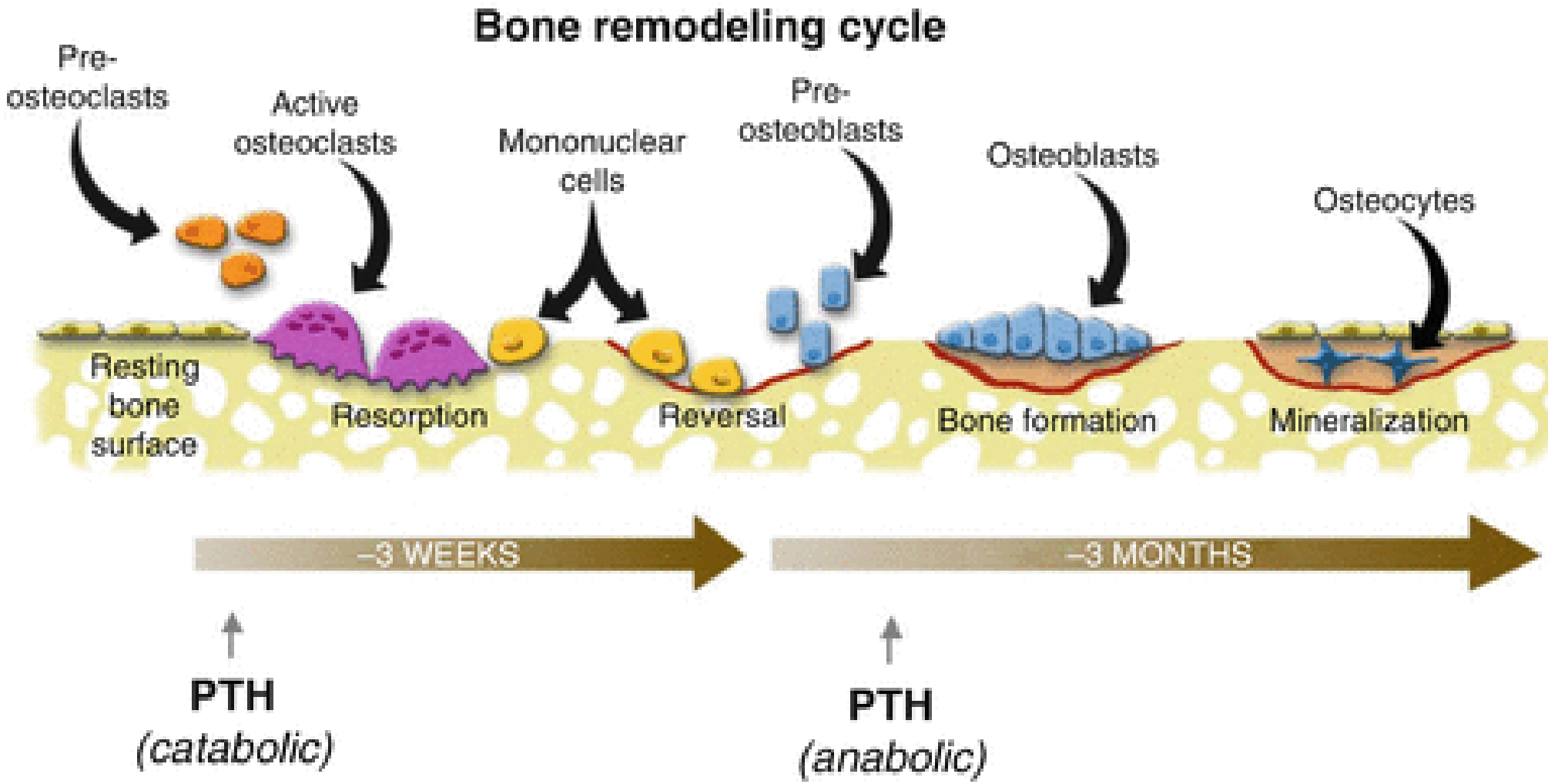
•Internal remodeling occurs in response to stresses placed on bone to ensure osteons are positioned to maximize resistance to these forces

•Osteoclasts are multinucleate cells derived from the monocyte lineage that resorb bone matrix

•The cells attach to bone and form a resorption bay by releasing H and Cl ions to digest inorganic matrix and cathepsin K and metalloproteinases to digest organic matrix

•The products of their digestion are resorbed and processed by the bod


mineralized
bone
osteoid
osteoblasts
osteocytes
Periosteum
OSTEOBLAST ACTIVITY &
BONE DEPOSITION
ON THIS SIDE
Play (k)


Bone remodeling cycle
Pre-
osteoclasts
Active
osteoclasts
Mononuclear
cells
Pre-
osteoblasts
Osteoblasts
Osteocytes
Resting
bone
surface
Resorption
Reversal
Bone formation
Mineralization
~3 WEEKS
~3 MONTHS
PTH
(catabolic)
PTH
(anabolic)

السير نحو النجاح
رحلة لا نهاية لها
توقف قليلاً عن
السير وراجع ما
قطعته في رحلتك
وصحح أخطائك
وطور مهاراتك
واشحذ همتك وانظر
للحياة بتفائل
وسعادة ثم أكمل المسير