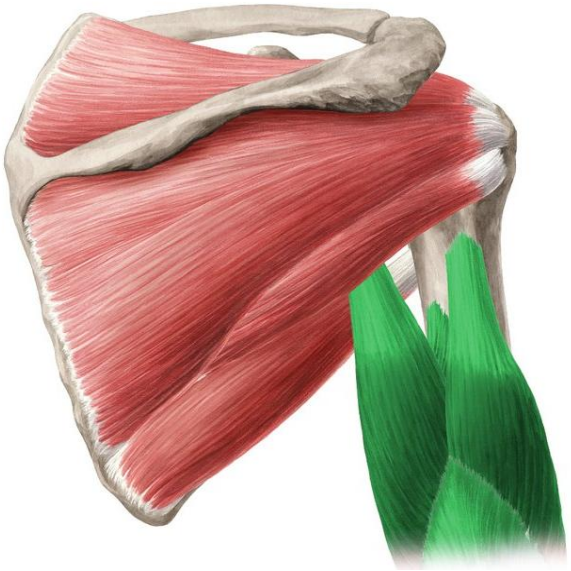
Bone Tissue

Dr. Heba Kalbouneh
Associate Professor of Anatomy and Histology



KEN HUB

Functions

- Support
- Protection (protect internal organs)
- Movement (provide leverage system for skeletal muscles, tendons, ligaments and joints)
- Mineral homeostasis (bones act as reserves of minerals important for the body like calcium or phosphorus)
- Hematopoiesis: blood cell formation
- Storage of adipose tissue: yellow marrow

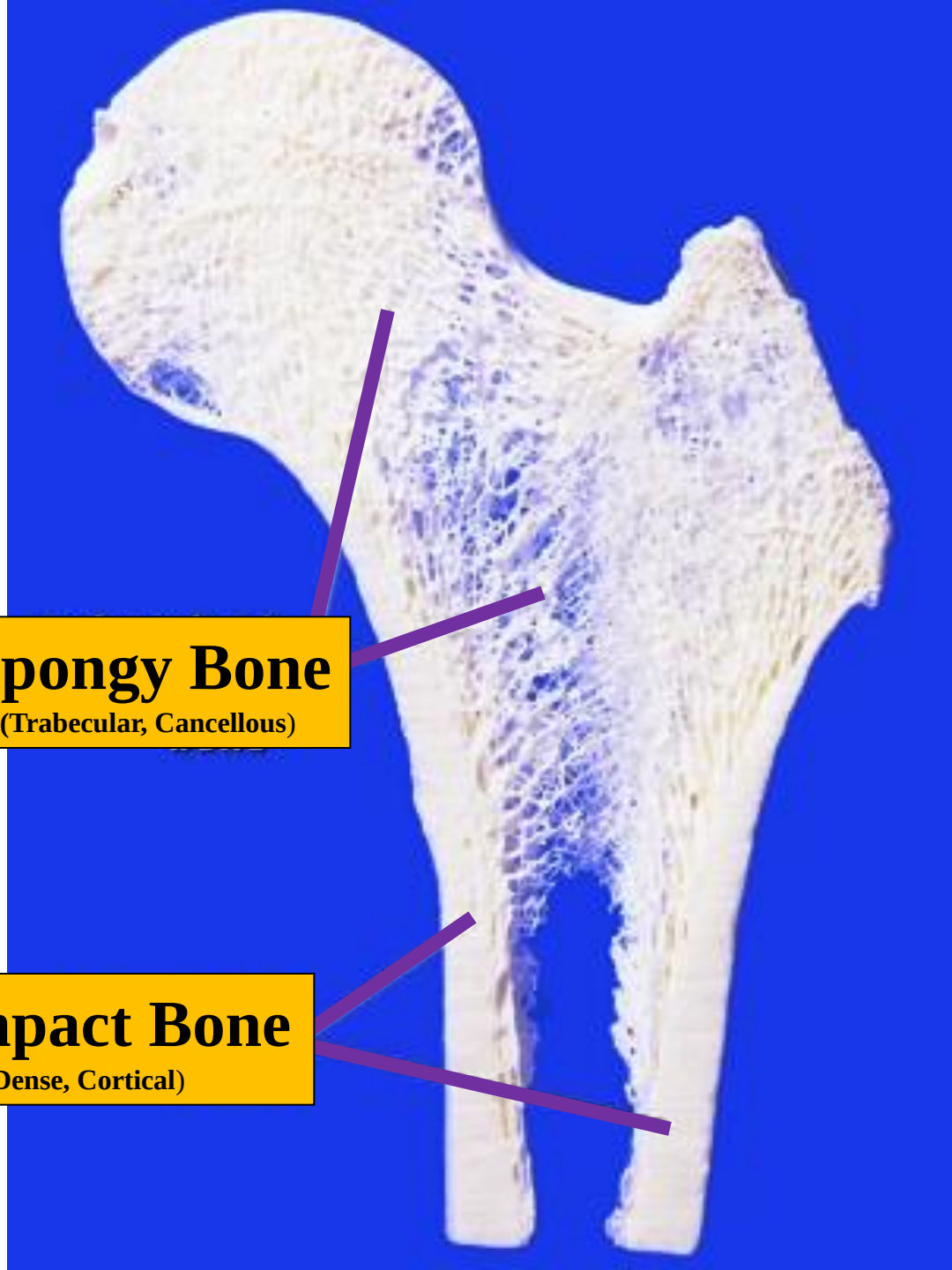
Dr. Heba Kalbouneh

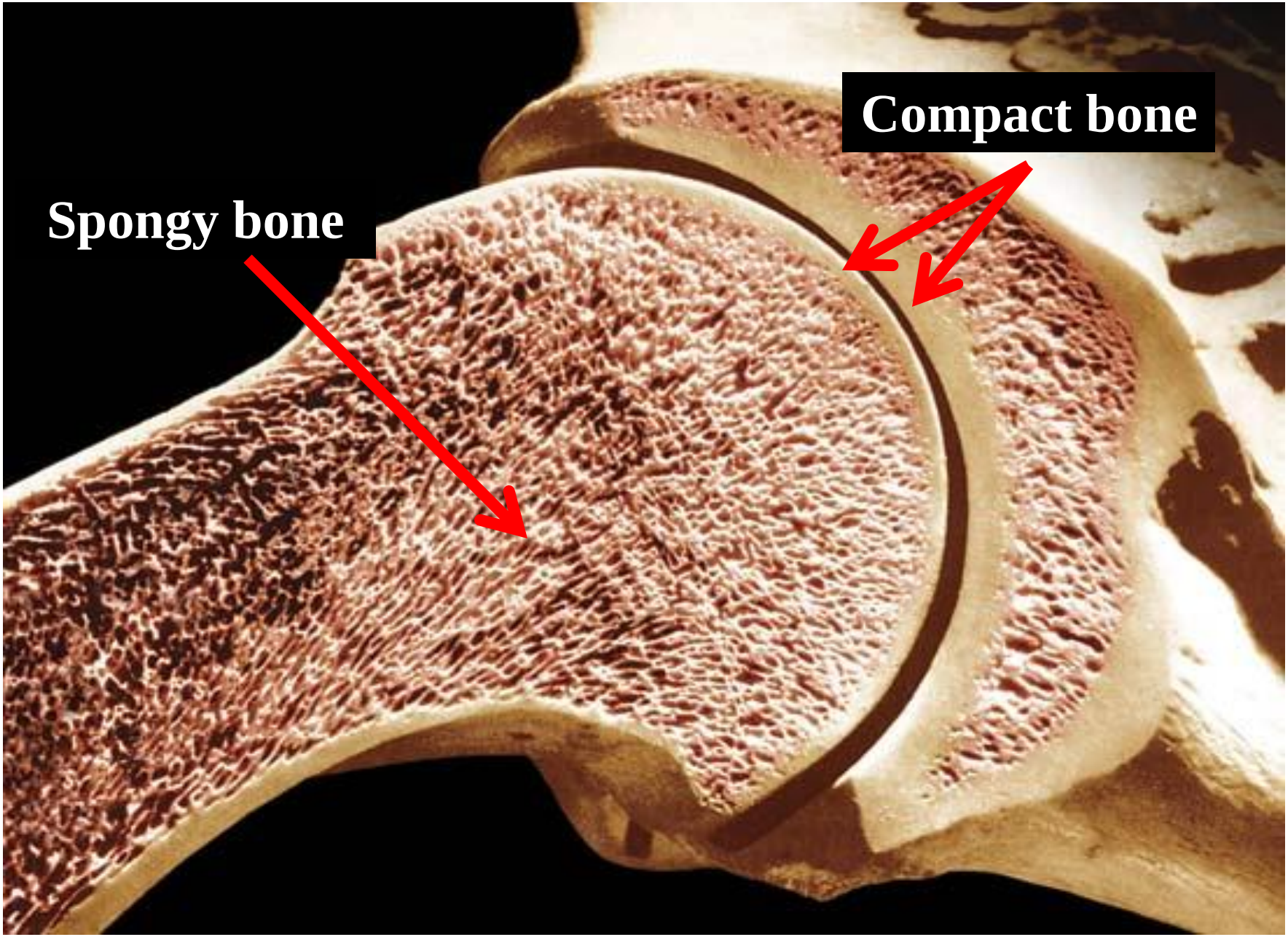
Types of Bones:

- **Gross observation**:

Compact (cortical) bone:
a dense area near the surface, which represents 80% of the total bone mass.

Cancellous (trabecular or spongy) bone:
deeper areas with numerous interconnecting cavities, consisting about 20 % of total bone mass.




Compact bone
Spongy bone

Types of Bone:

- Anatomical:
  - Long
  - Short
  - Flat
  - Irregular
  - Sesamoid

Long Bone

Sesamoid Bone

Flat Bone

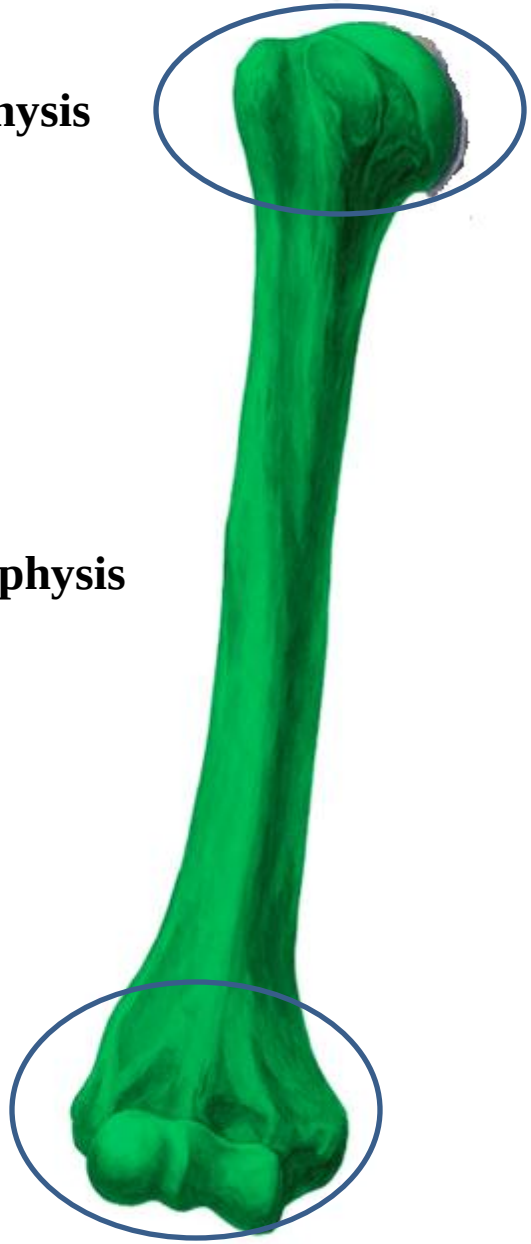
Irregular Bone

Short Bone

PRIMAL PICTURES

LONG BONES

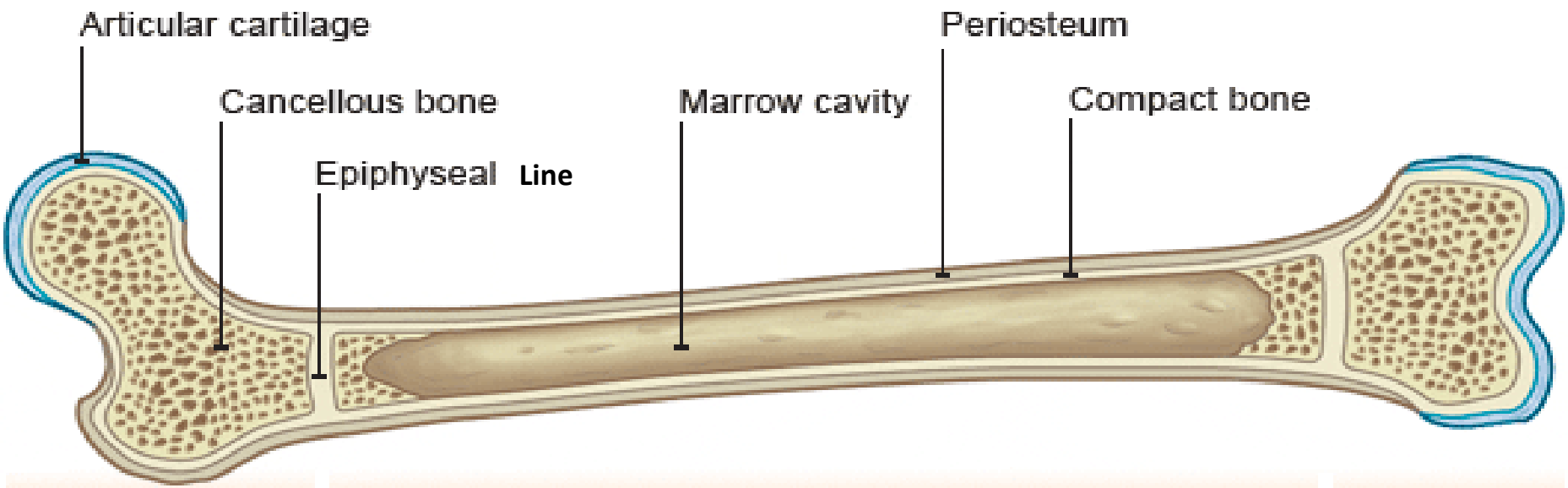
Head, Proximal end, Epiphysis



Shaft , Body, Diaphysis

Distal end, Epiphysis

LONG BONES



Epiphysis
Head

Diaphysis
Shaft

Epiphysis

Spongy Bone

Compact Bone

Spongy Bone

BONE ANATOMY

Diaphysis: long shaft of bone

Epiphysis: ends of bone

Metaphysis: b/w epiphysis and diaphysis

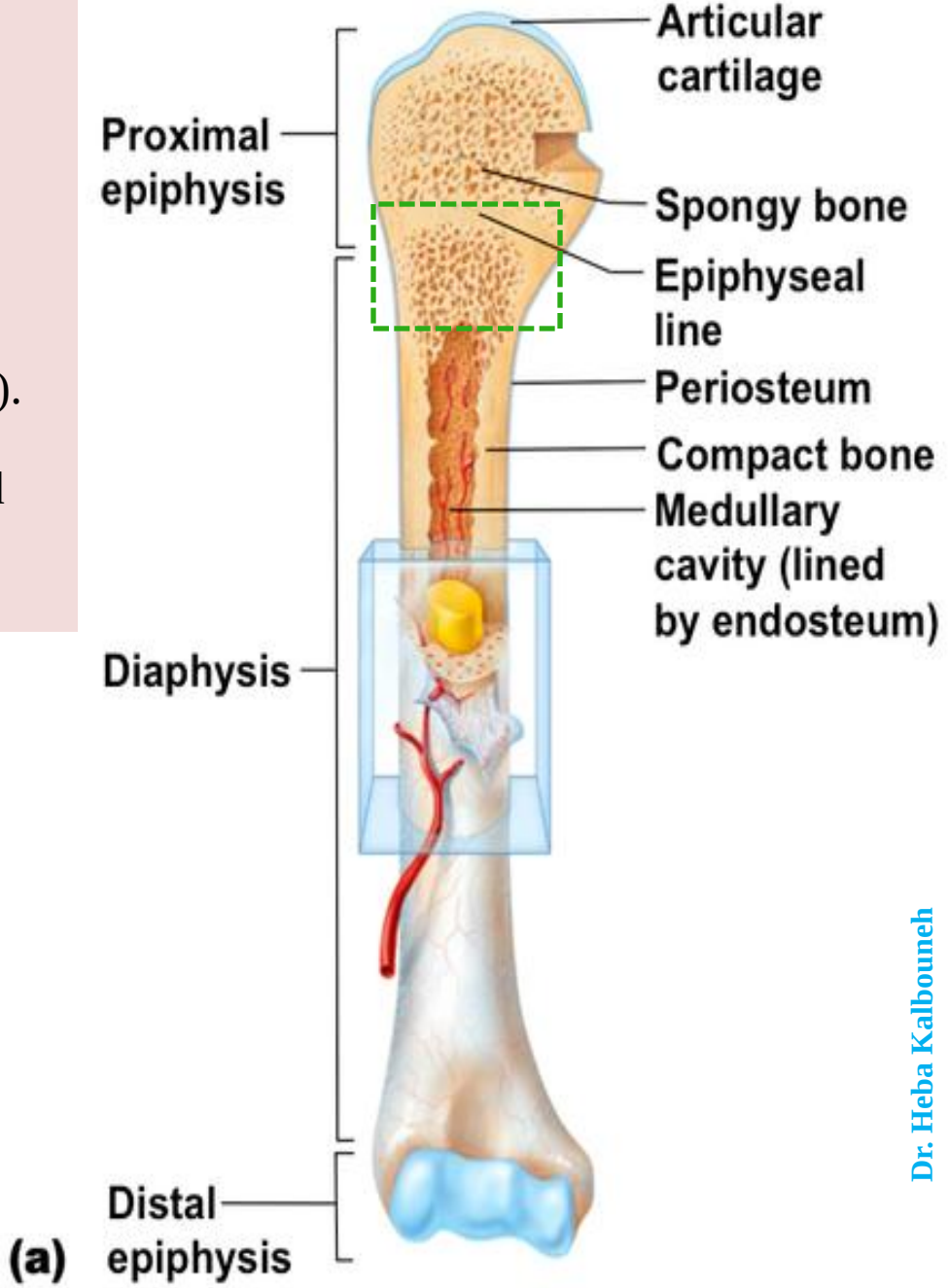
Epiphyseal (growth) plate (layer of hyaline cartilage that allows the bone to grow in length).

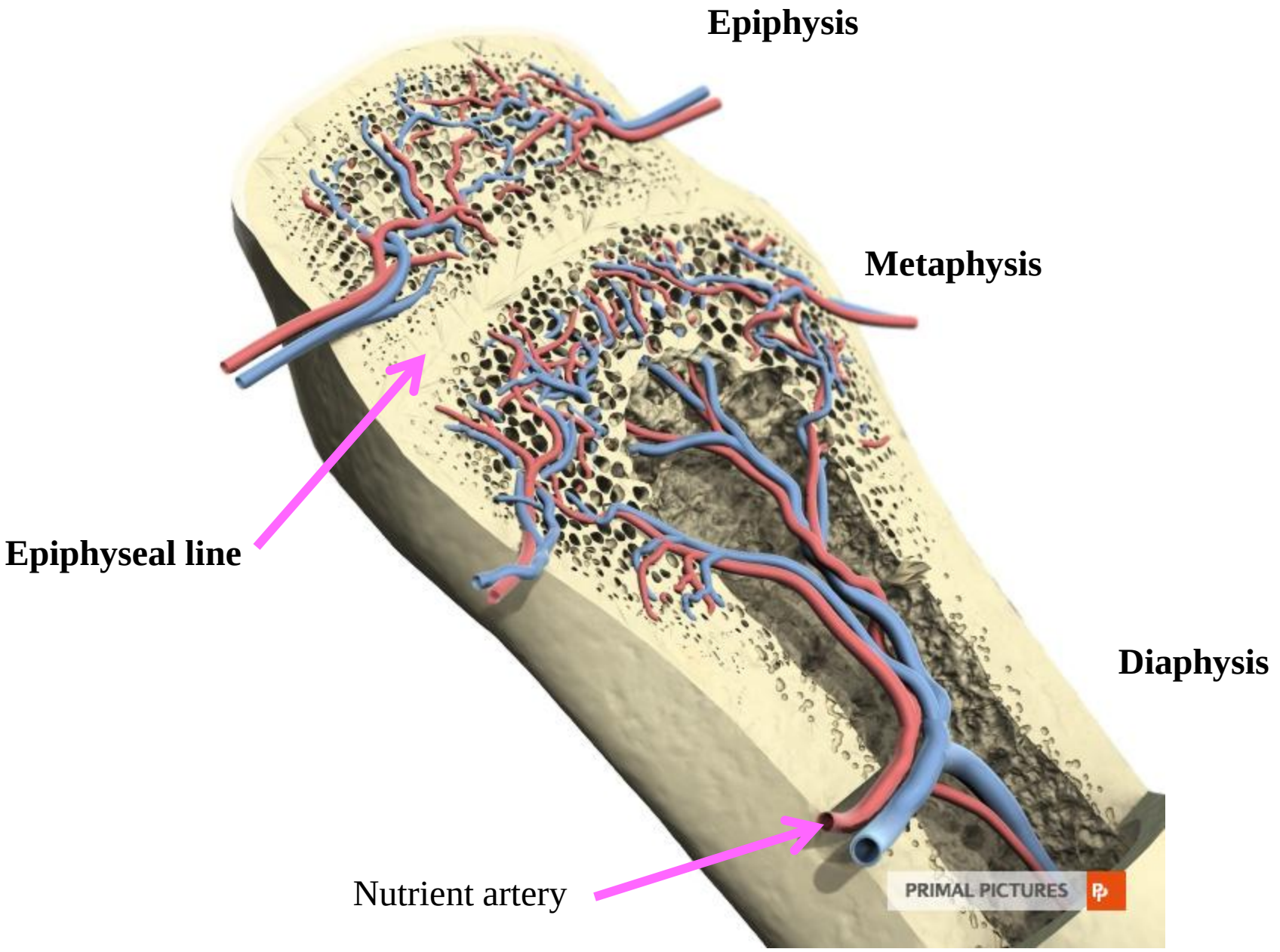
The cartilage in the epiphyseal plate is replaced by bone at the age of 18-21, and the resulting bony structure is called the **epiphyseal line**.

Articular cartilage: thin layer of hyaline cartilage covering the part of the epiphysis where the bone forms an articulation (joint).

Function:
reduces friction and absorbs shock.

Articular cartilage lacks a perichondrium and lacks blood vessels, repair of damage is limited



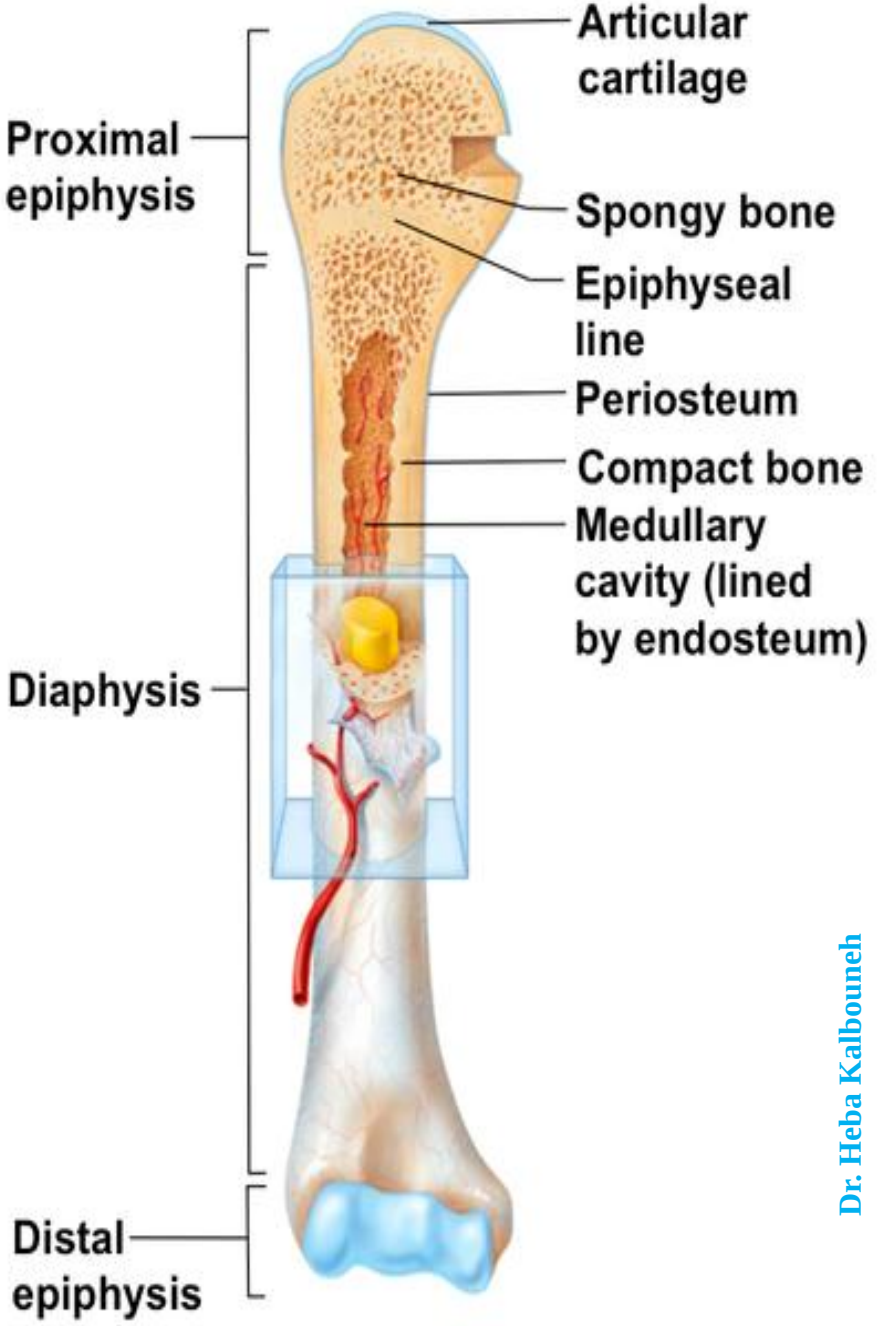


Periosteum: bone covering (pain sensitive)

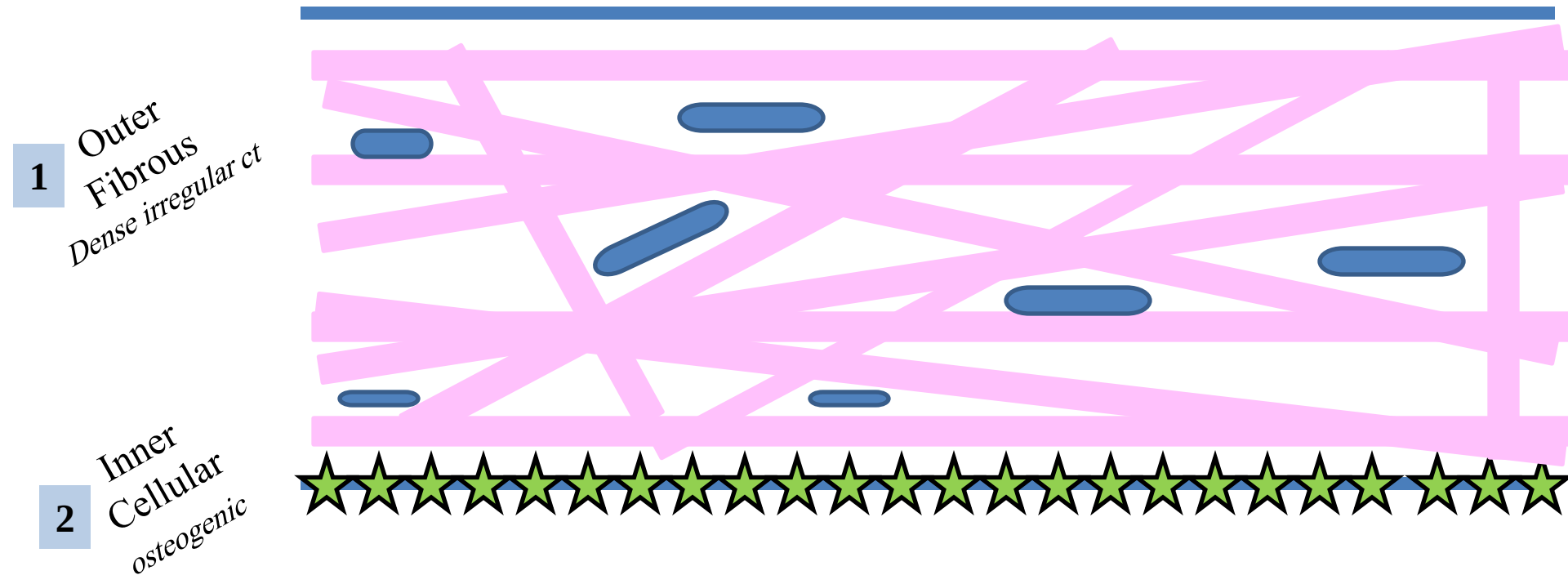
Sharpey's fibers: thick bundles of collagen that extend from the periosteum into the bone extracellular matrix

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

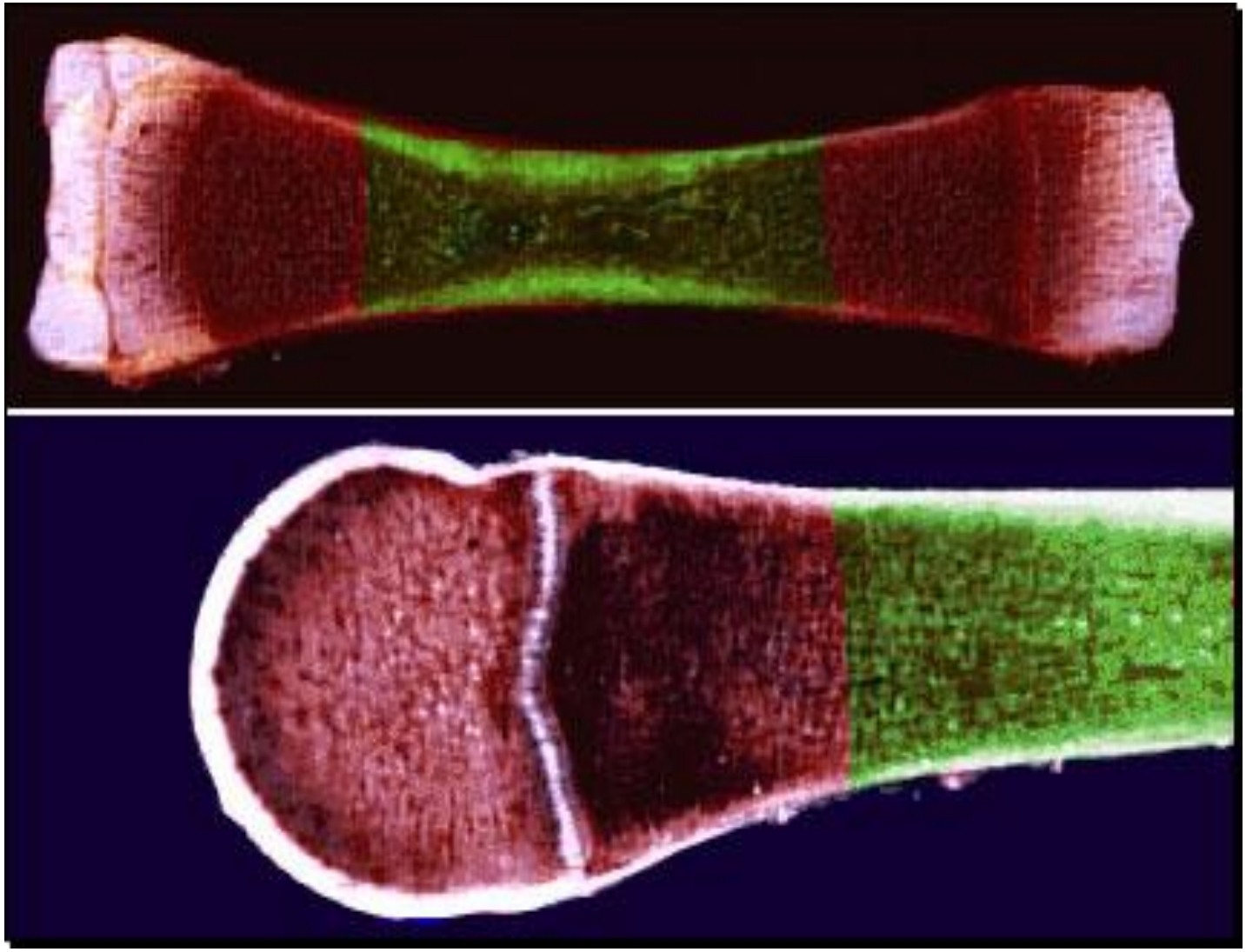
Endosteum: thin layer lining the medullary cavity



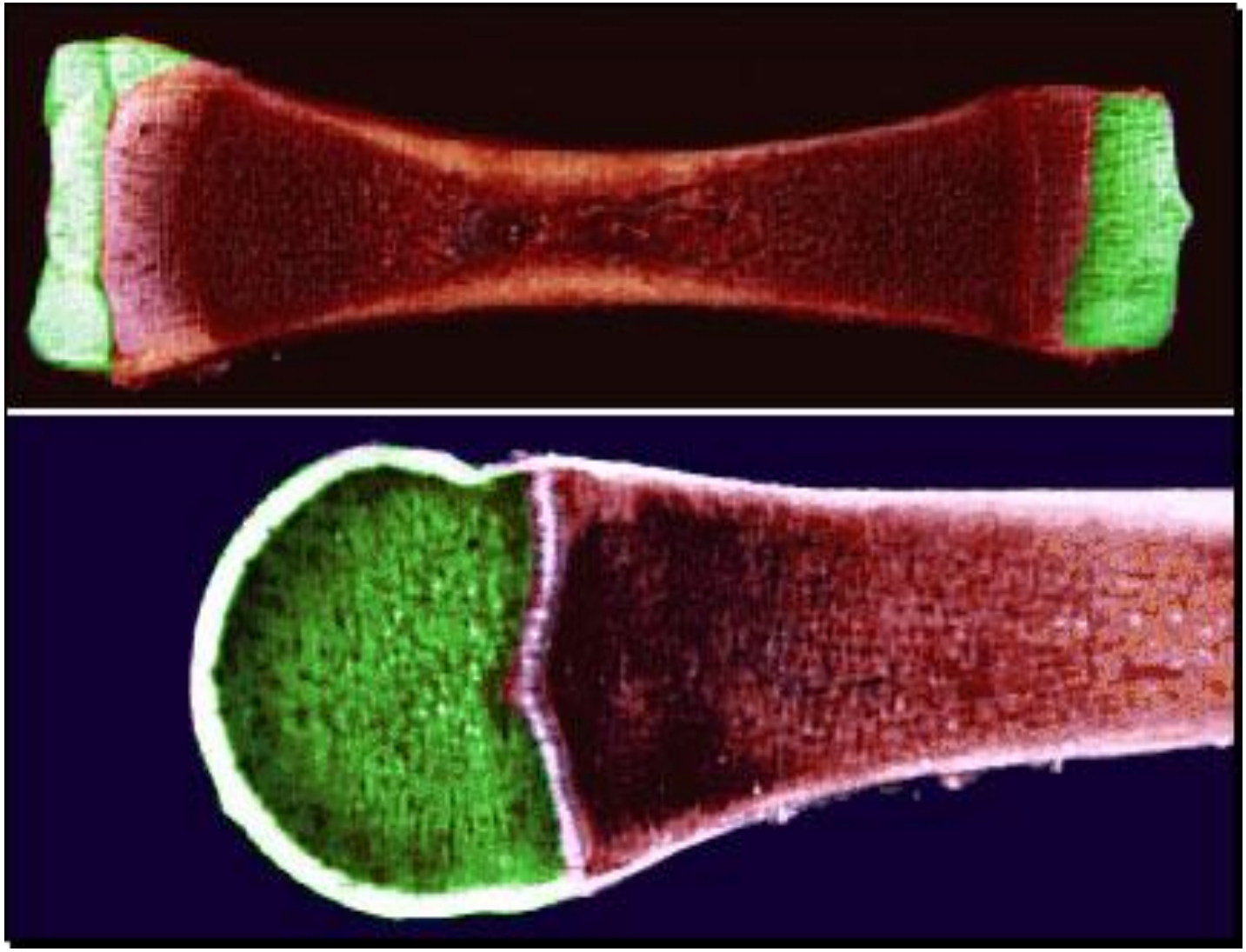
Periosteum


1
Outer
Fibrous
Dense irregular ct
2
Inner
Cellular
osteogenic

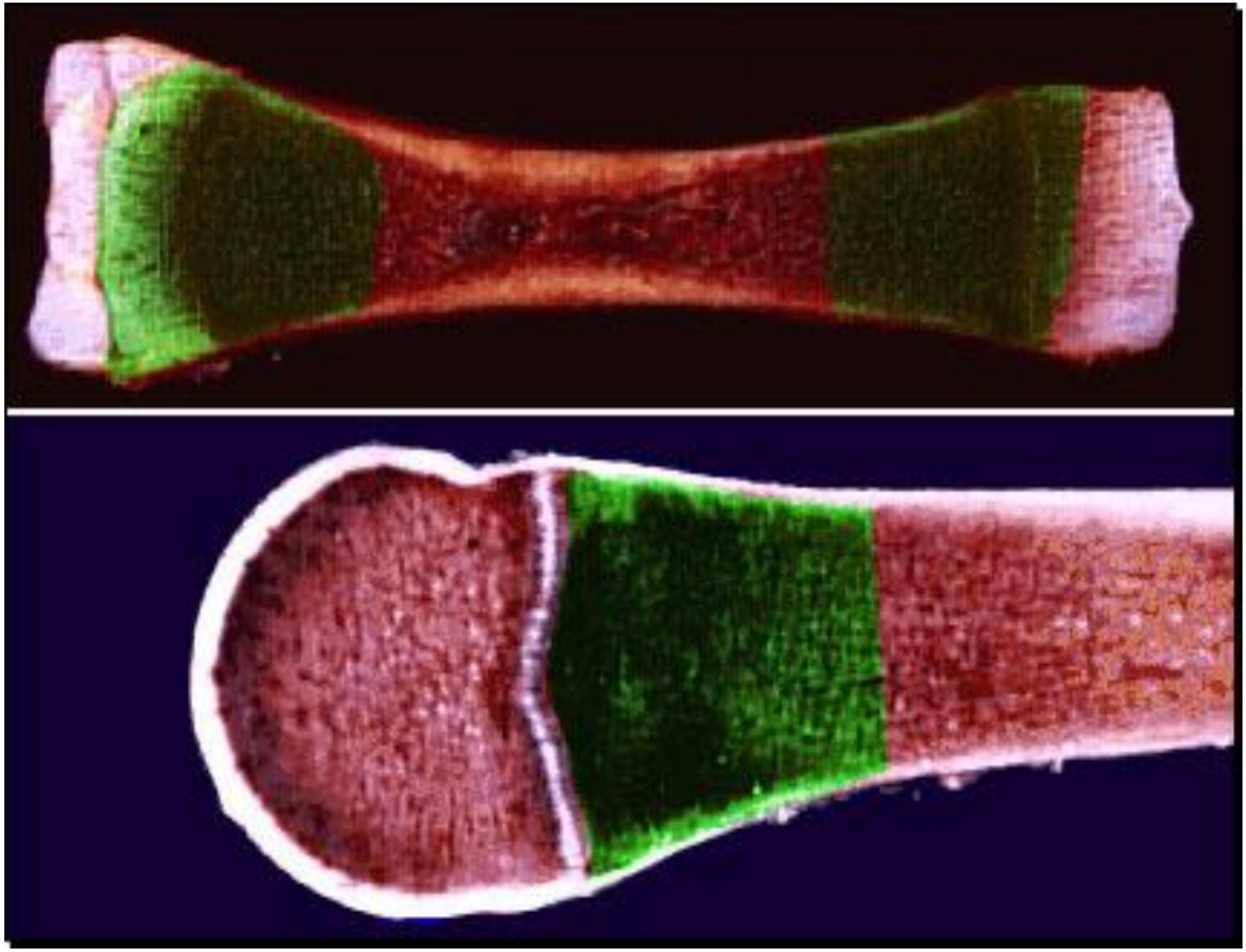
Diaphysis



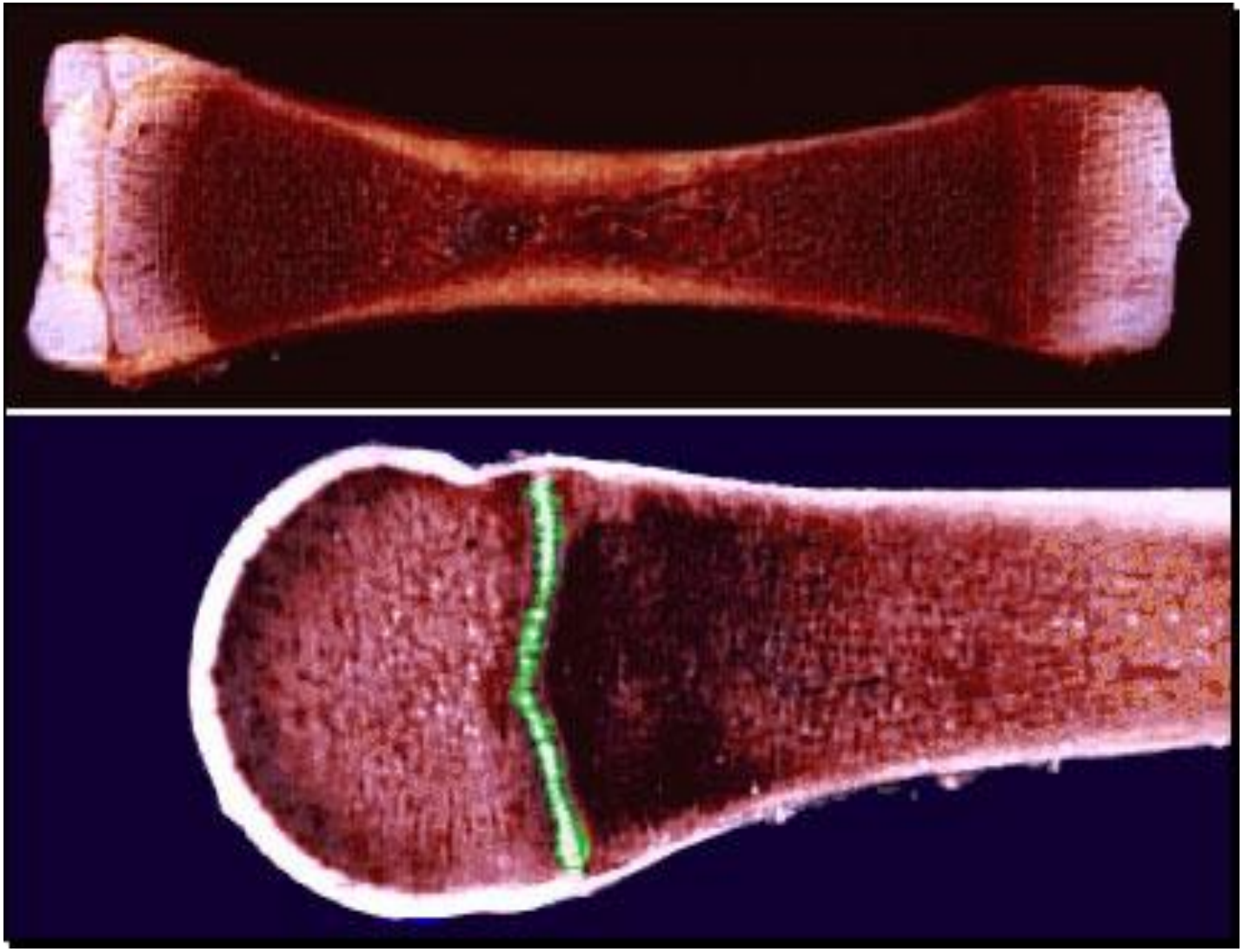
Epiphysis



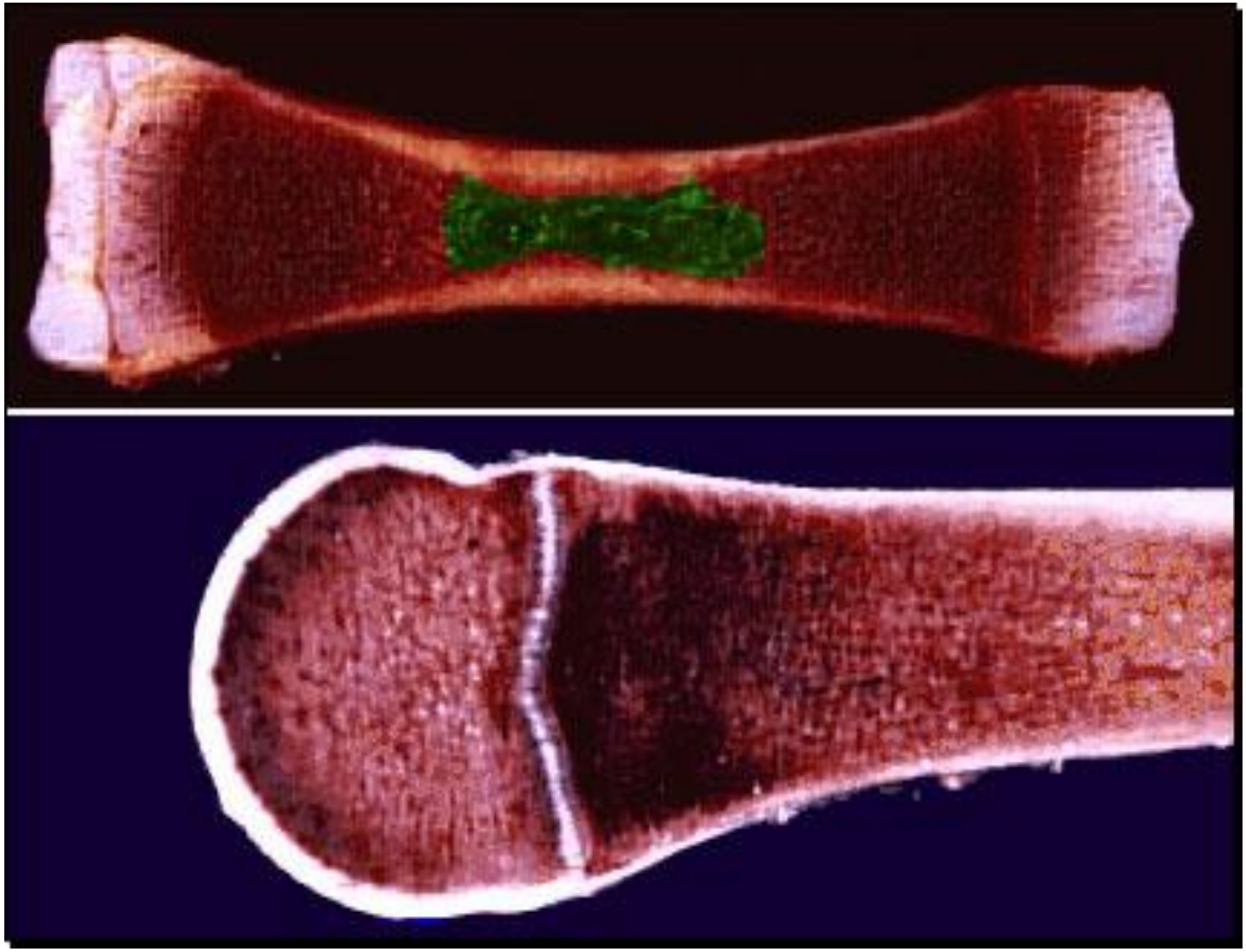
Metaphysis



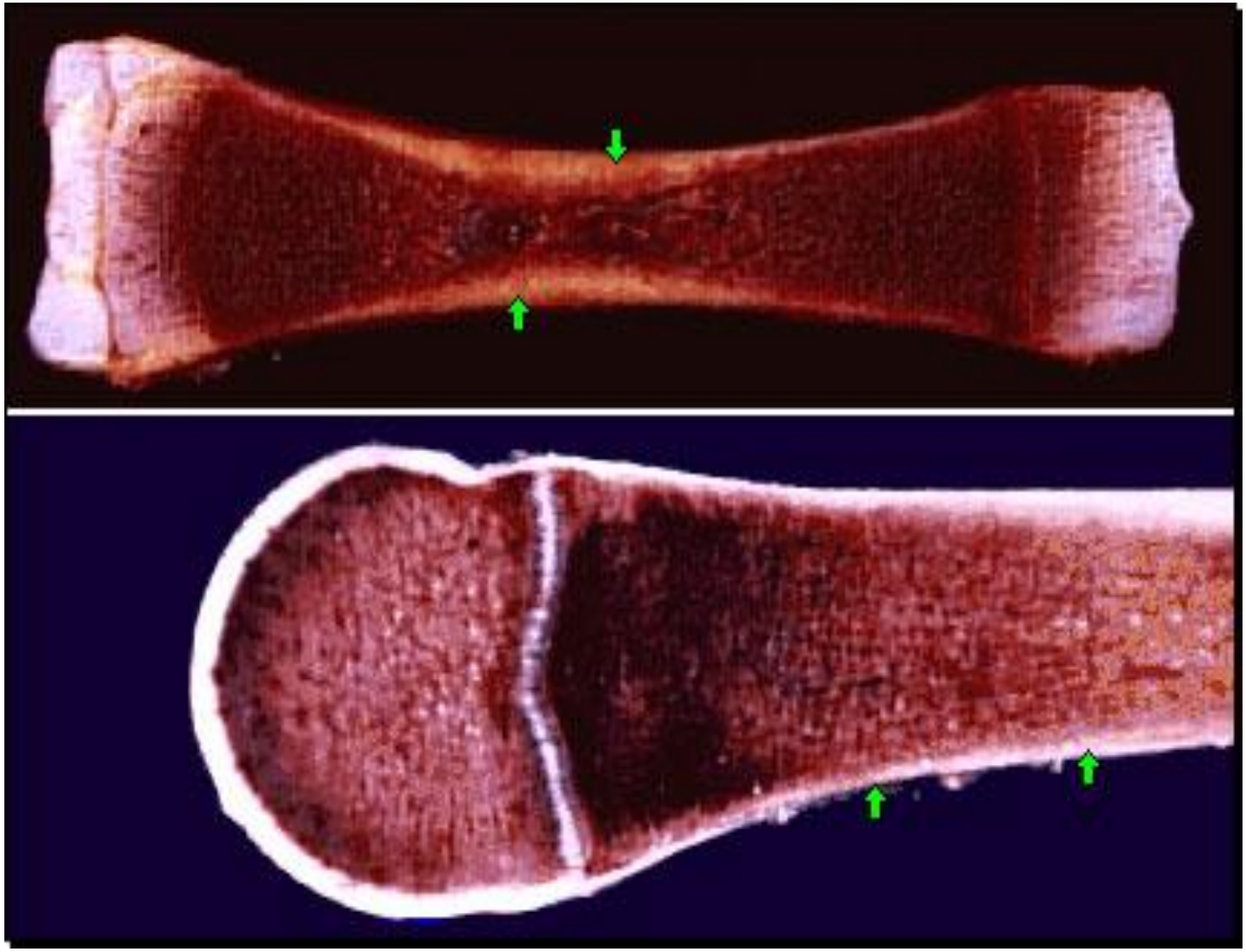
Epiphyseal (growth) plate/ line



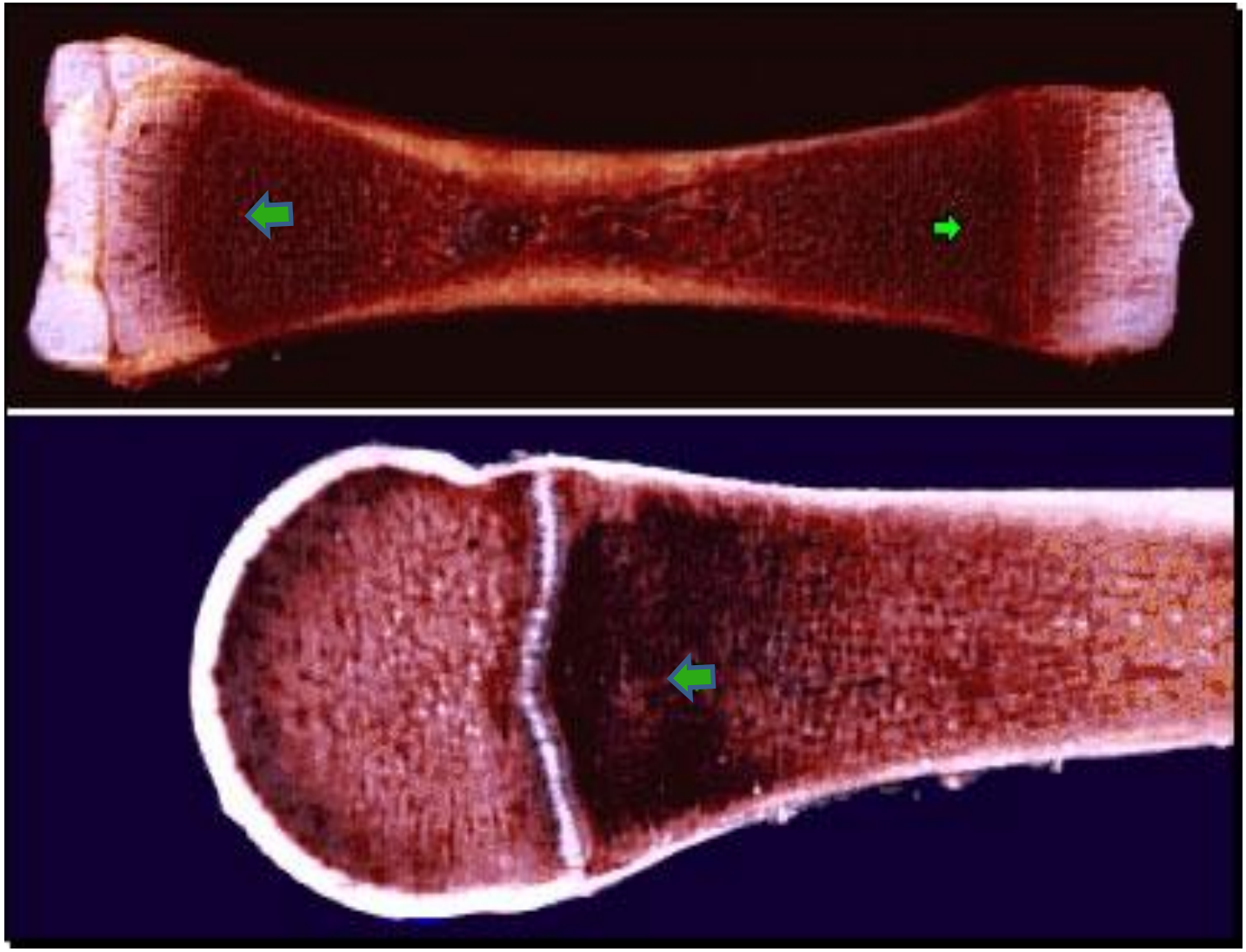
Medullary canal (cavity)



Compact bone

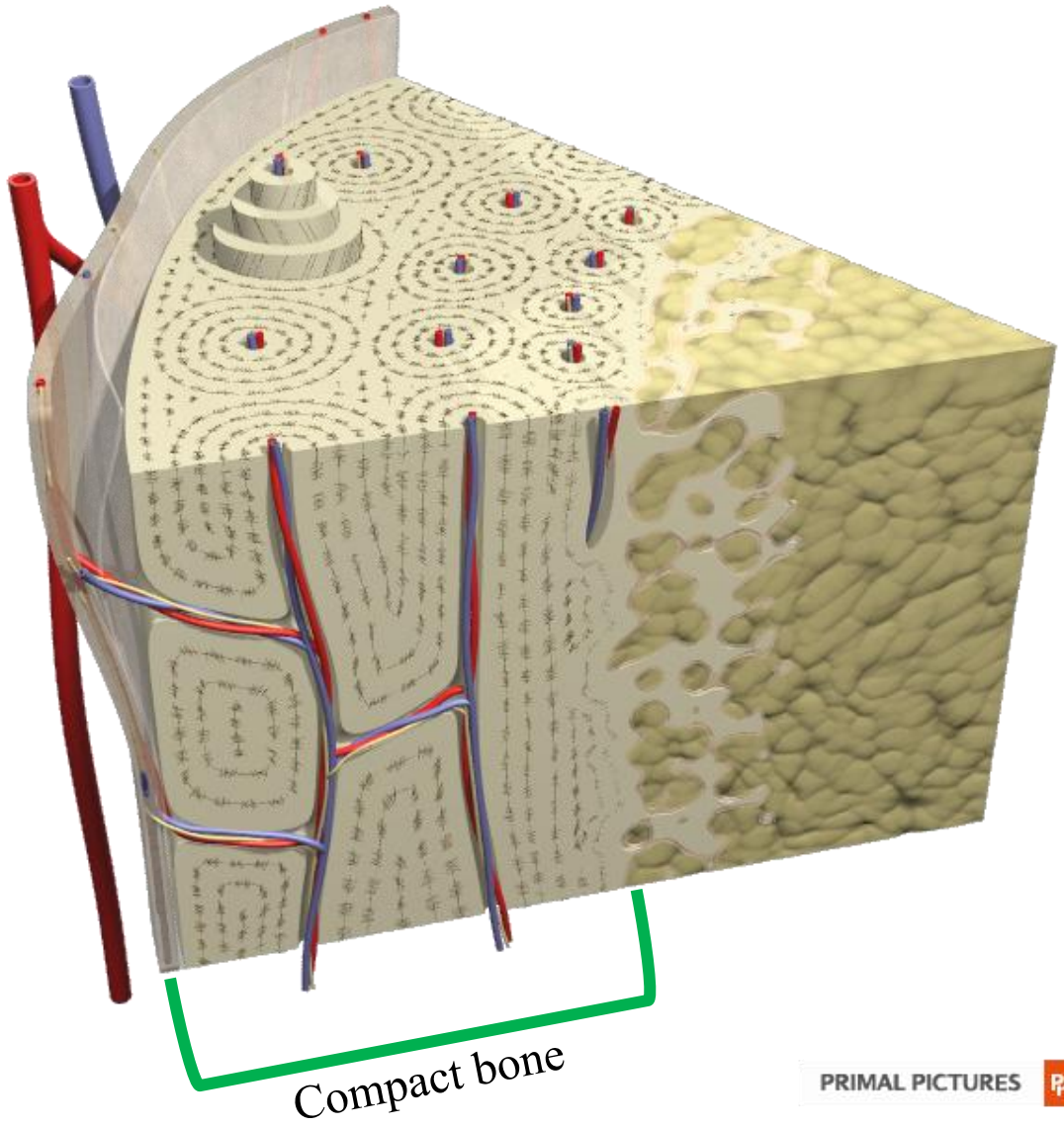


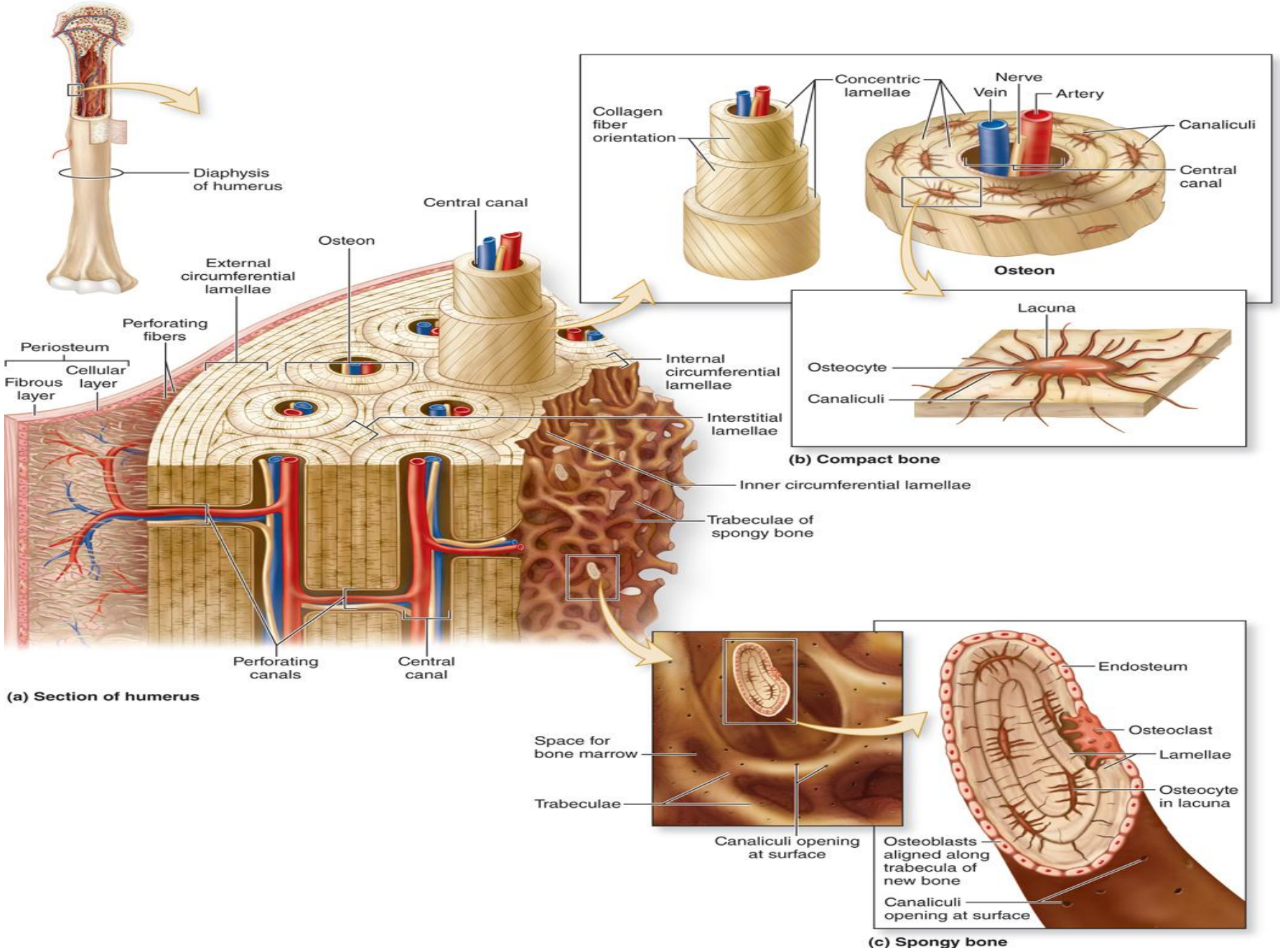
Cancellous (spongy) bone

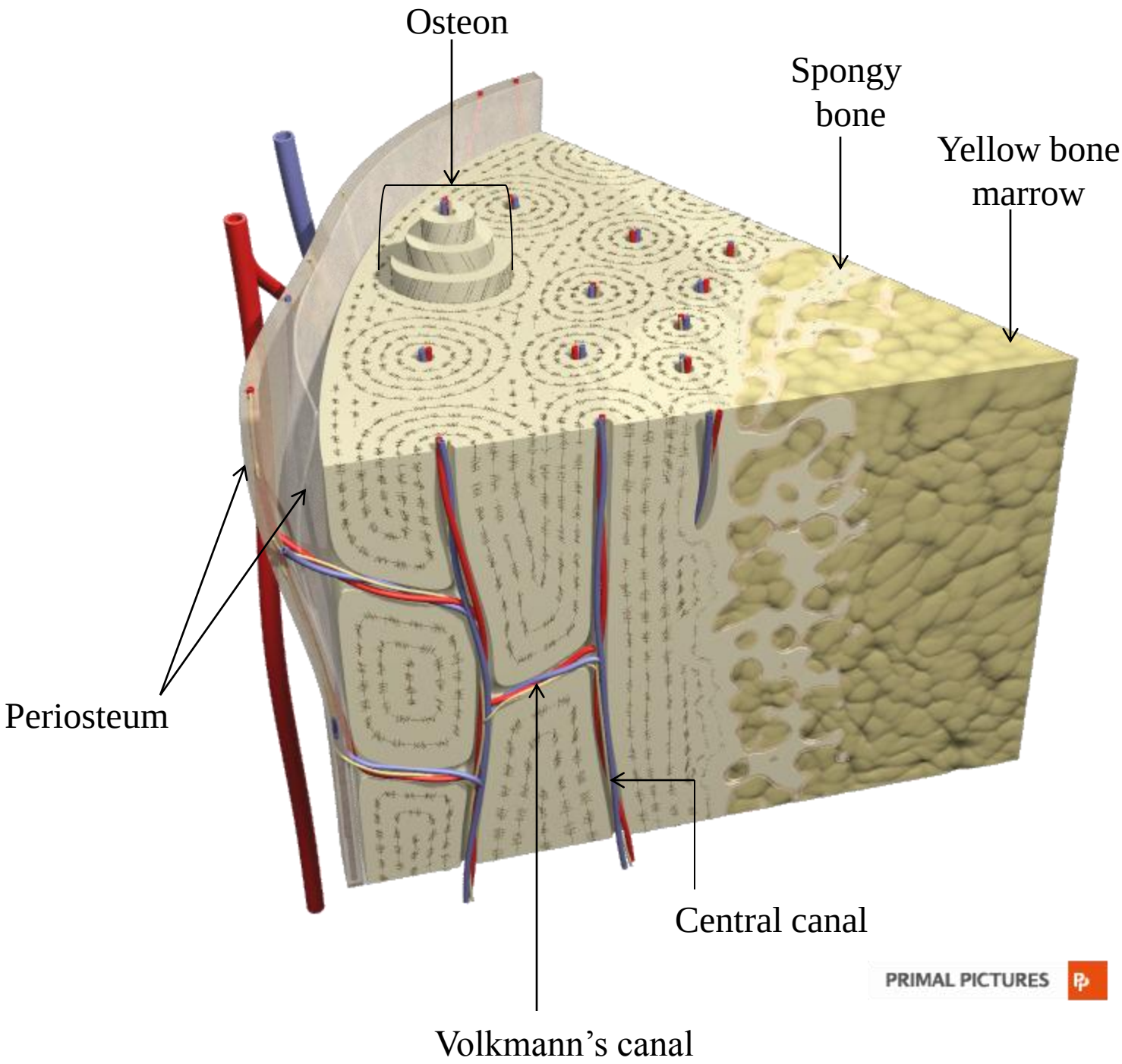


Compact (cortical) bone

- ✓ An **osteon (or Haversian system**): concentric lamellae surrounding a small canal containing blood vessels, nerves, loose CT and lined by endosteum.
- ✓ Between successive lamellae are lacunae (each with one osteocyte).
- ✓ The outer boundary of each osteon is called the **cement line.**
- ✓ The central canal communicate with the marrow cavity and the periosteum and with one another through transverse **Perforating canals (or** Volkmann's canal).




Diaphysis of humerus
Central canal
Osteon
External circumferential lamellae
Perforating fibers
Periosteum
Fibrous layer
Cellular layer
Internal circumferential lamellae
Interstitial lamellae
Inner circumferential lamellae
Trabeculae of spongy bone
Perforating canals
Central canal
(a) Section of humerus
Concentric lamellae
Collagen fiber orientation
Nerve
Vein
Artery
Canaliculi
Central canal
Osteon
Lacuna
Osteocyte
Canaliculi
(b) Compact bone
Space for bone marrow
Trabeculae
Canaliculi opening at surface
Endosteum
Osteoclast
Lamellae
Osteocyte in lacuna
Osteoblasts aligned along trabecula of new bone
Canaliculi opening at surface
(c) Spongy bone



PERIOSTEUM & ENDOSTEUM

- Surfaces of bone are covered by tissue layers with bone forming cells.
- External surfaces: **Periosteum.**
- Internal surfaces: **Endosteum.**
- **Functions:**
  - Nutrition of bone.
  - Continuous supplying of osteoblasts from progenitor cells for bone growth or repair

Osteogenic stem cells differentiate (specialize) into bone cells "osteoblasts" (bone forming).

Endosteum:

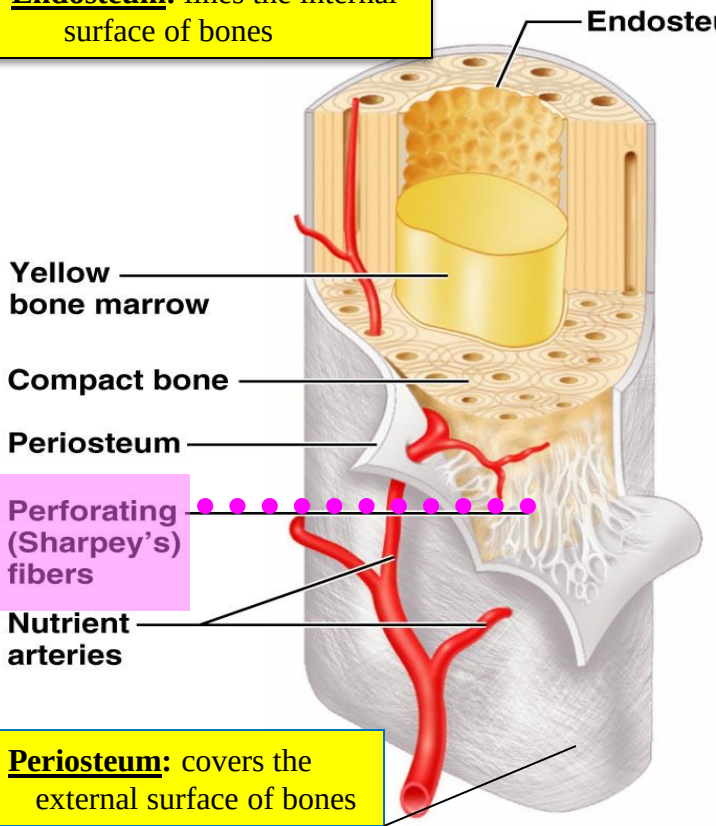
- Lines the internal cavity of the bone.
- Covers trabeculae of spongy bone
- Composed of a single layer of flat osteoprogenitor cel
- Has the same functions as periosteum.

Periosteum:

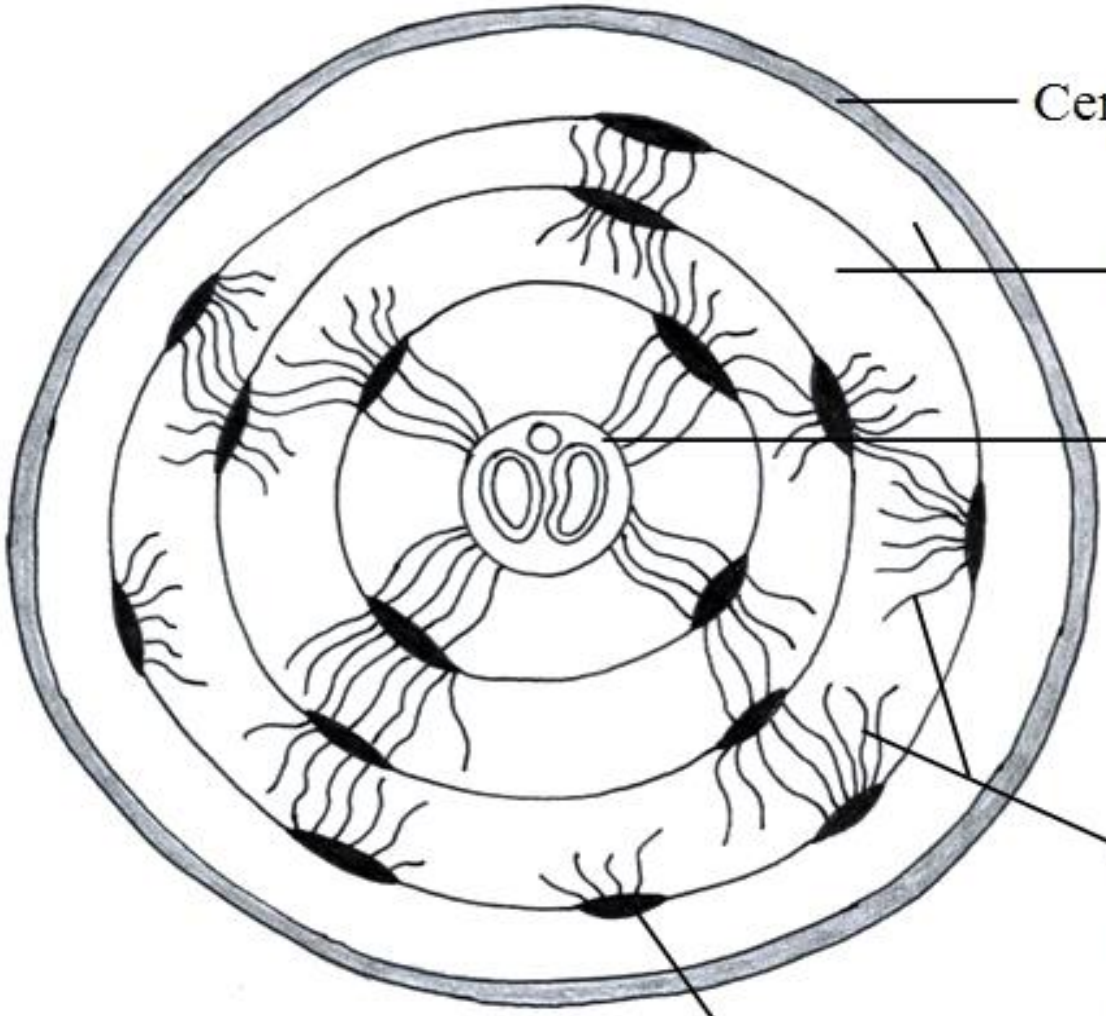
Dense irregular connective tissue

- Outer fibrous
  - Some fibers penetrate through bone substance ⇨Sharpey's fibers.
- Inner cellular contains osteoprogenitor cells.

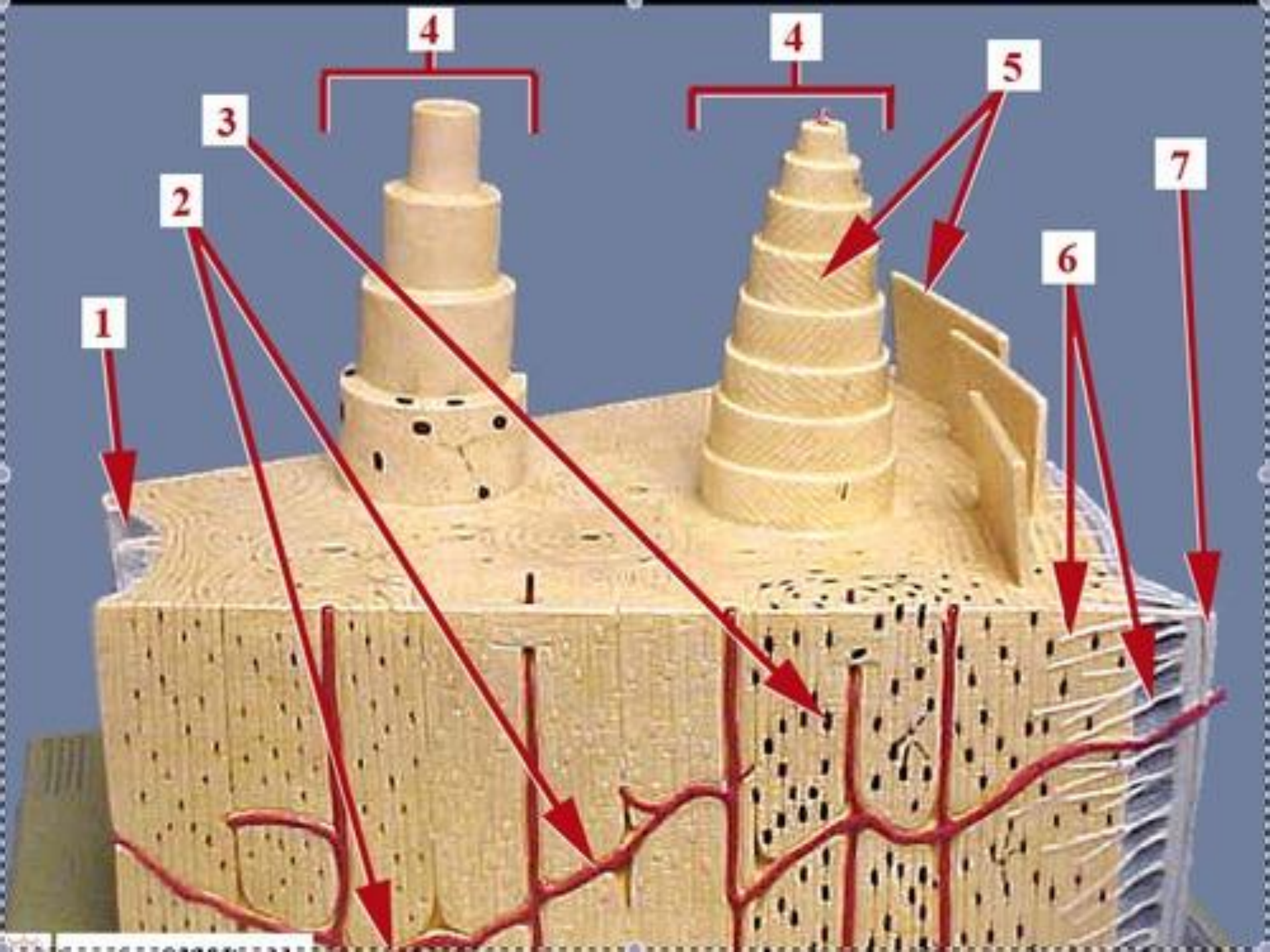
Endosteum: lines the internal surface of bones

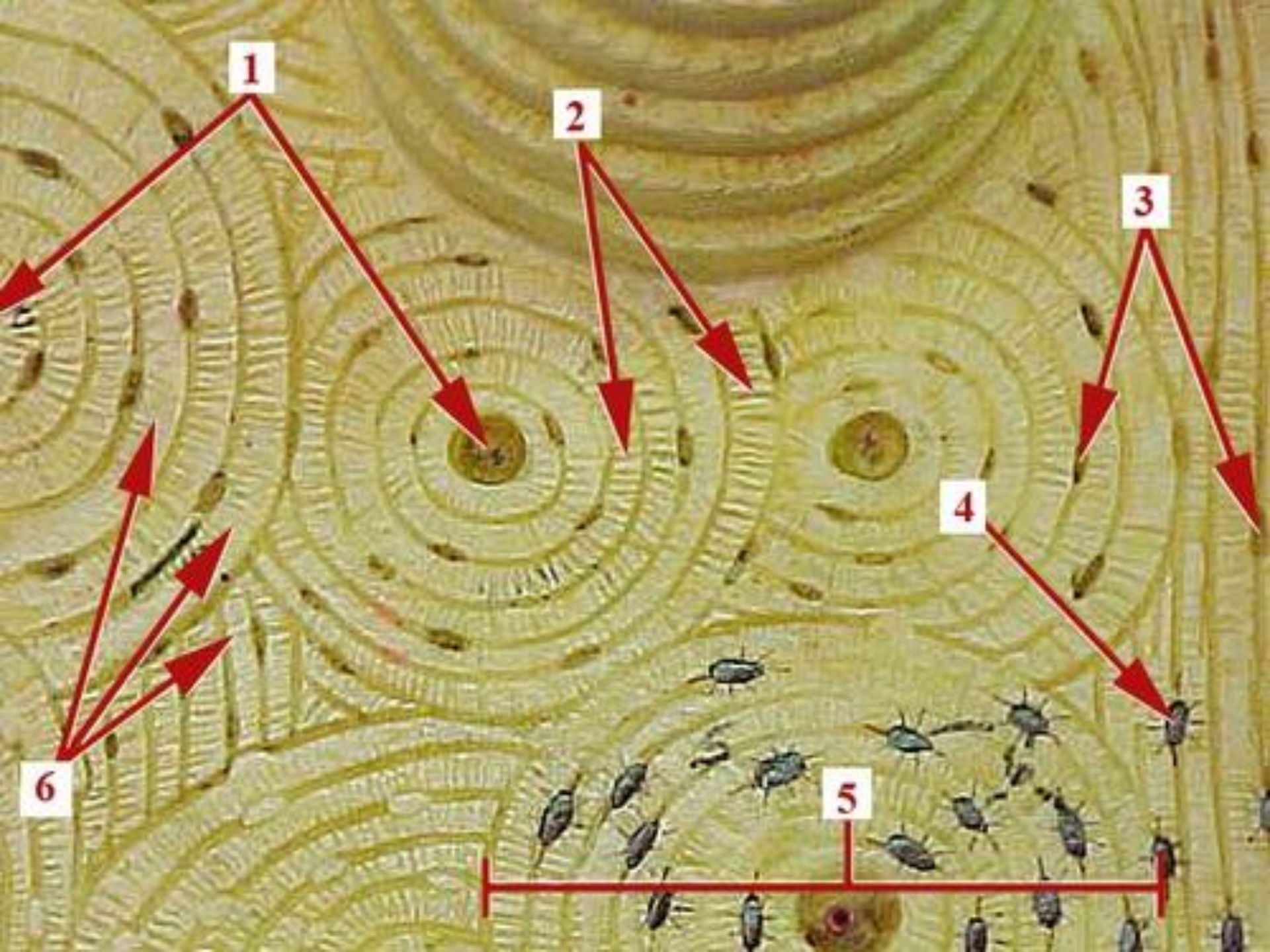


Periosteum: covers the external surface of bones



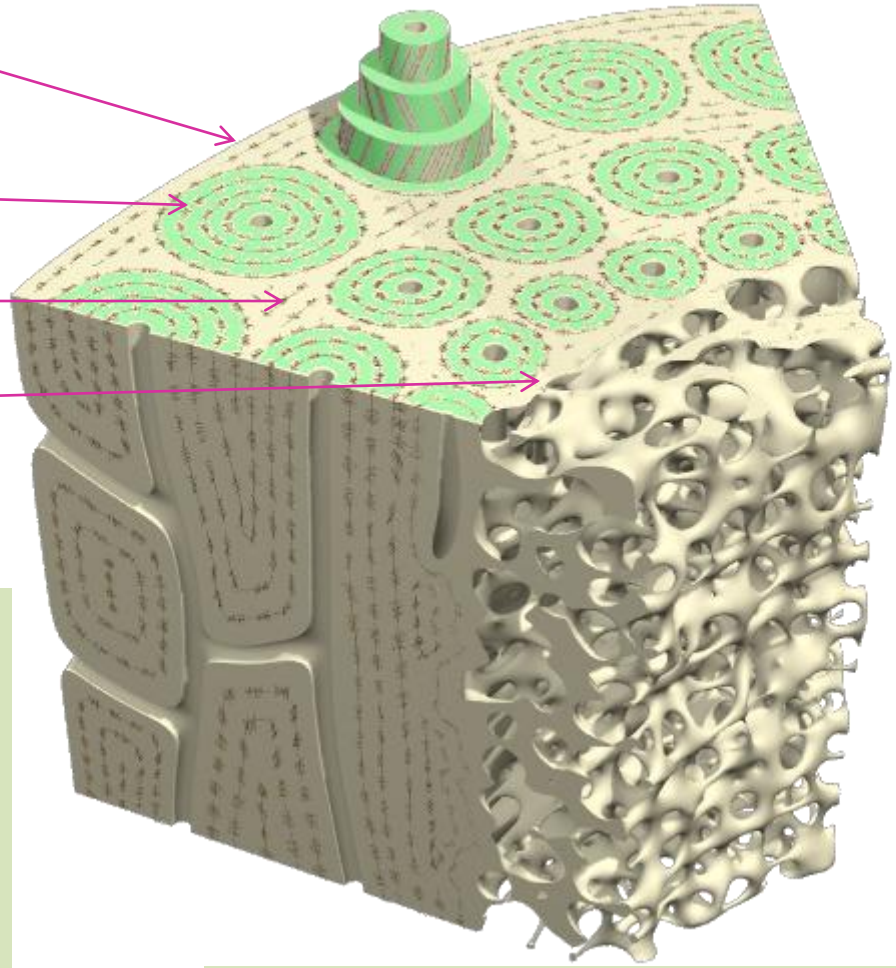
A single osteon in cross-section


4
4
5
3
2
7
6
1


1
2
3
4
5
6

Types of lamella:

- Outer circumferential
- Concentric
- Interstitial
- Inner circumferential



Interstitial lamellae

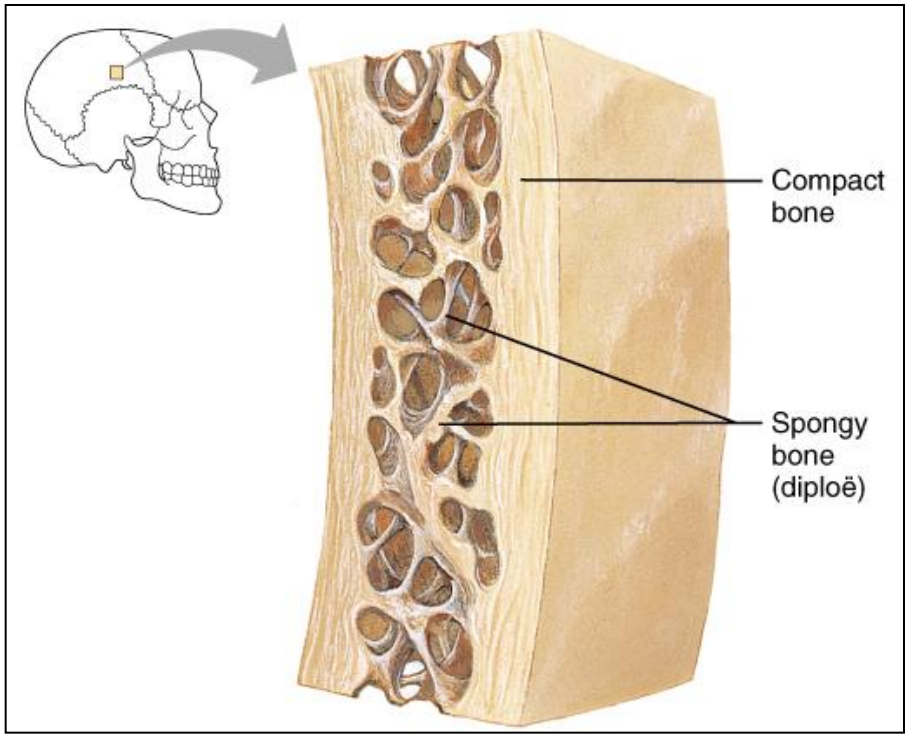
- Scattered among the intact osteons.
- Are numerous irregularly shaped groups of parallel lamellae.
- Are lamellae remaining from osteons partially destroyed by osteoclasts during growth and remodeling of bone.

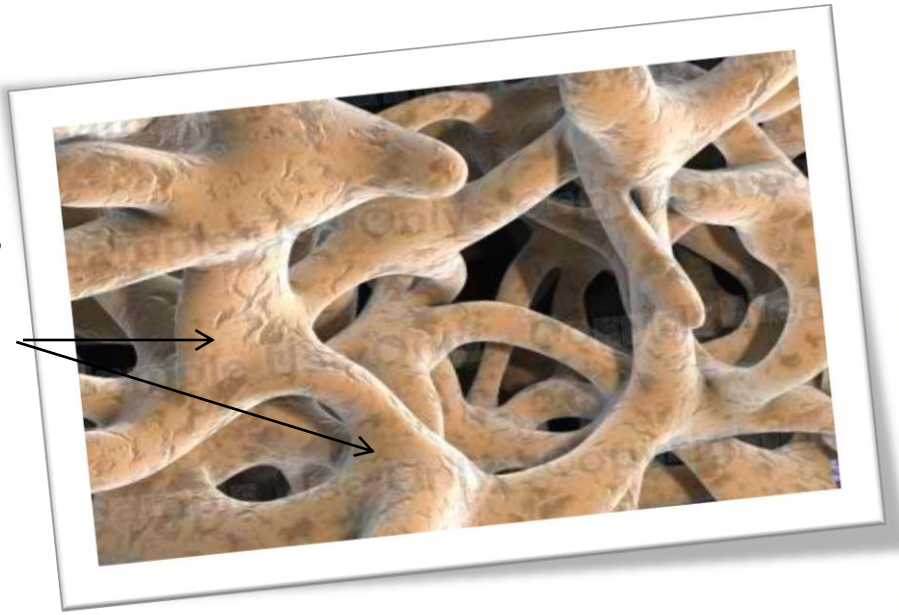
Outer circumferential: located immediately beneath the periosteum.

Inner circumferential: located around the marrow cavity.

Short, Irregular, and Flat Bones

- Spongy bone (mainly) covered by compact bone
- Spongy bone of flat bones is called diploë
- Have no diaphysis or epiphyses
- Contain bone marrow between the trabeculae





Spongy bone

Haphazard arrangement of trabeculae

No osteons

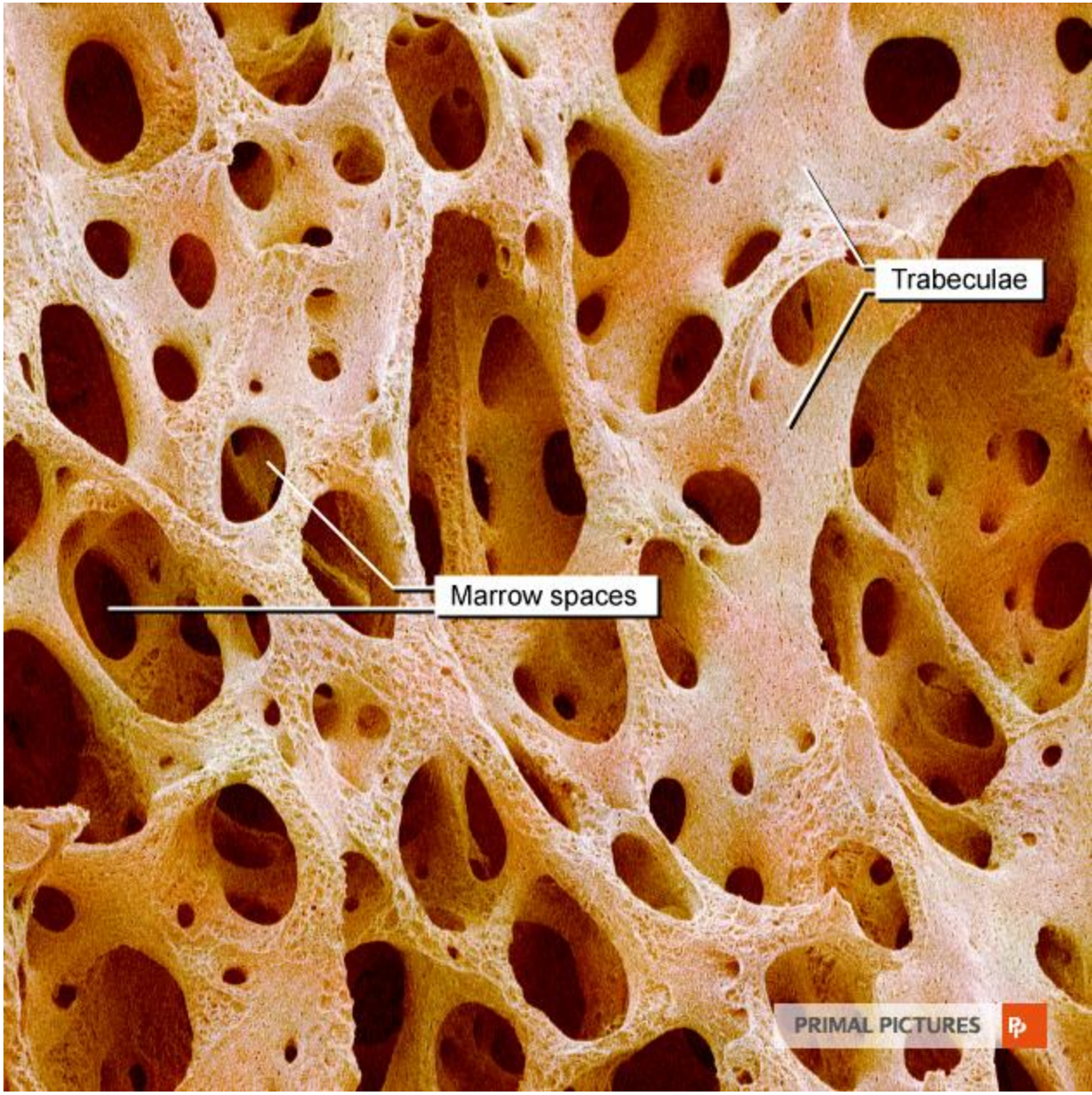
Lighter and porous

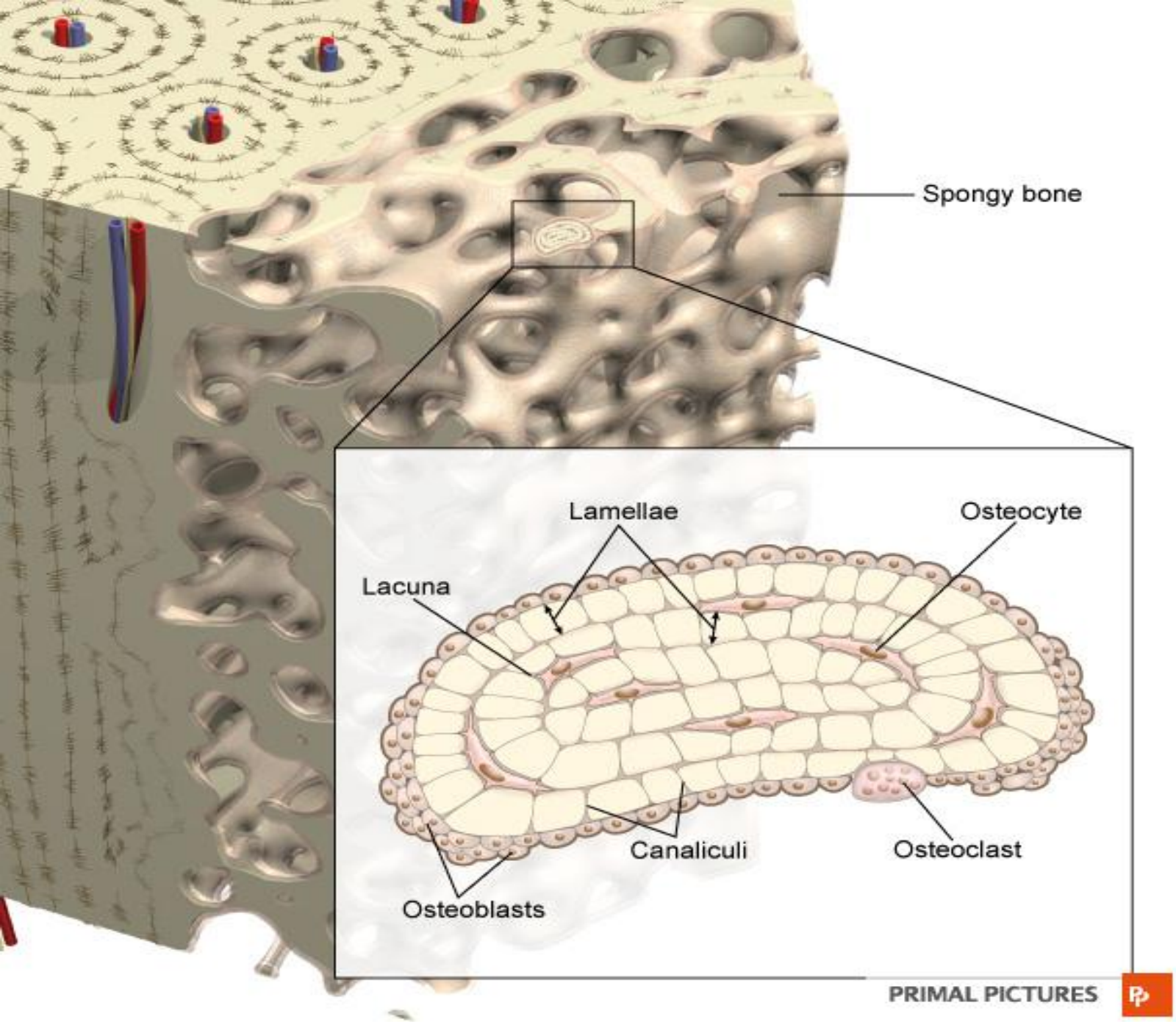
Trabeculae: Arches, rods, plates of bone, Branching network of bony tissue, Strong in many directions

Spaces filled with red/ yellow bone marrow

Osteocytes get nutrients directly from circulating blood

Short, flat and irregular bone are made up of mostly spongy bone





Bone Matrix:

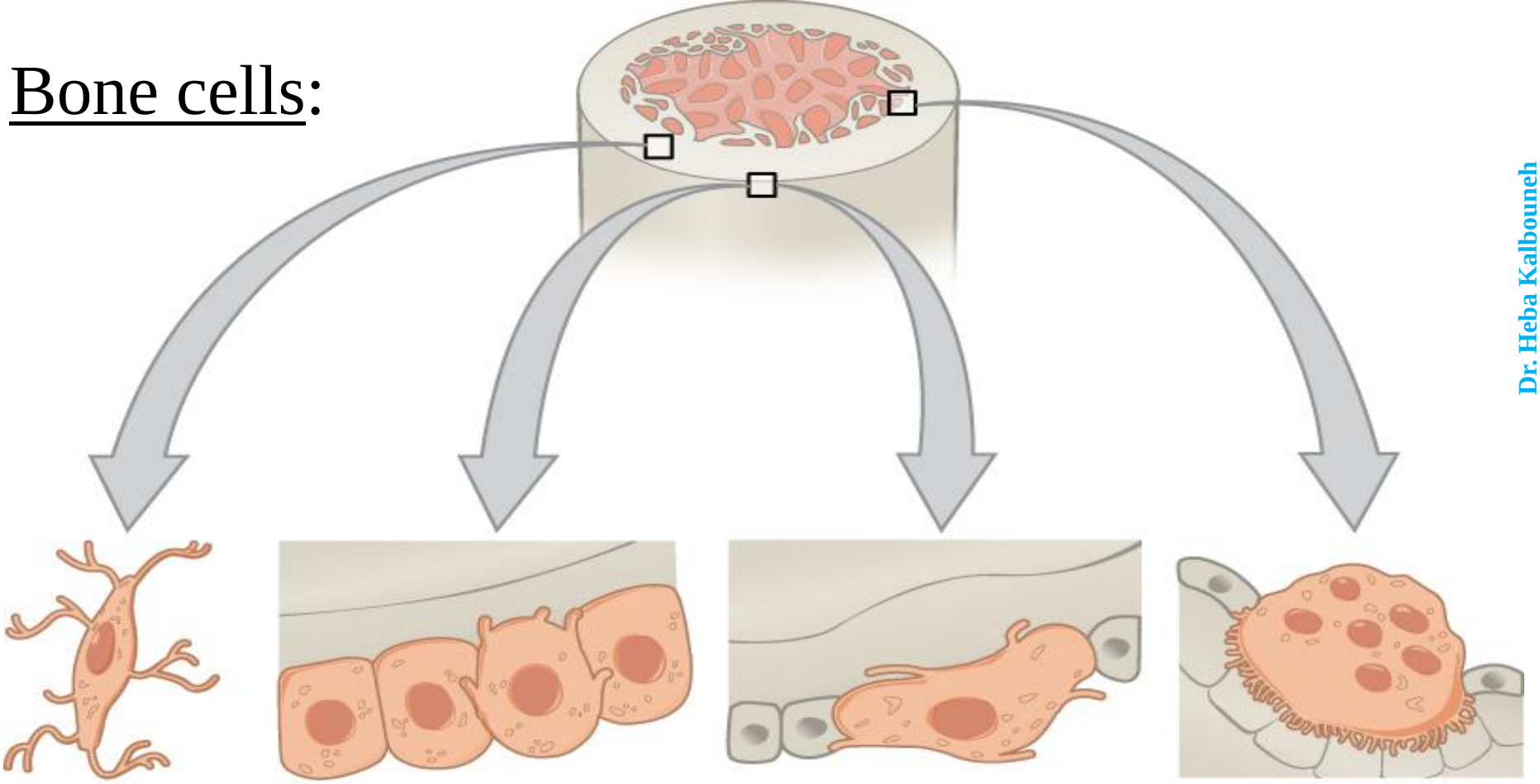
2/3

- **Inorganic matter** = ~ 67% of dry weight.
  - Most of ions are: **Ca^{+2}** & **PO^{-4}**
  - Others: Mg, K, HCO3, Citrate.
  - Ca^{+2} & PO^{-4} form $C_{10}(PO_4)_6(OH)_2$ = ***hydroxyapatite***

1/3

- **Organic matter** = collagen type I & ground substance.

Bone cells:



Osteocyte (maintains bone tissue)

Osteoblast (forms bone matrix)

Osteogenic cell (stem cell)

Osteoclast (resorbs bone)

Situated inside lacuna

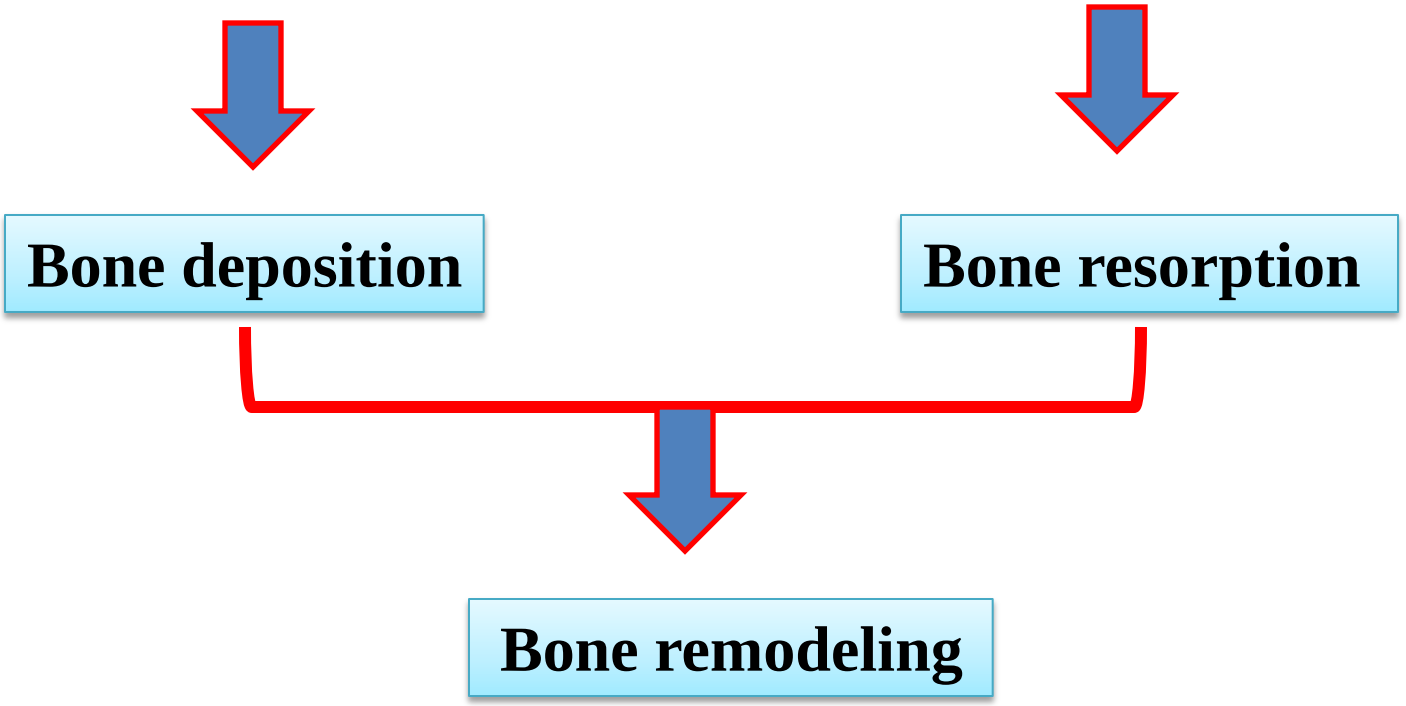
Found in both the periosteum and the endosteum

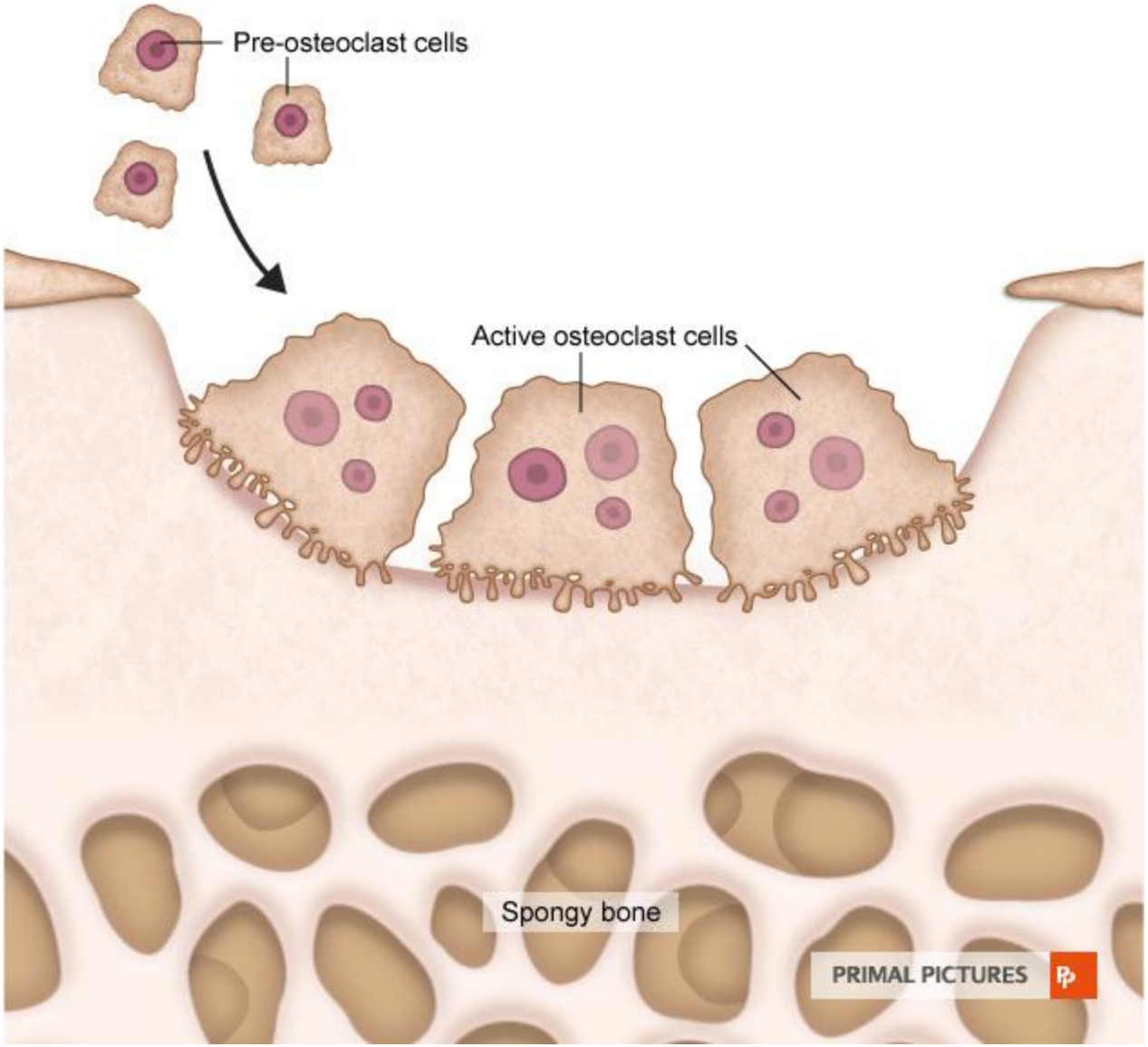
Osteoblasts

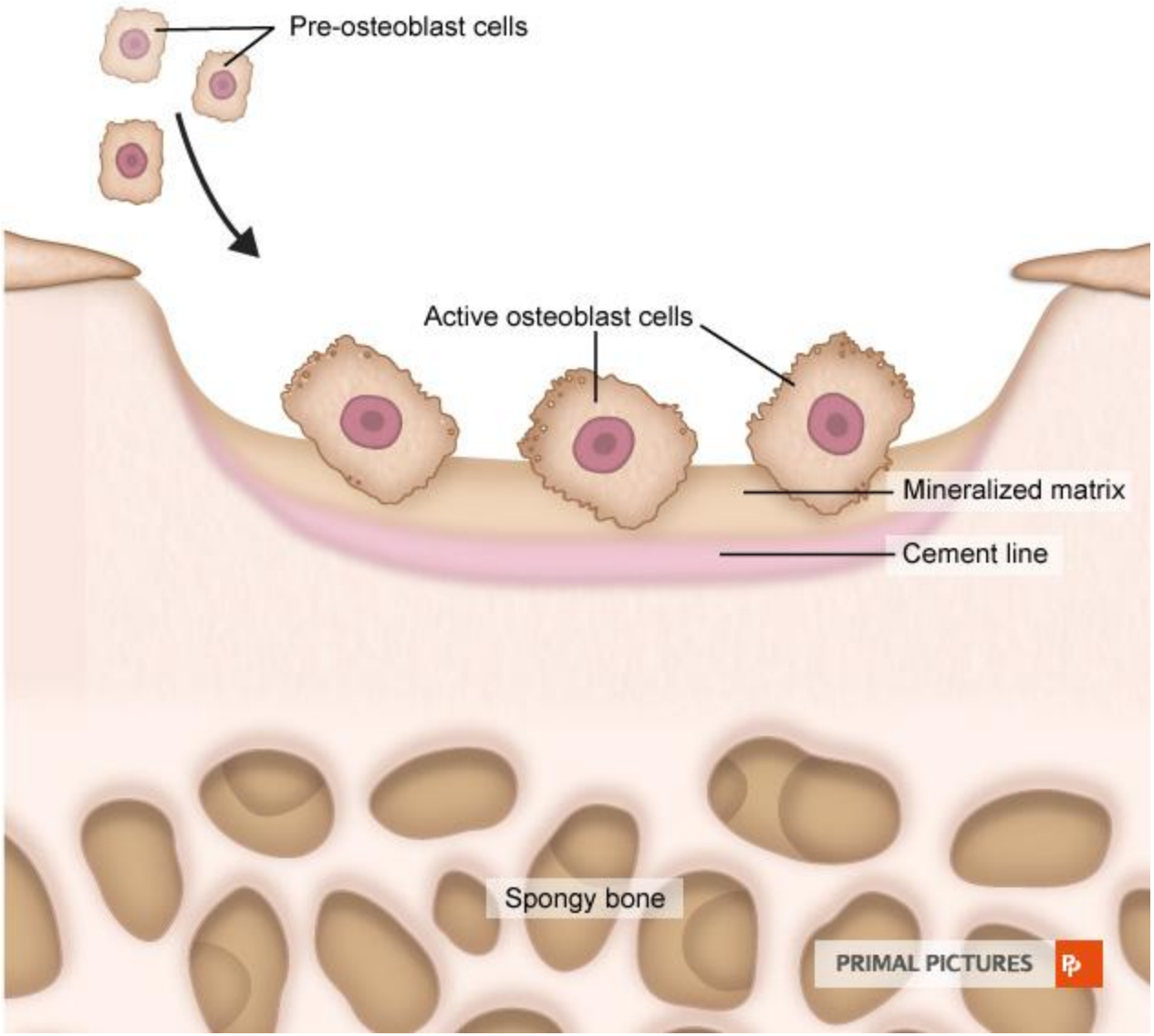
Bone **b**uilding cells

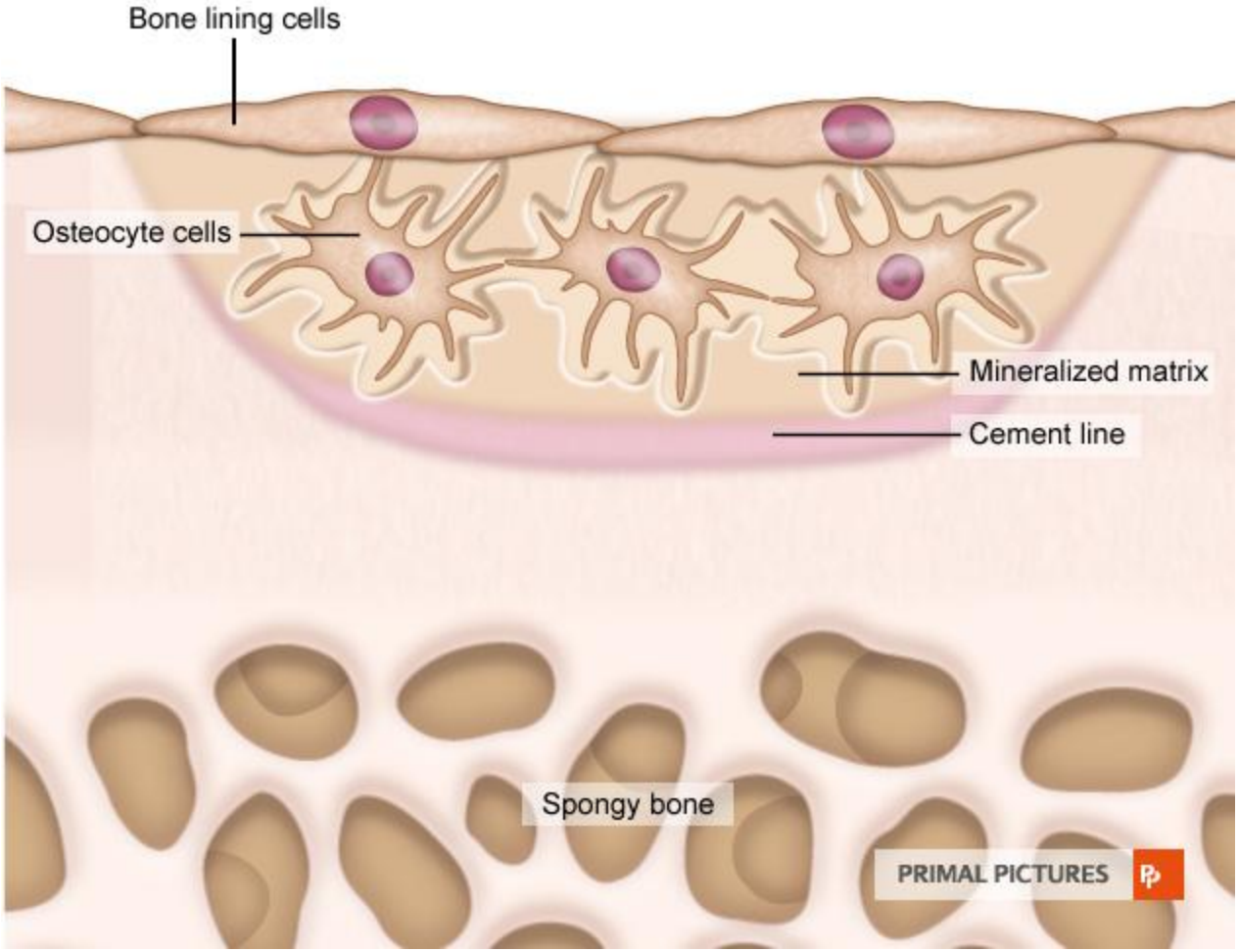
Osteoclasts

Bone **c**utting cells



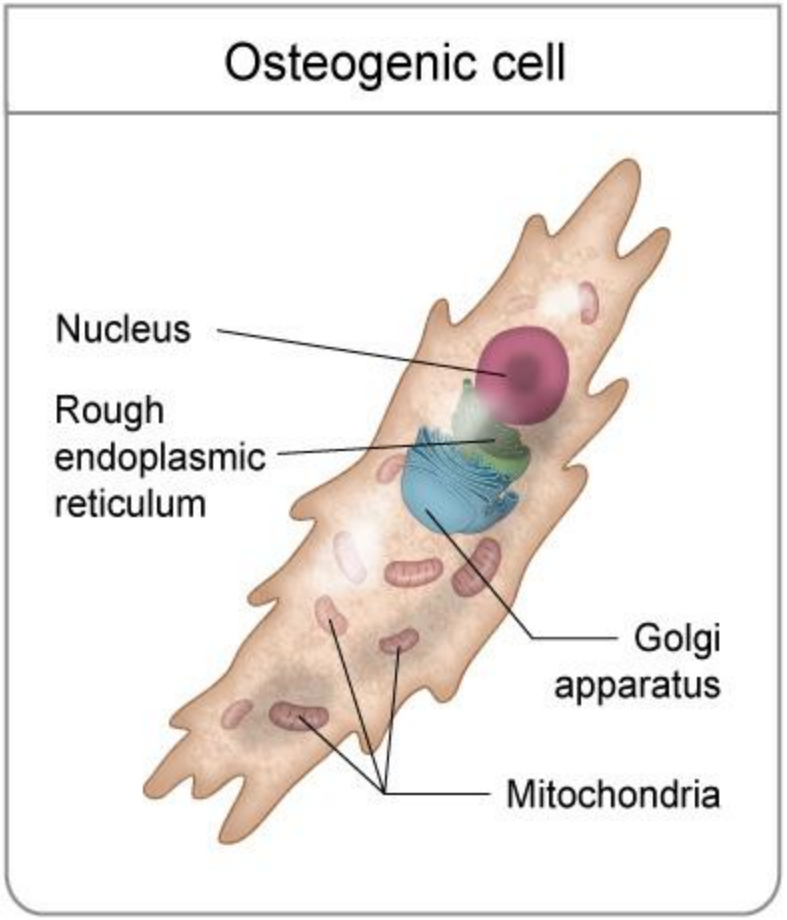






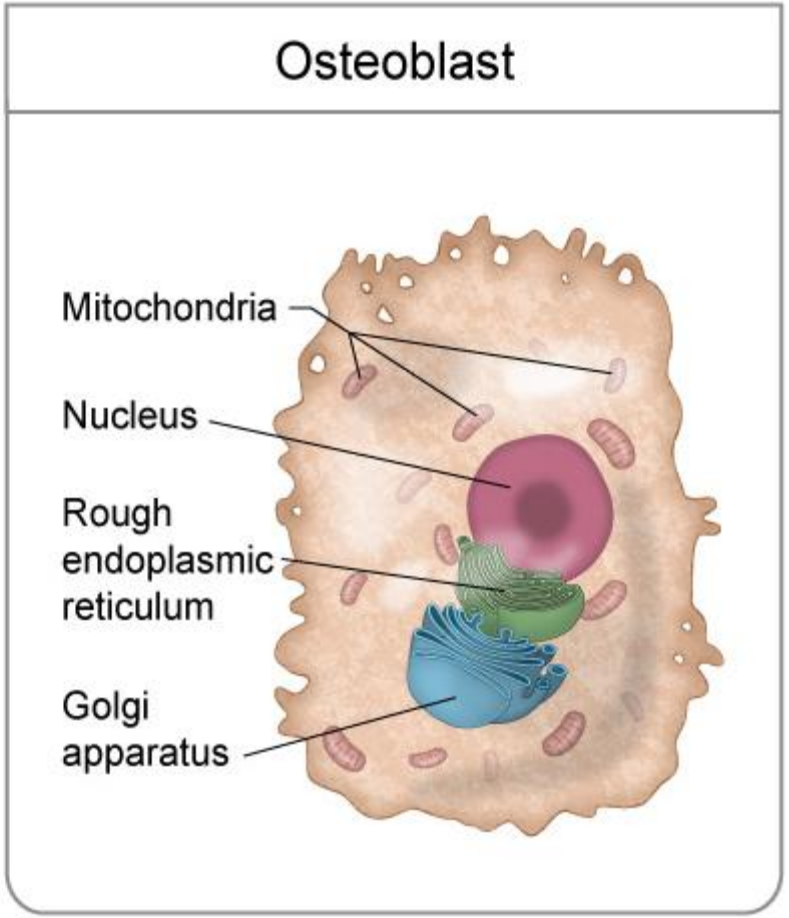
Osteoprogenitor Cells

- Derived from **embryonic mesenchymal cells**
- Located in the inner cellular layer of the periosteum and in the endosteum.
- Have the potential to differentiate into osteoblasts.



Osteoblast

- Responsible for synthesis of the organic components of the matrix.
- Deposition of inorganic components also depends on osteoblasts.
- When active, appear cuboidal-columnar, typical protein synthesizing cells.
- The newly laid matrix is not calcified and called ***osteoid***.
- Osteoblast ⇨ Osteocyte
  - **Inactive** osteoblasts are flat cells that cover the bone surface. These cells resemble **bone lining cells** in both the endosteum and periosteum.
  - Secrete alkaline phosphatase (ALP) and osteocalcin, their circulating levels are used clinically as markers of osteoblast activity.



- ✓ The newly deposited matrix is not immediately calcified. It stains lightly or not at all compared with the mature mineralized matrix, which stains heavily with eosin.
- ✓ Because of this staining property of the newly formed matrix, osteoblasts appear to be separated from the bone by a light band.
- ✓ This band represents the **osteoid**, the nonmineralized matrix, between the osteoblast layer and the preexisting bone surface

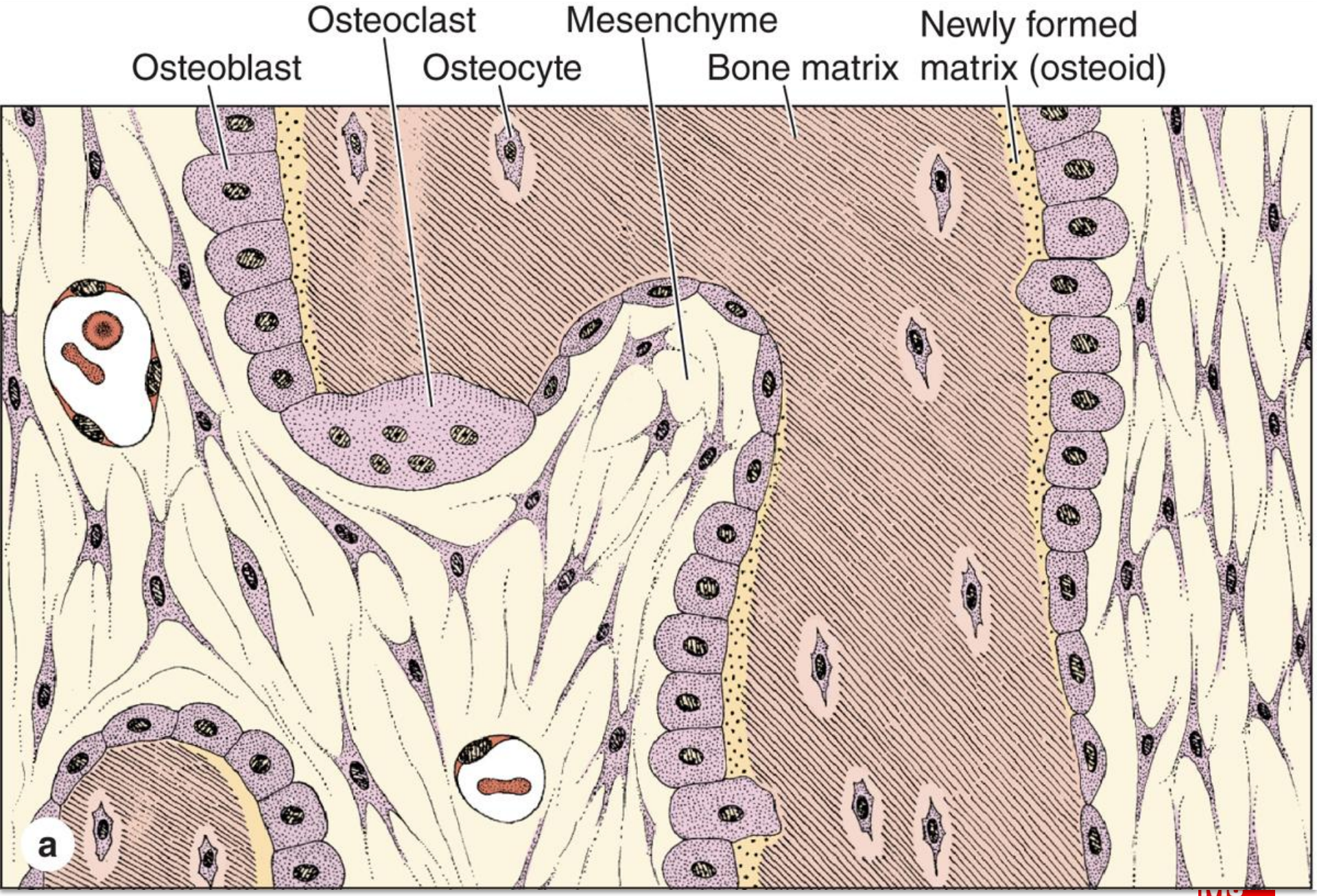
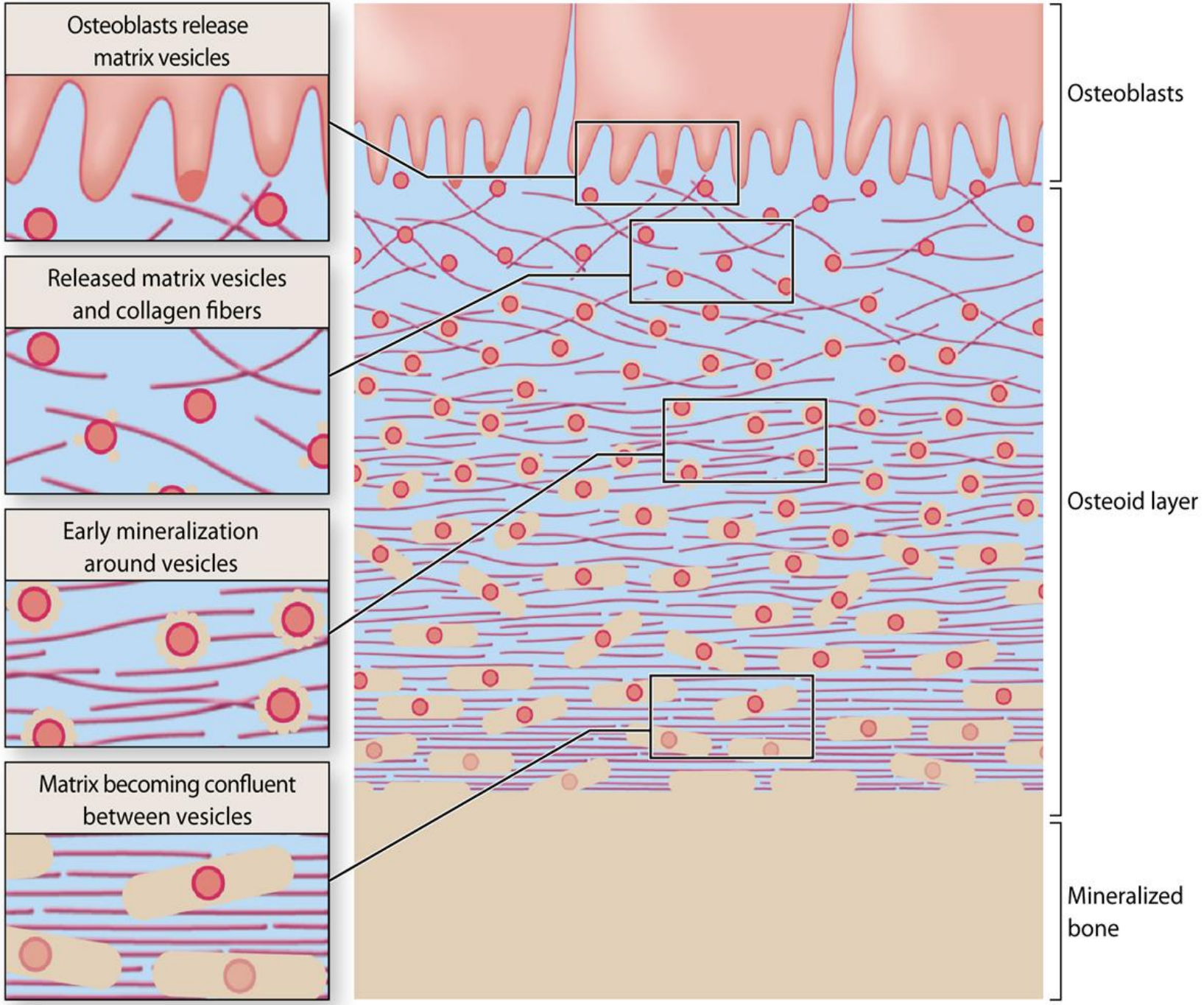
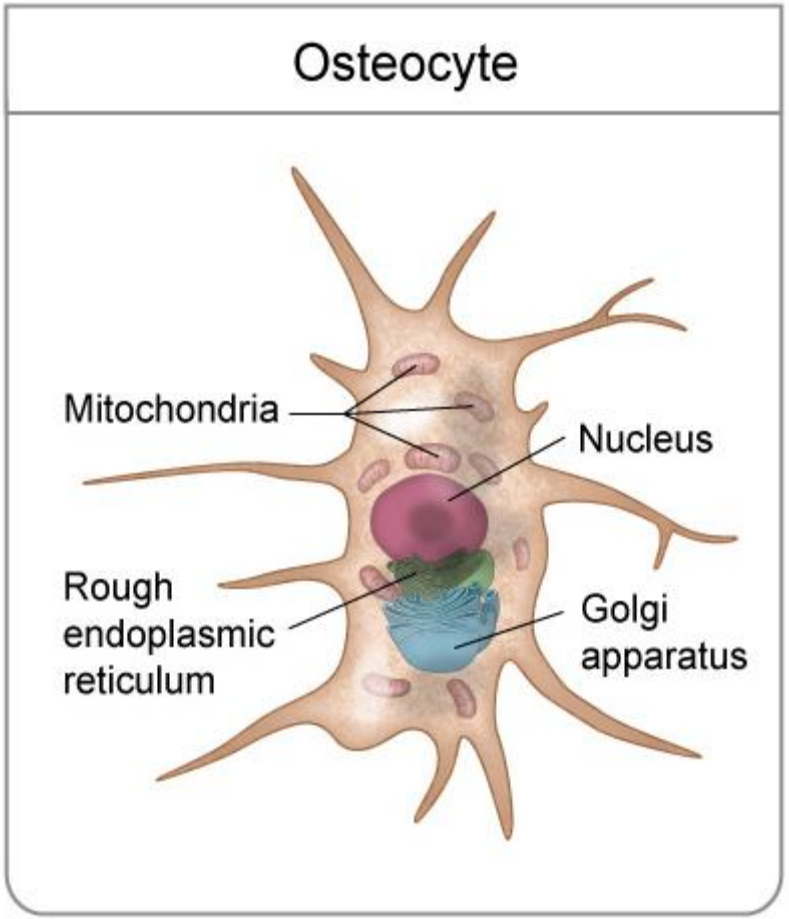


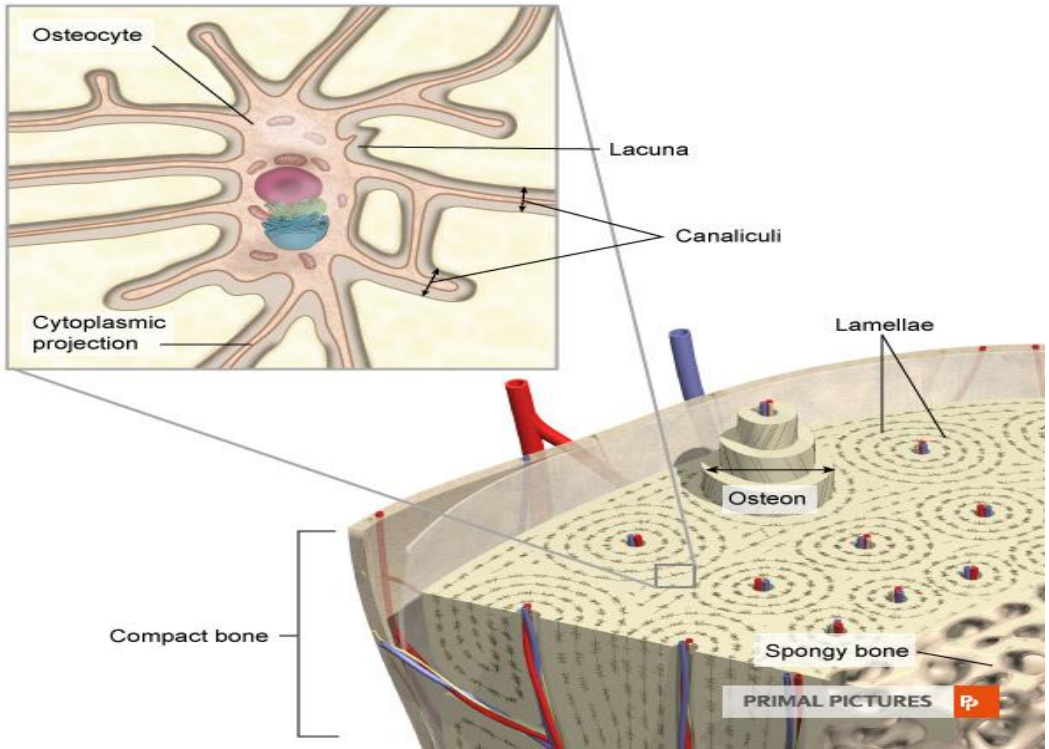
Figure 8-3

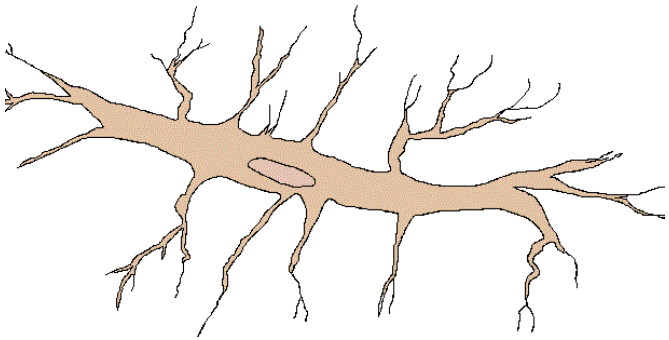

Osteoblasts release matrix vesicles
Released matrix vesicles and collagen fibers
Early mineralization around vesicles
Matrix becoming confluent between vesicles
Osteoblasts
Osteoid layer
Mineralized bone

Osteocyte

- Smaller than osteoblasts, almond shaped, with fewer rER, and condensed Golgi.
- Situated inside lacuna, one cell in each lacuna.
- Cells have processes (filopodial) passing through canaliculi in the thin surrounding matrix.
- Adjacent cells make contact through gap junctions in the processes.
- Involved in maintenance of matrix.

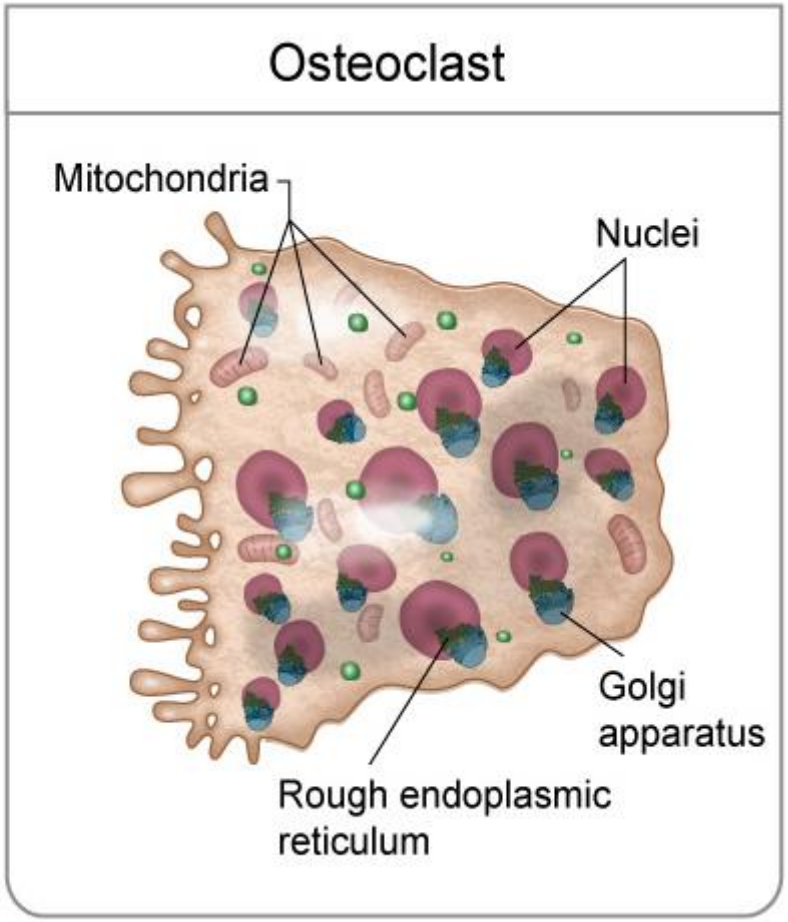


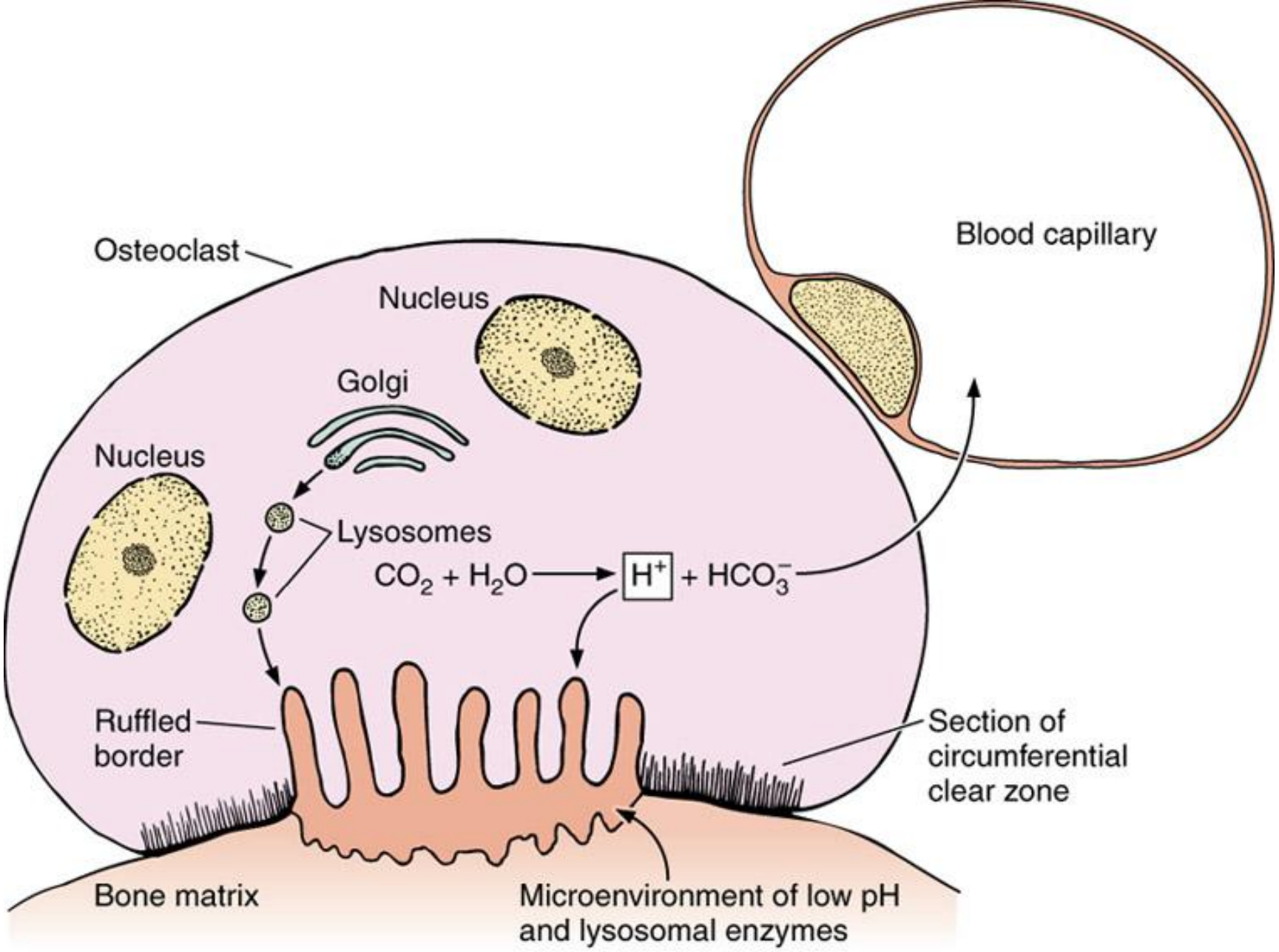




Osteoclast

- Large, branched motile, multinucleated cells.
- Originates from fusion of monocytes.
- Secretes collagenase and some enzymes.
- **When active**, they lie in Howship's lacuna:
  - Enzymatically etched depression on the surface.
- The surface facing the matrix shows irregular foldings; **ruffled border**.
  - The ruffled border is surrounded by **clear zone**:
    - Clear of organelles, rich in actin.
    - Creates microenvironment for bone resorption.




Blood capillary
Osteoclast
Nucleus
Golgi
Nucleus
Lysosomes
$CO_2 + H_2O \rightarrow H^+ + HCO_3^-$
Ruffled border
Section of circumferential clear zone
Bone matrix
Microenvironment of low pH and lysosomal enzymes

Clinical Application

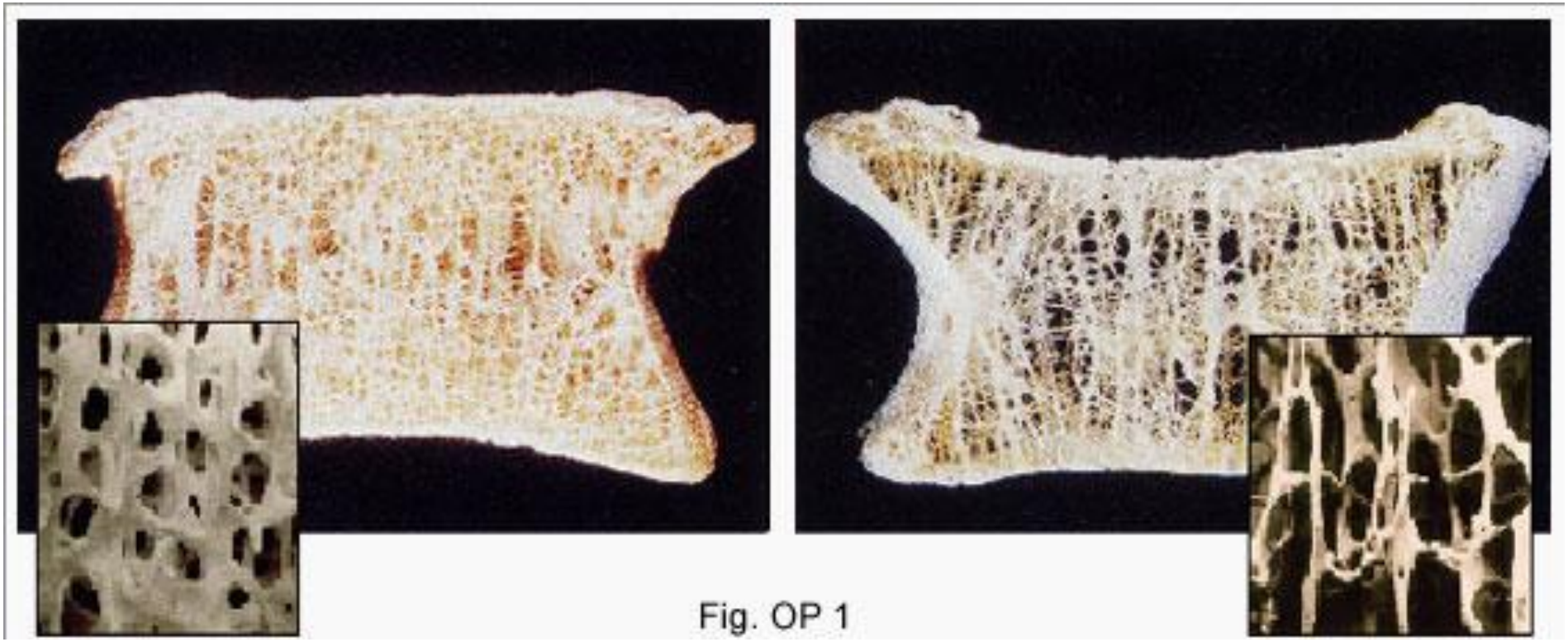


Fig. OP 1

Osteoporosis

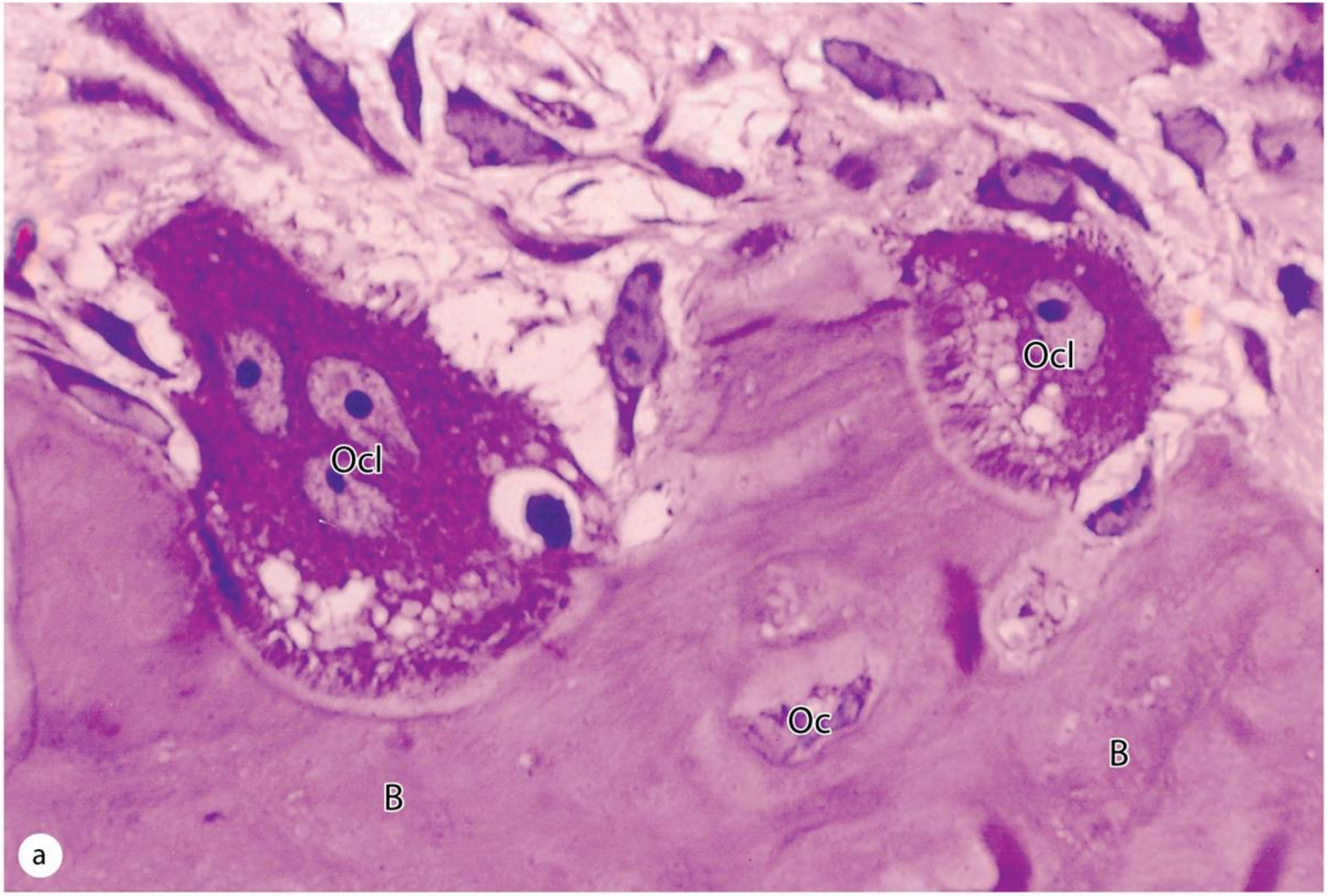


Figure 8-6

TECHNIQUE OF PREPARATION

Decalcified bone:

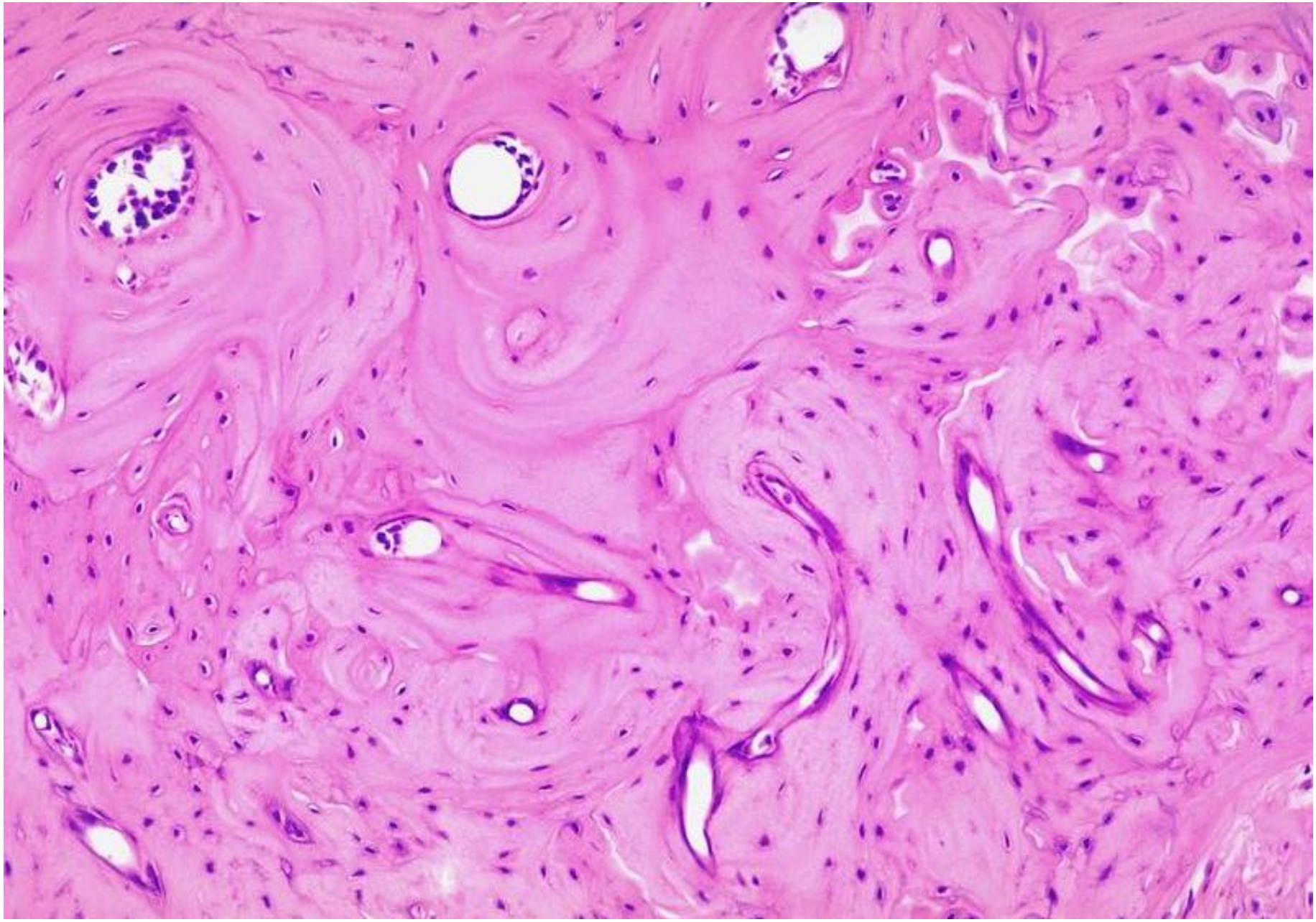
Because of its hardness, bone cannot be sectioned routinely. Bone matrix is softened by immersion in a decalcifying solution before paraffin embedding.

Ground bone

Decalcified bone

Dr. Heba Kalbouneh

Decalcified bone section



Ground bone section

Figure 8-9

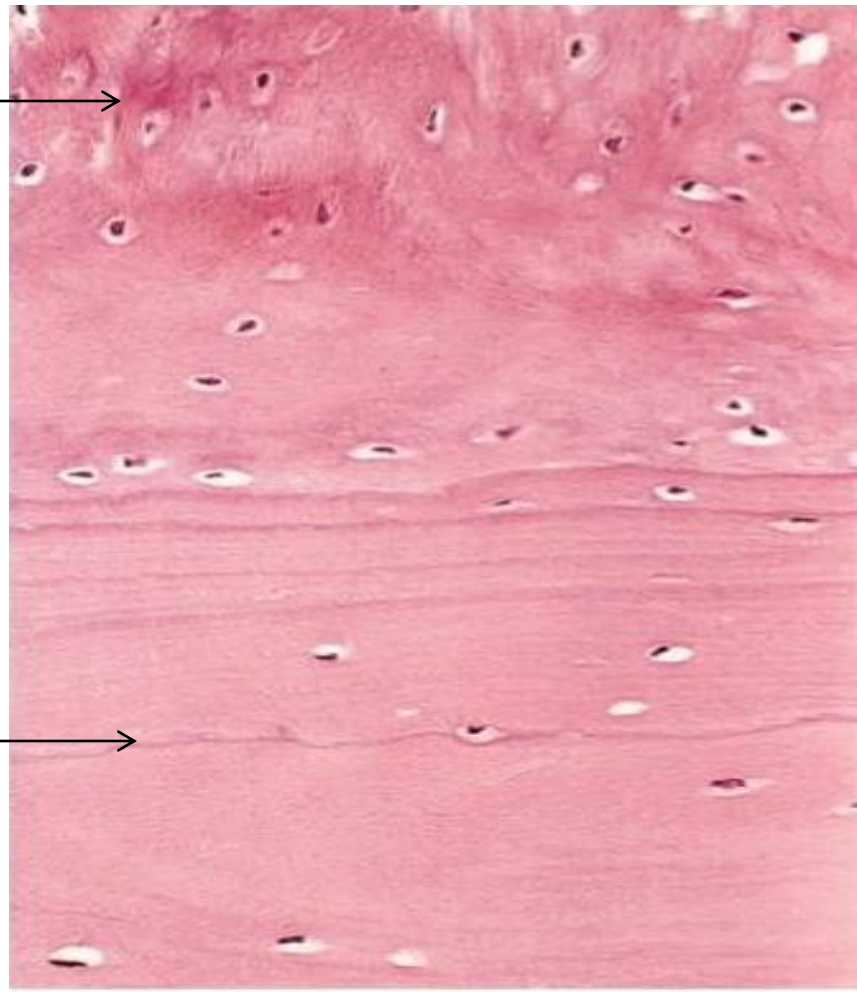
Woven Bone

- Is nonlamellar.
- Is the first bone tissue to appear in embryonic development and in fracture repair.
- Temporary, is replaced in adult by lamellar bone.
- Random deposition of type I collagen fibers
- Lower mineral content.
- Easily penetrated by x-ray.
- Number of osteocytes is relatively high.

Histological Classification

Primary = Immature = Woven

Secondary = Mature = lamellar



Lamellar Bone

- Most bone in adults, **compact or cancellous** , is organized as **lamellar bone**.
- Is multiple layers or lamellae of calcified matrix.
- The lamellae are organized either parallel to each other (cancellous) or concentrically around a central canal (compact).
- In each lamella = mainly collagen fibers type I

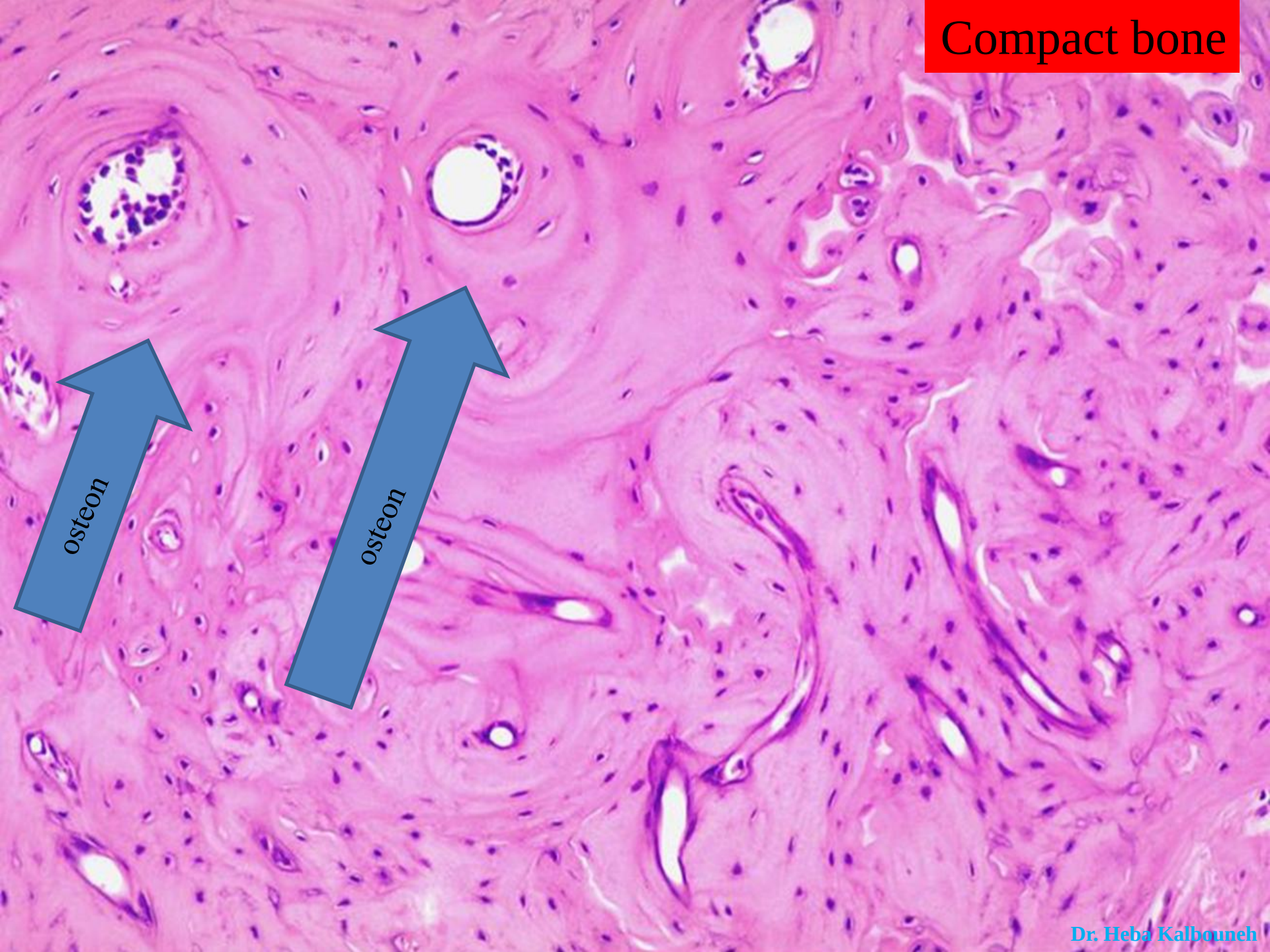
Terms:

- **Matrix**
- **periosteum**
- **Osteoprogenitor cells (osteogenic cells)**
- **Osteoblasts**
- **Osteocytes**
- **Lacuna**
- **Osteoclasts**
- **Canaliculi**
- **Filopodial process**
- **Haversian canal, system**
- **Osteon**
- **Volkmann canal**
- **Endosteum**
- **Osteoid**

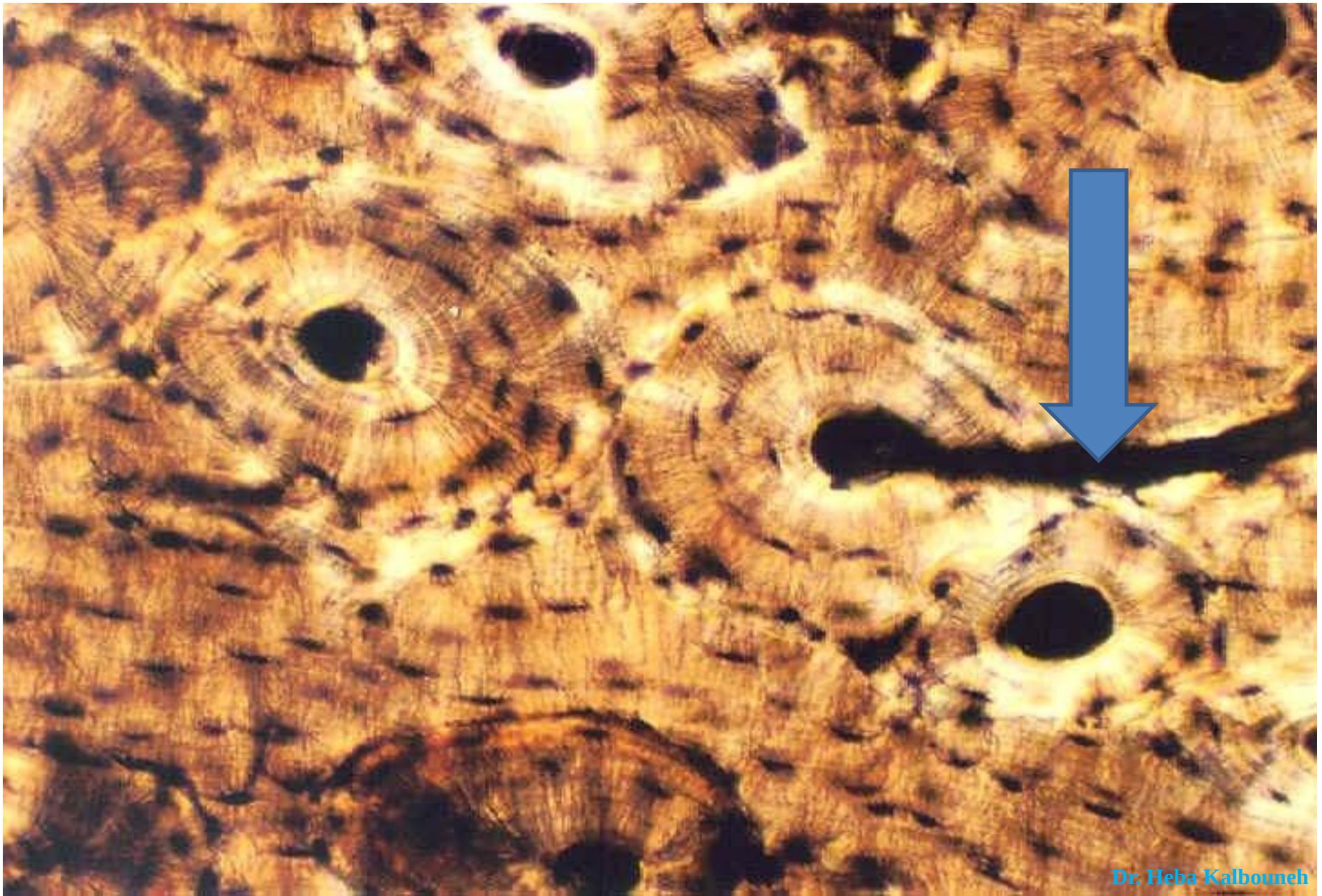
Bone tissue

Practical part

Dr. Heba Kalbouneh
Associate Professor of Anatomy and Histology

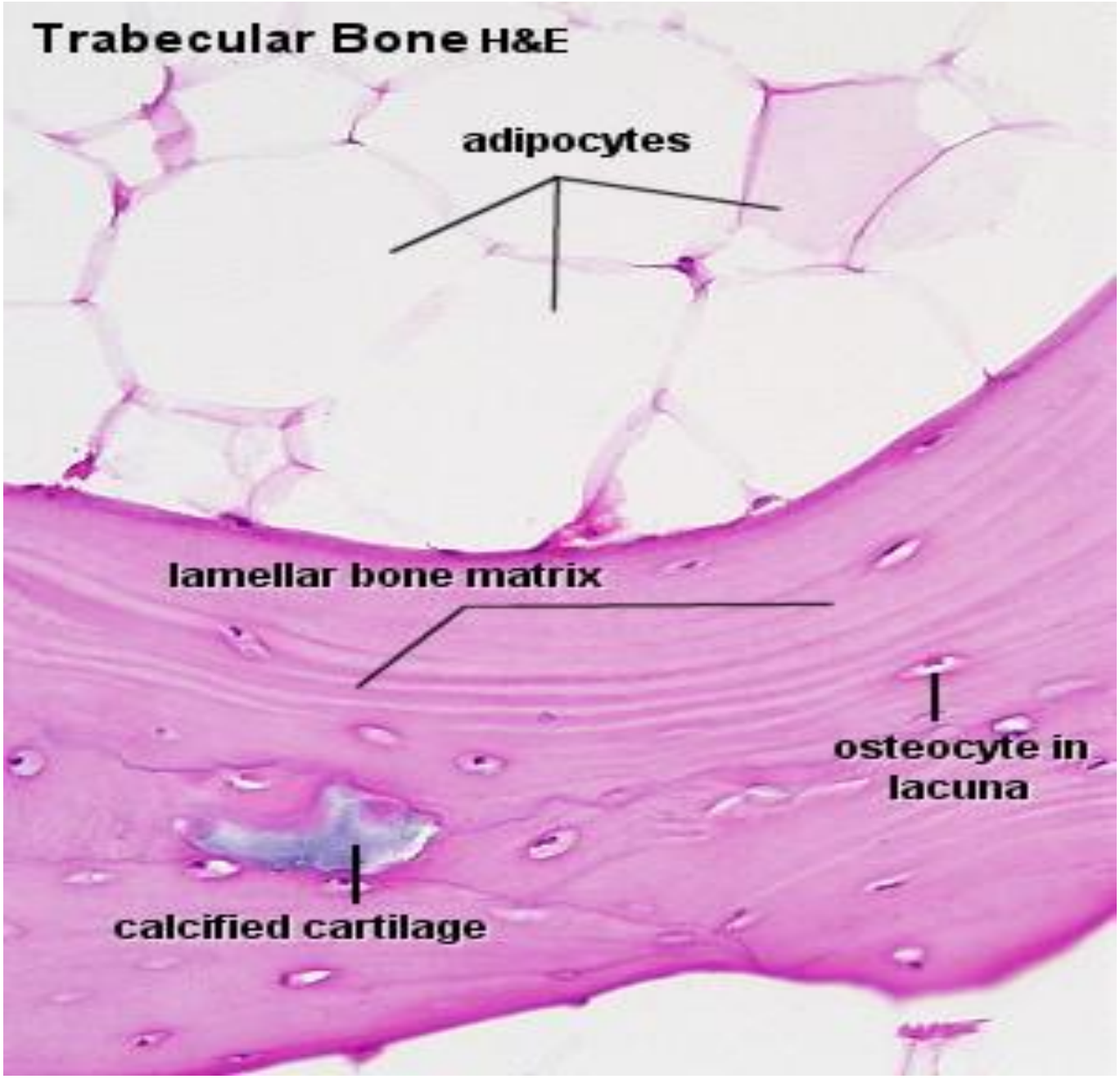

Compact bone
osteon
osteon
Dr. Heba Kalbouneh

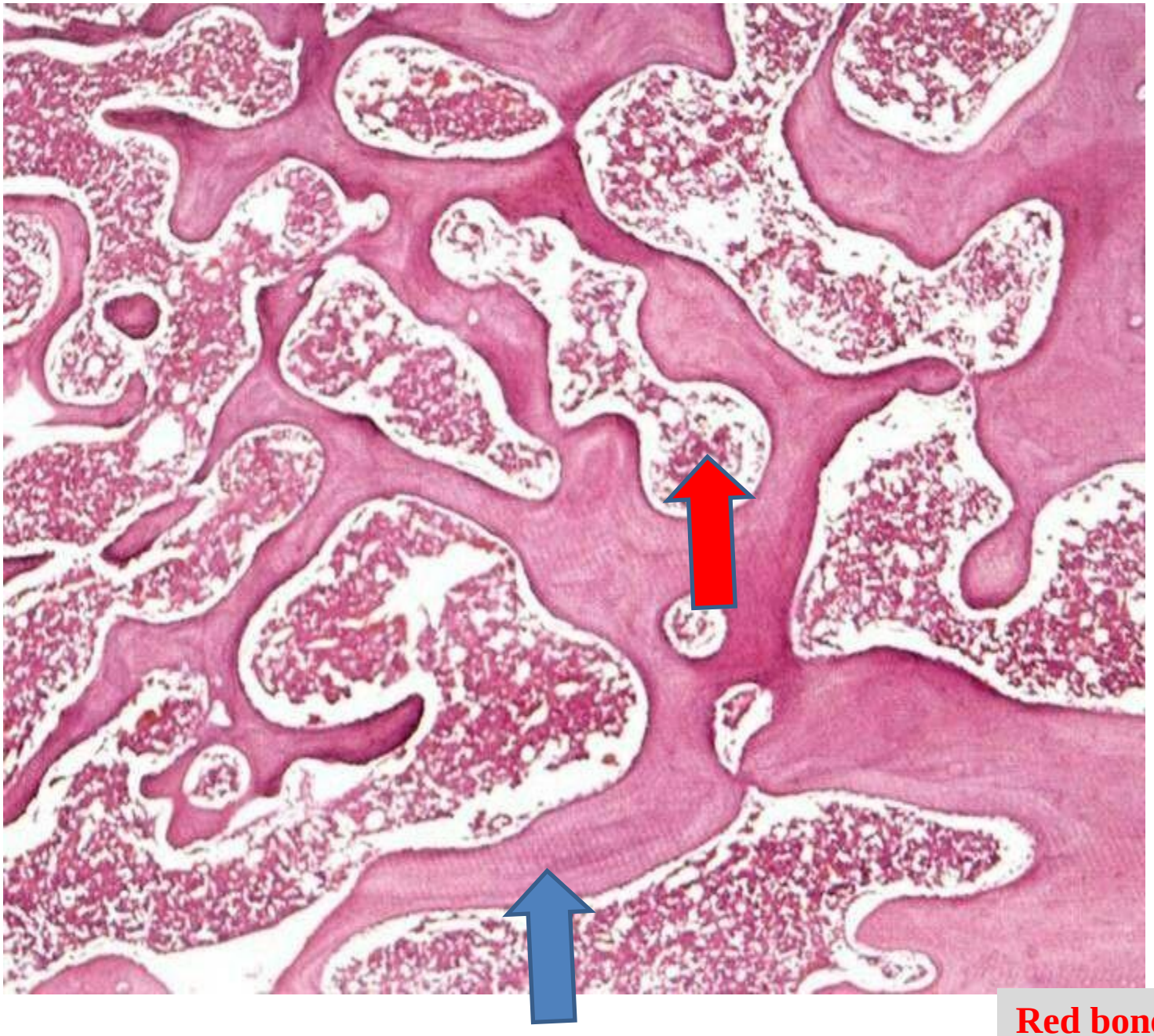
VOLKMANN'S CANAL



Red bone marrow
Trabecular bone

Dr. Heba Kalbouneh

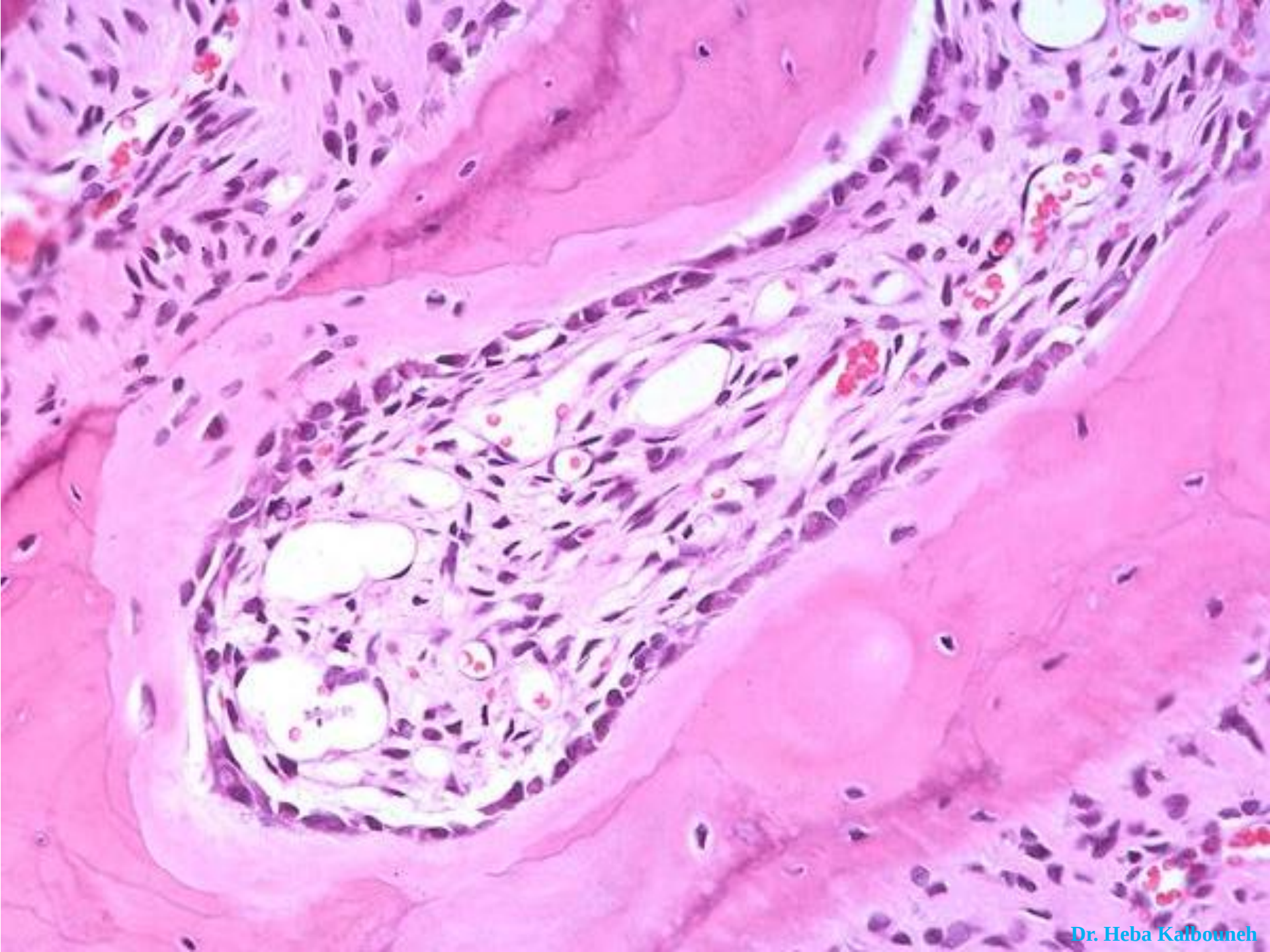

Trabecular Bone H&E
adipocytes
lamellar bone matrix
osteocyte in lacuna
calcified cartilage

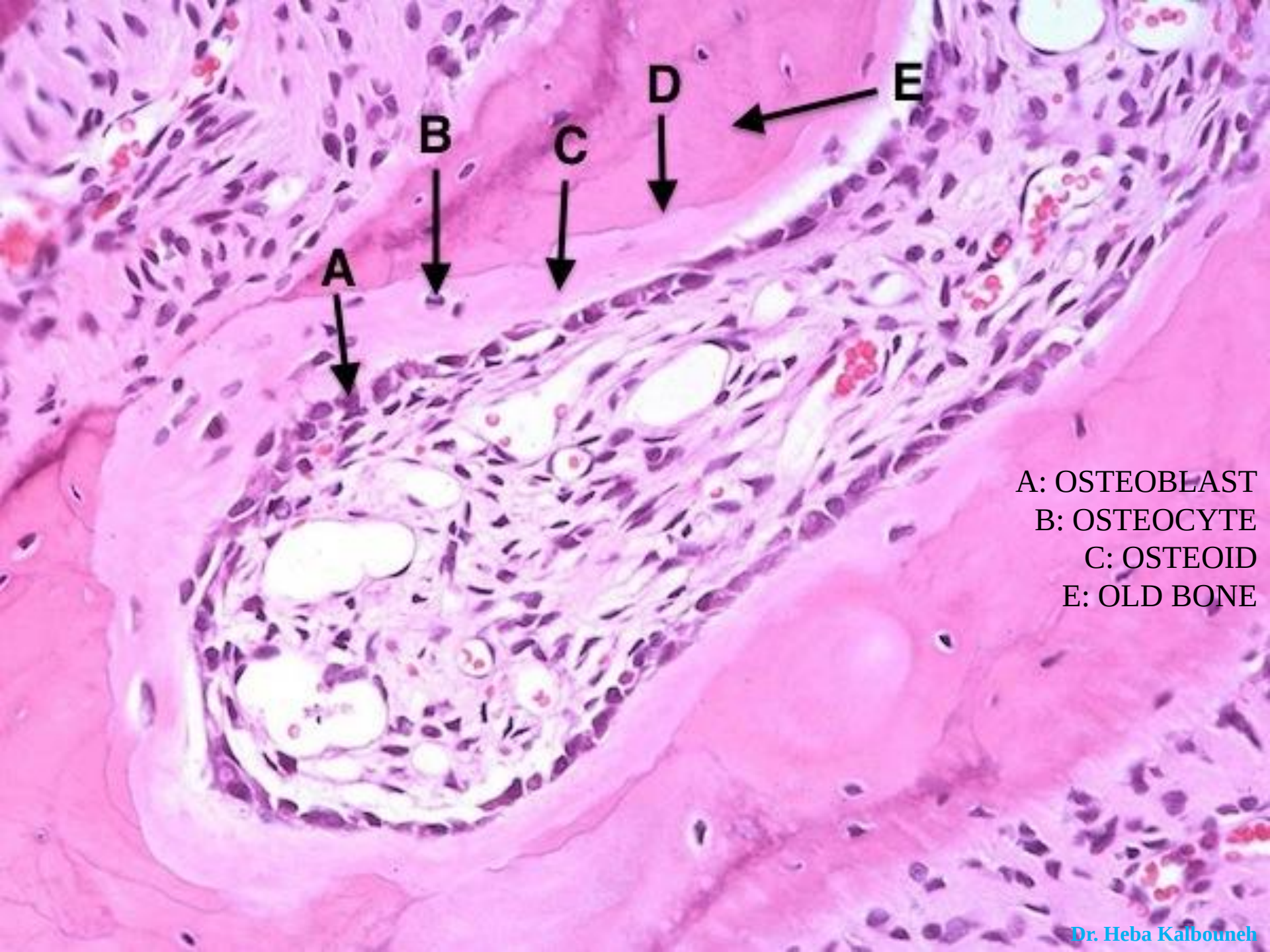


Red bone marrow
Trabecular bone

Yellow bone marrow

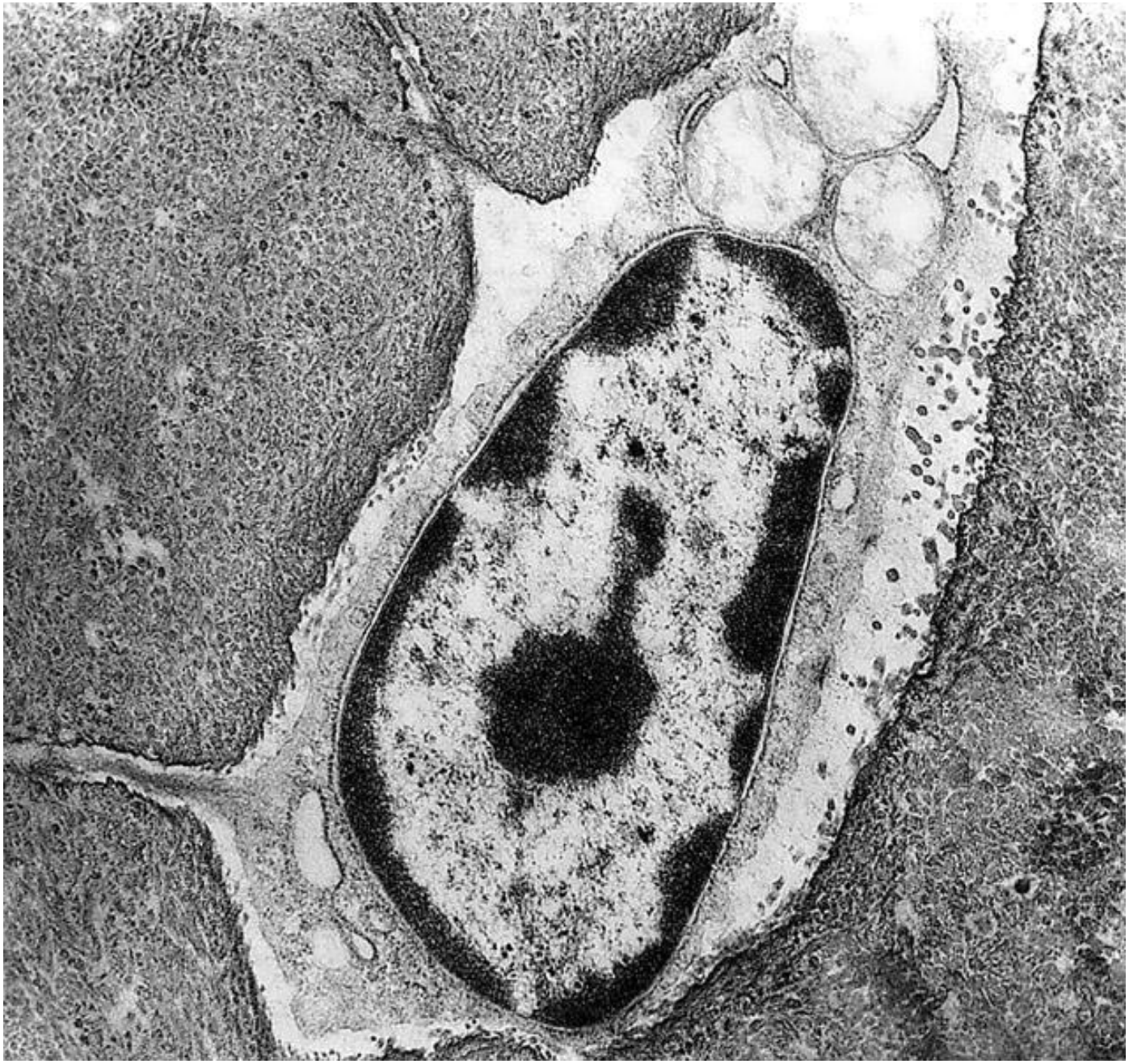
Trabecular bone

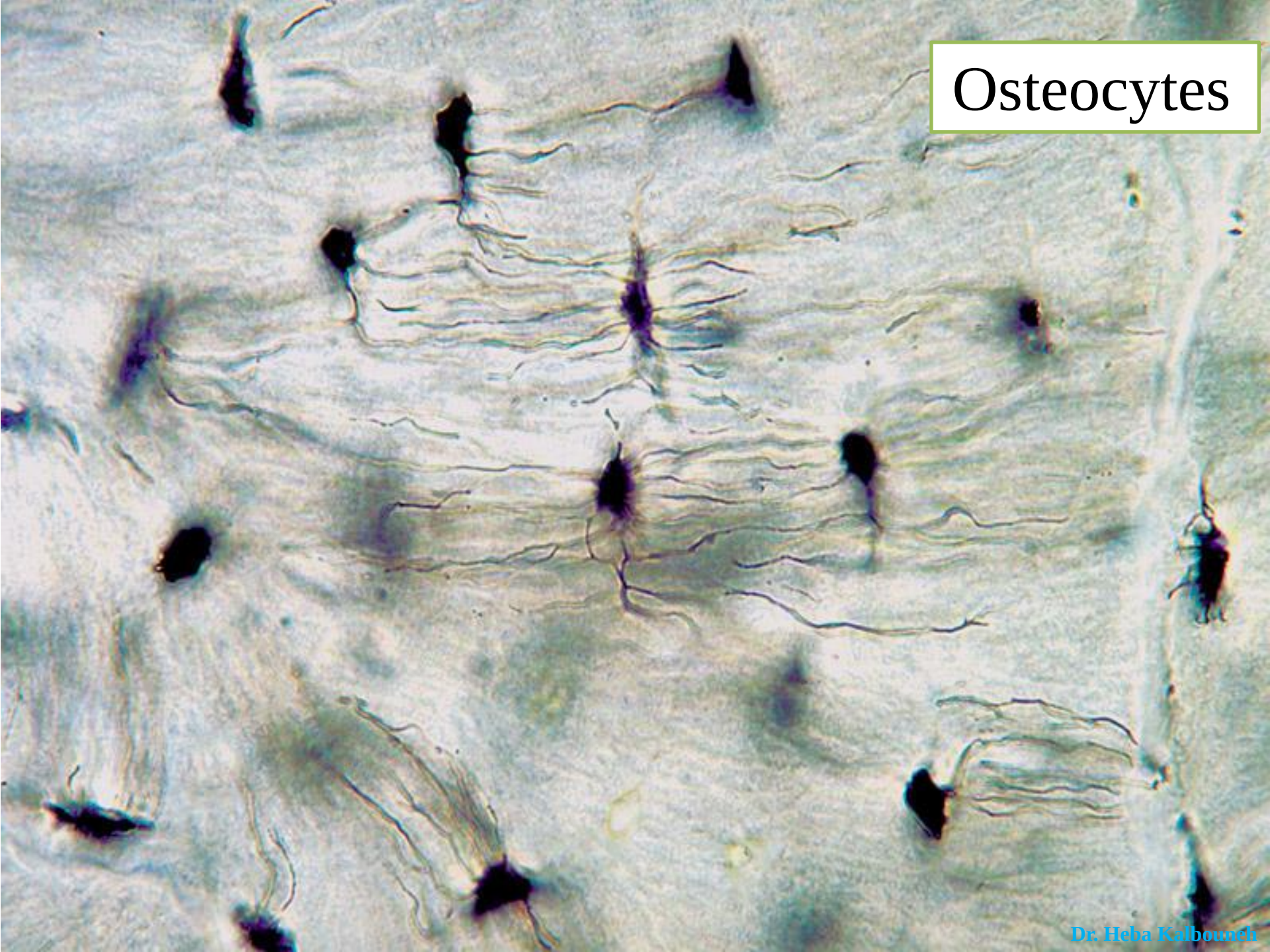




A: OSTEOBLAST
B: OSTEOCYTE
C: OSTEOID
E: OLD BONE

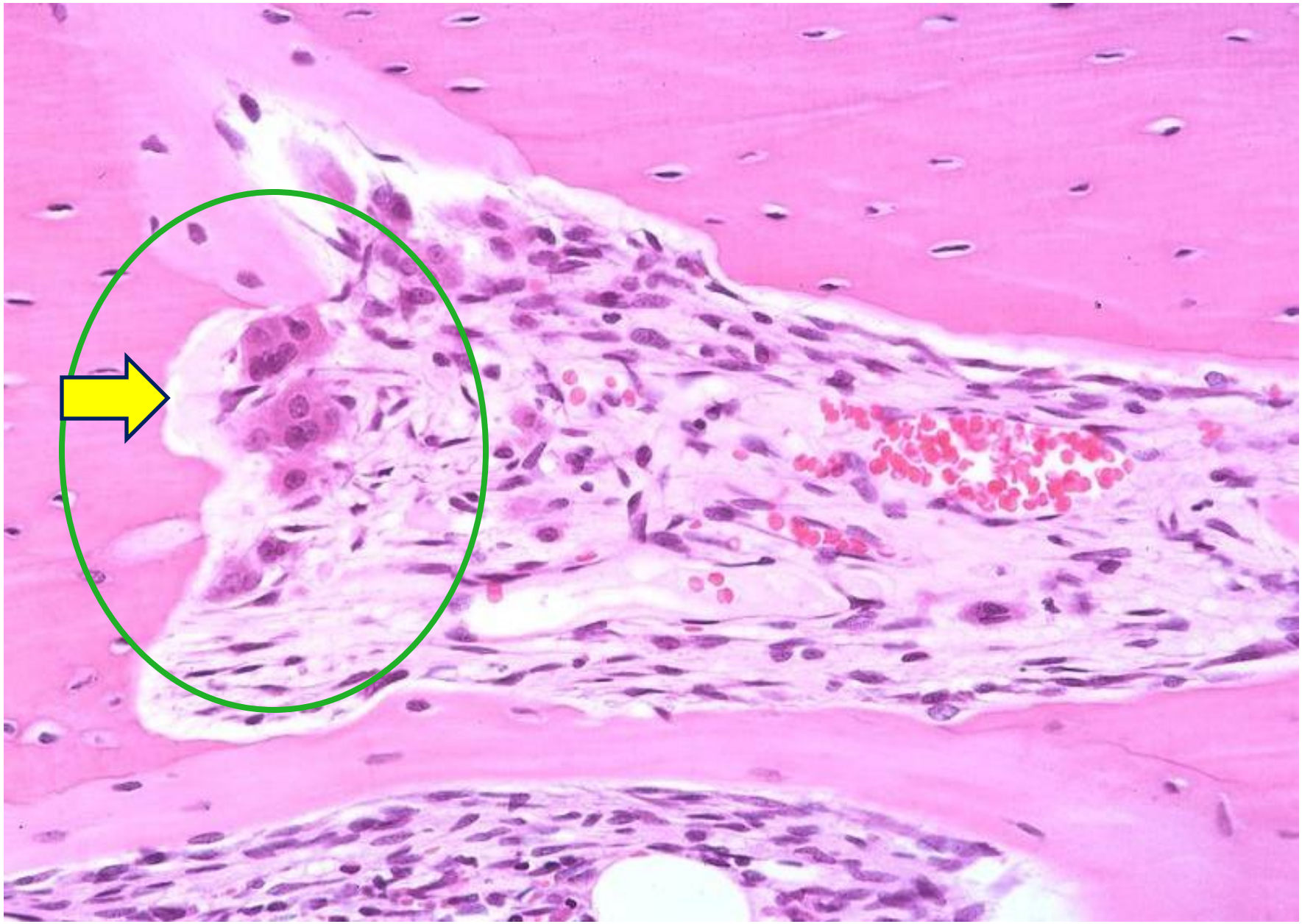
Osteocyte

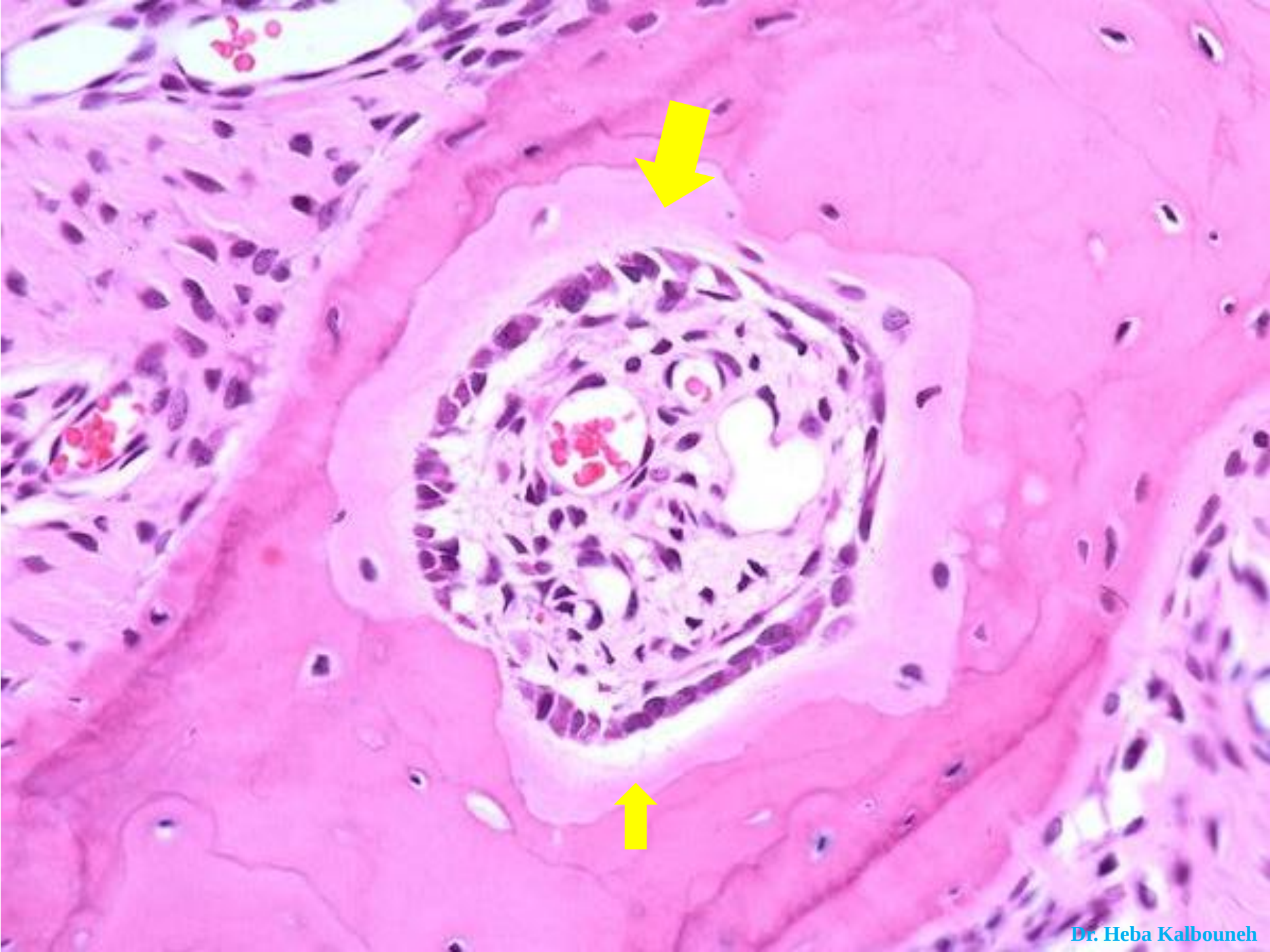


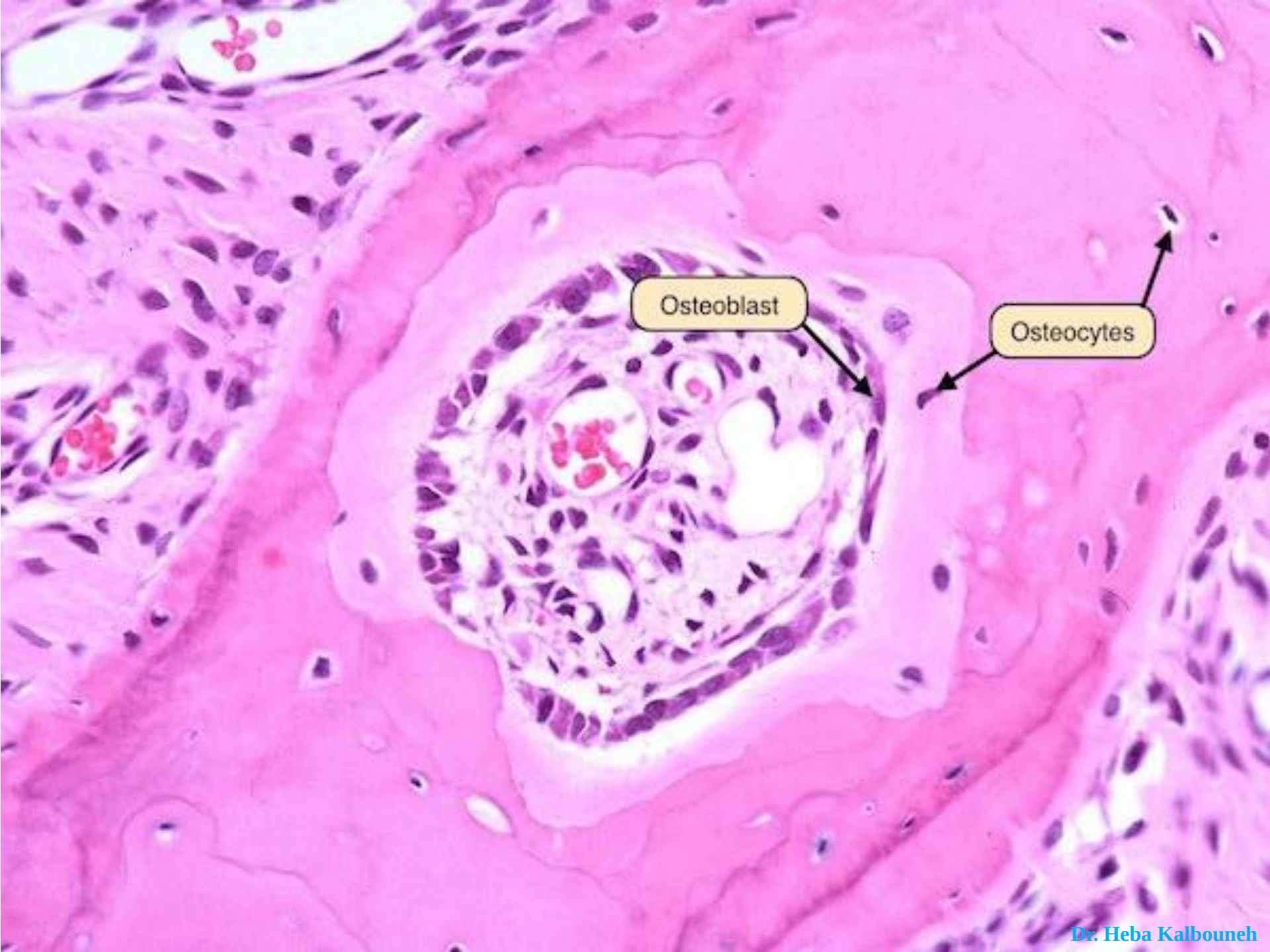

Osteocytes
Dr. Heba Kalbouneh

Howship's lacuna

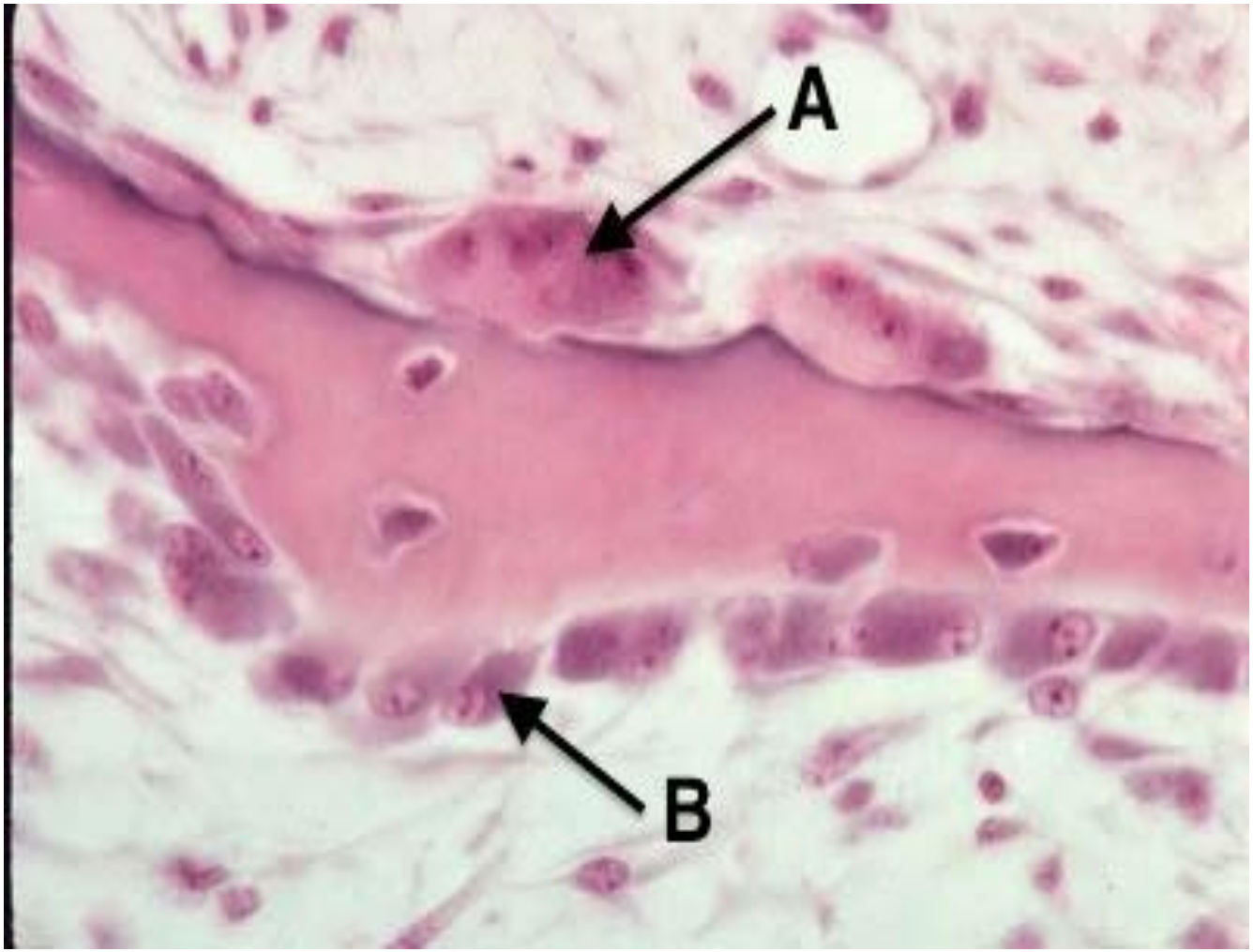
Osteoclasts







Identify



A: Osteoclast
B: Osteoblast