



HISTOLOGY OF BONE

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OUTLINE

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D. Inner Circumferential Lamellae	

SUMMARY OF ABBREVIATIONS

ABBREV	Meaning
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LEGENDS

Must know	Lecturer	Book	Presentation	Old Trans
!	👤	📖	💻	📄

LEARNING OBJECTIVES

At the end of the lecture, the student should be able to:

- ✓ Describe the general histology organization of bone as specialized connective and contractile tissues.
- ✓ Identify the major cell types, extracellular matrix components, and structural organization characteristics of each tissue.
- ✓ Differentiate the major types of bone based on their microscopic features.
- ✓ Correlate the microscopic structure of these tissues with their mechanical, metabolic, and physiologic functions.
- ✓ Interpret the basic histologic images of bone using characteristic diagnostic features.
- ✓ Apply knowledge of normal histology to selected clinical conditions involving bone

INTRODUCTION TO BONE

- Bone is a specialized connective tissue
- Major functions:
 - Mechanical support
 - Protection
 - Movement
 - Mineral storage
 - Calcium and phosphate
 - Hematopoietic support
 - Specially for babies
 - Endocrine/metabolic functions

BONE MATRIX

Organic Component	Inorganic Component
• Type 1 collagen - 90% • Osteocalcin-	• Calcium hydroxyapatite - maintains rigidity of

maintenance of bones

- Phosphatases

bone; most abundant

- Bicarbonate - 2nd most abundant
- Citrate
- Magnesium
- Potassium
- Sodium - small amounts
- Calcium phosphate - small amounts

around 50% of the bone are the minerals or inorganic

BONE CELLS

- Osteoprogenitor cells
- Osteoblasts
- Osteocytes
- Osteoclasts

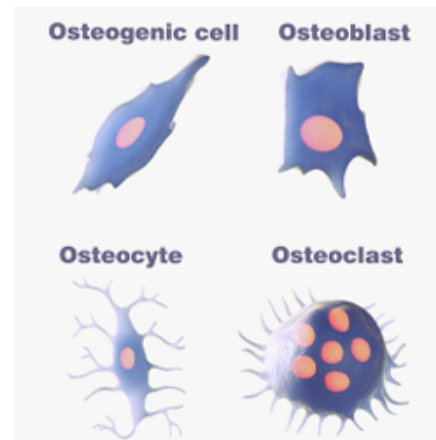


Figure 1. Different types of bone cells

OSTEOPROGENITOR CELLS

- Mesenchymal stem cells
- Stellate to squamous in shape
- Give rise to osteoblasts
 - May differentiate into other types of connective tissue cells
- Can be found in:
 - Mesenchyme
 - Innermost layer of periosteum (covering of bone)
 - Endosteum
 - Bone marrow

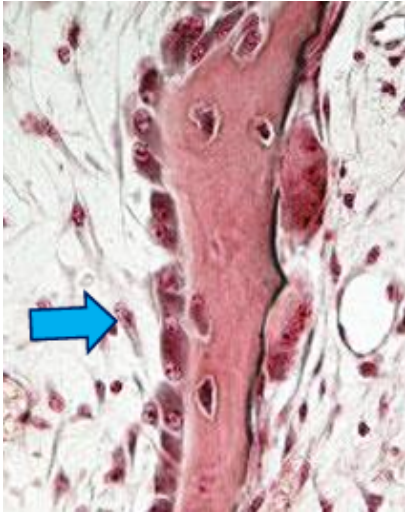


Figure 2. Osteoprogenitor cells (*may buntot daw and squamous*)

OSTEOBLASTS

- Originate from mesenchymal stem cells
- Morphology:
 - **Active:** Cuboidal to columnar with basophilic cytoplasm and euchromatic nuclei and distinct nucleoli
 - **Inactive:** Squamous → difficult to identify
- Secrete **osteoid** (organic matrix)
- Can be found in:
 - Innermost layer of periosteum
 - Endosteum
 - Newly forming bone tissue

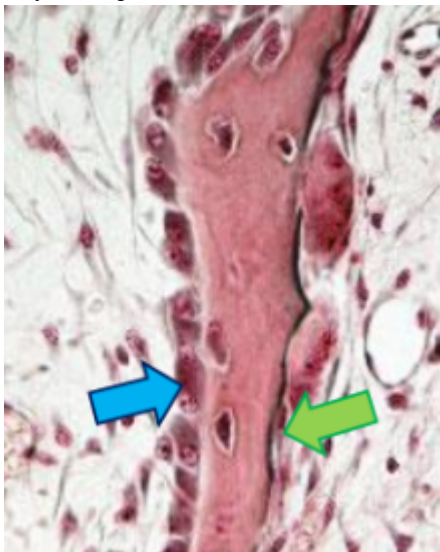


Figure 3. Osteoblast (Blue arrow- active; Green arrow- inactive; *nasa lining nakadikit*)

OSTEOCYTES

- Originated from osteoblasts encased in calcified matrix
 - parang chondrocytes
- Has a dendritic morphology
- Maintains the bony matrix and has a role in mechanotransduction
- Can be found in:
 - Lacunae
 - Cell processes in canaliculi

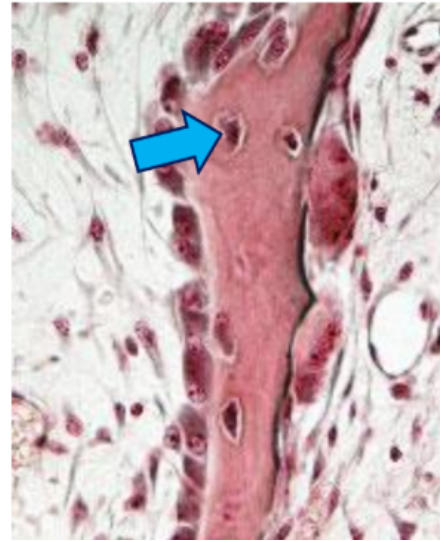


Figure 4. Osteocytes (*irregular shape in light microscopy*).

OSTEOCLASTS

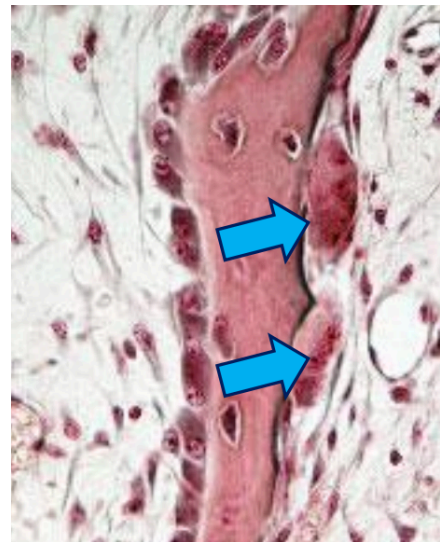
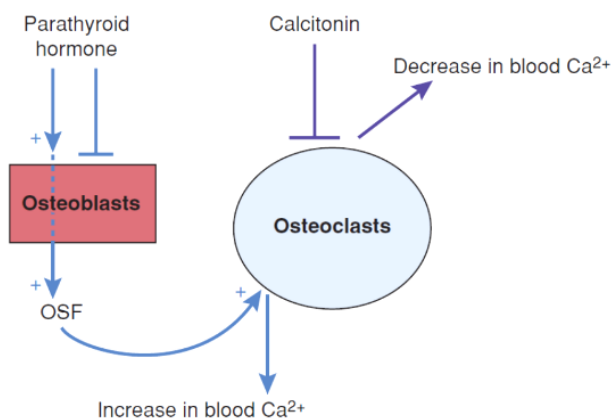


Figure 5. Osteoclasts (blue arrow).

- Large, multinucleated macrophage derivative
- Resorb bone tissue
- Can be found in:
 - **Resorption bays or Howship lacunae**
 - A concave depression on bone surface, scattered throughout endosteum and periosteum



🧑‍🔬 Yung ating mga [bone] cells, hindi lang nag function on their own, but also influenced by our hormones. **Parathyroid hormone** acts on the **osteoblasts**, while **Calcitonin** acts on **osteoclasts**.

🧑‍🔬 Calcitonin activates osteoclasts, then yung osteoclasts kakainin niya kaunti yung bone para mag release tayo ng calcium.

🧑‍🔬 PTH activate the osteoblasts for development of bone. Then magkakaroon ng stimulating factor (OSF) and other substances (nas secreted by the osteoblasts) to influence activation of osteoclasts.

PERIOSTEUM

- Dense connective tissue
- Function:
 - Deliver neurovascular supply to the bone
 - Allow tight attachment of the muscles and other structures to the bone
- Located at: outer surfaces of most compact bones

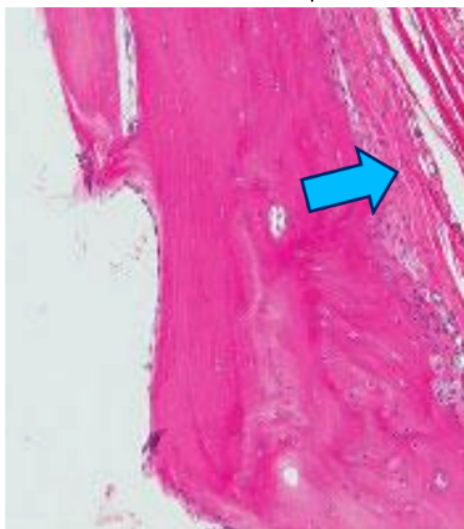


Figure 6. Periosteum (blue arrow)

- Outer fibrous layer
 - Dense connective tissue
 - Contains mostly type I collagen, fibroblasts and blood vessels
 - Perforating or Sharpey fibers
 - Bundles of periosteal collagen that bind the periosteum to the bone
 - Inner osteogenic layer
 - Contains osteoblasts, bone lining cells, and osteoprogenitor cells.

ENDOSTEUM

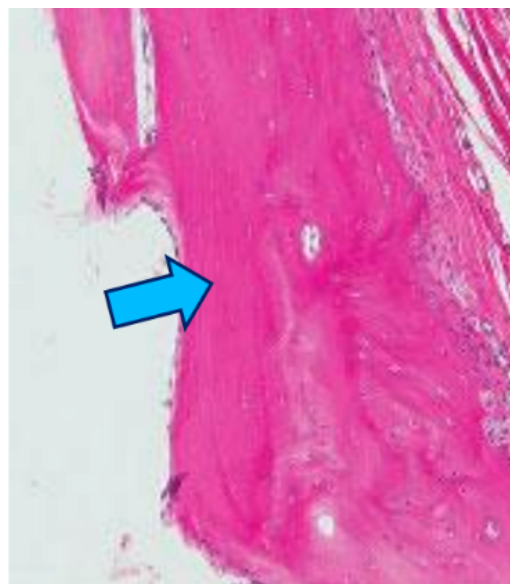


Figure 7. Endosteum (blue arrow)

- Resembles simple squamous epithelium
- Composed of inactive osteoblasts, osteoprogenitors, and osteoclasts within a sparse, delicate matrix of collagen fibers.
- Covers trabeculae of bony matrix that project into the marrow cavities
- Located at:
 - Inner surfaces of compact bones, canals
 - Outer surfaces of all spongy bones

TYPES OF BONE

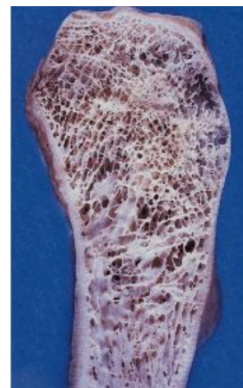


Figure 8. Bone.

- 🧑‍🔬 classified as to structural pattern:
 - **Compact bone**
 - **Cancellous bone**
- 🧑‍🔬 classified as to the distribution of collagen fibers in the bone matrix
 - **Woven bone**
 - **Lamellar bone**

COMPACT (CORTICAL) BONE

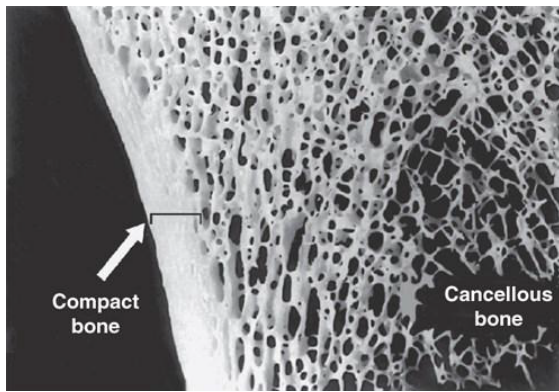


Figure 9. Compact bone (white arrow).

- Represents 80% of the total bone mass
- Made up of parallel bony columns which are disposed parallel to the long axis
- 🧑 Usually, our long bones kasi patayo, so kailangan parallel din yung ating mga fibers and bone matrix. WHY? For structural integrity. Since weight-bearing ang long bones natin and its line of stress is from top to bottom. If perpendicular ang fibers, mababasag ang bone.
- Function:
 - Weight bearing and weight transfer
 - Protection
 - Site of muscle attachment
- Found in the peripheries of most bone
 - Thicker in the diaphysis of long bones
- 🧑 in the compact bone, you can also find the osteon or haversian system

OSTEON OR HAVERSIAN SYSTEM

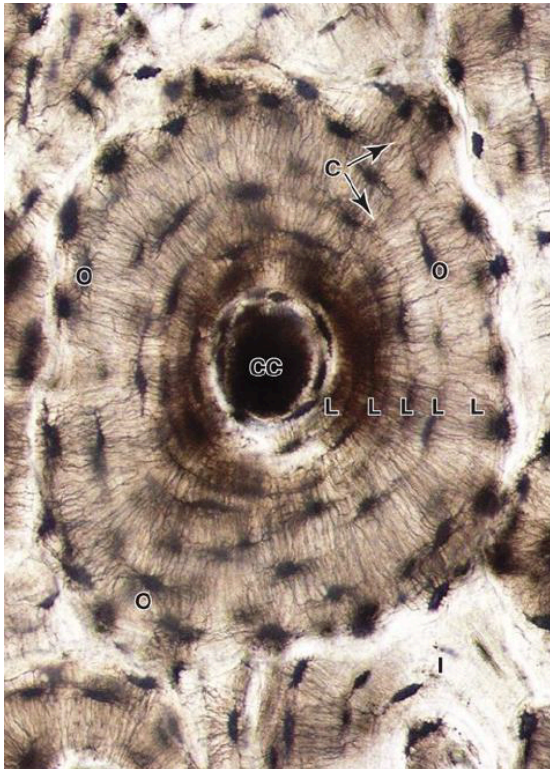


Figure 10. Osteon or haversian system

CC = Central Canal
L = Lamellae
O = osteons in lacunae
C = Canaliculi
I = Interstitial lamellae

- Refers to the complex 5-20 concentric lamellae, surrounding a central canal that contains small blood vessels, nerves, and endosteum
- Constitute most of the compact bone
- Found throughout compact bone
- Oriented parallel to the long axis of the bone or in the direction of applied force

Central/ Haversian Canal

- Central channel for vessels and nerves
- Conduct vessels and nerves throughout the length of the osteon
- Located at the center of each osteon

Perforating/ Volkmann Canal

- Channel that runs perpendicular to the long axis of osteon
 - once it becomes a transverse line it becomes a volkmann canal
- Function:
 - Conduct vessels and nerves throughout the length of the osteon
 - Deliver vessels and nerves throughout the thickness of the compact bone
- Location varies
 - due to being transversal so it has no fixed location

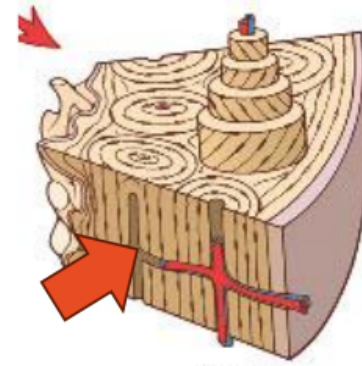


Figure 11. Volkmann Canal (red arrow)

Concentric Lamellae

- Concentric layers of bony matrix with collagen fibers in each layer running in opposite directions
 - layered arrangements and fiber orientation allow optimal weight bearing and even weight transfer
- Located at the rings of bony matrix in each osteon
- 🧑 para mas madali hanapin una hanapin ang central canal tapos hanapin mo yung black line na pabilog tapos ayun na yung concentric lamellae

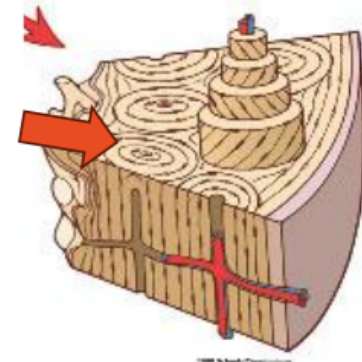


Figure 12. Concentric Lamellae (red arrow)

Cement Line

- Darker staining line
- Located at the outer boundary of each osteon
- Its function is to demarcate the outer limits of each osteon
- 🧑‍🔬 Minsan hindi lumalabas ang concentric lamellae at ito ang makikita instead
 - 🧑‍🔬 para makita lng yung border ng osteon

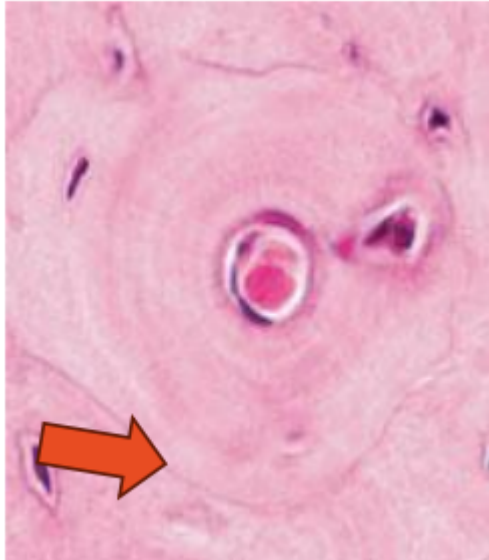


Figure 13. Cement Line (Red arrow) surrounds a single osteon with the middle being the central Haversian canal.

INTERSTITIAL LAMELLAE

- Irregularly shaped groups of parallel lamellae scattered among the intact osteons
- Located in between osteons
- Functions:
 - Fill the gap between osteons
 - 🧑‍🔬 for tensile strength leading to:
 - Weight bearing and transferring
 - Remnant of remodeled osteon

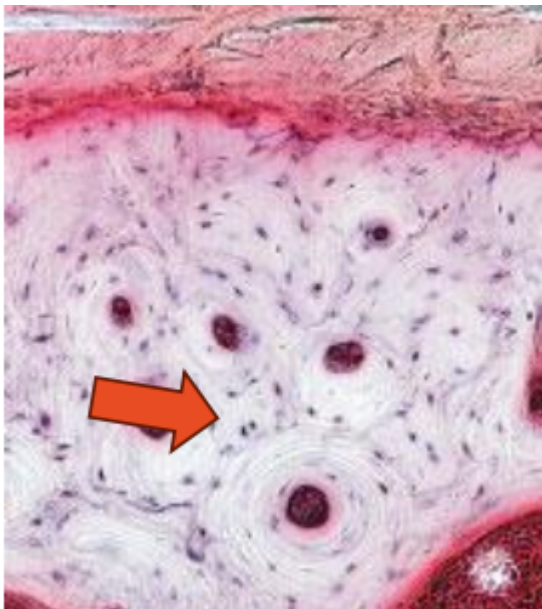


Figure 14. Interstitial lamellae (red arrow) spaces between osteons. The tiny black spots surrounding each osteon being lamellae and with the Haversian canal in the center of each osteon.

- 🧑‍🔬 If walang cement line or central canal then most likely it is an interstitial lamellae
 - 🧑‍🔬 Landmark : Cement Line and the Central Canal

OUTER CIRCUMFERENTIAL LAMELLAE

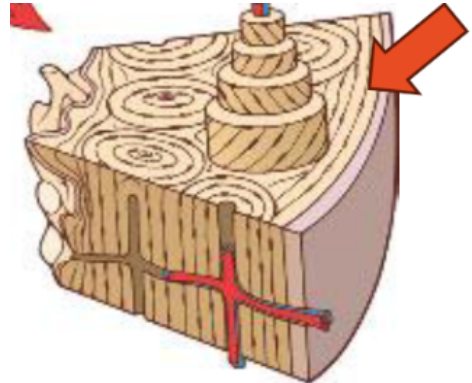


Figure 15. Outer circumferential lamellae (red arrow).

- Several layers of bony matrix on the outermost side of the compact bone.
- Located in the outermost layer of the compact bone.
- Function:
 - Bind the osteons from the outside
 - Serves as the site of attachments for periosteum
- 🧑‍🔬 pag ang **layer** is katabi ng periosteum, at walang (absence) osteons, that **layer** is **outer circumferential lamellae**.

Sharpey Fibers

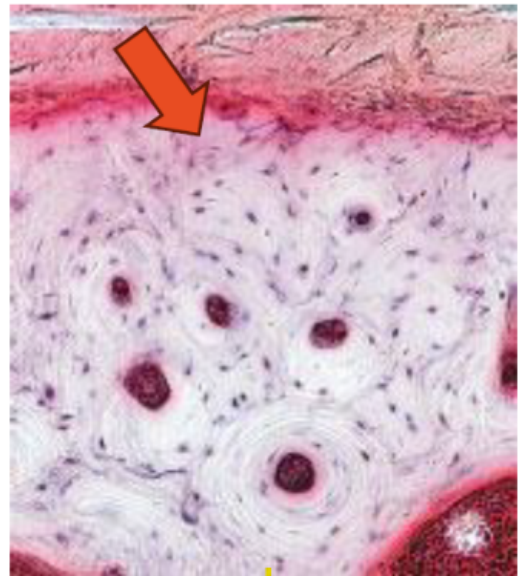


Figure 16. Sharpey Fibers (red arrow)

- 🧑‍🔬 as we can see on the figure, deep pink line is the **periosteum**, outer dense pink layer is the **muscle layer**, inner light pink layer na may "itim-itim" are the **Sharpey fibers**.
- Thick, ropy bundles of collagen type I fibers
- Extend from periosteum into the outer concentric lamellae and often deeper into the peripheral osteons (🧑‍🔬 because as we can see, some Sharpey fibers are in the first set of osteons, immediately after the OCL)
- Function:
 - Tightly anchor periosteum to the compact bone

INNER CIRCUMFERENTIAL LAMELLAE

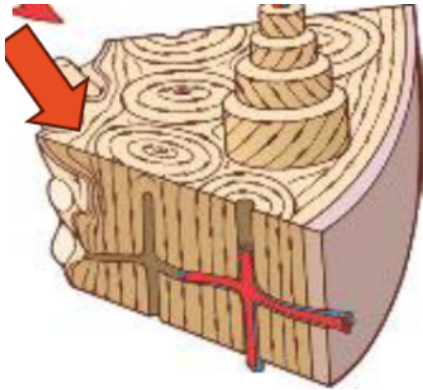


Figure 17. Inner circumferential lamellae.

- absence of osteons in this layer
- Several layers of bony matrix on the inside of the compact bone
- Innermost layer of the compact bone
- Function:
 - Bind the osteons from the inside
 - Site of attachment for endosteum
- **REMEMBER!** sa inner circumferential lamellae (ICL) ang naka-attach is endosteum, sa OCL naman naka-attach is periosteum

TRABECULAR OR SPONGY BONE

- Cancellous or Medullary bone
- represents 20% of the total bone mass
 - usually seen at the ends of long bones
- made up of a network of thin plates of bony tissues with spaces in between
- Function:
 - has some role in weight transfer
 - since maraming spaces, hindi lang basta downward 'yung direction ng force; nadi-disperse 'yung force so hindi masiyadong naste-stress 'yung bones
 - reduce the weight of the bones
 - provide a large surface area for bone resorption and formation
- found in the center of diaphysis and epiphysis of long bones and in the center of most bones
- **Histological features:** Interconnected thin spicules or trabeculae covered by endosteum
- **Major location:** inner region of bones, adjacent to marrow cavities

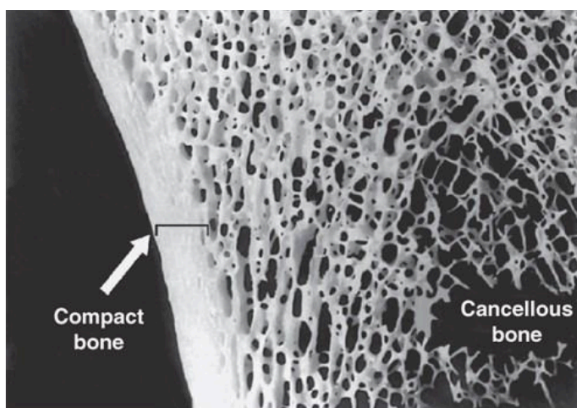


Figure 18. Cancellous Bone (Netting).

Trabecula

- small, thin, short bony tissues
- in adults, bony matrix is lamellar (layered)
- no osteons (! / 🧑🏻 osteons: only seen in the compact bone)
- Function:
 - collectively allow weight transfer
 - source of quick bone absorption and formation
- located throughout central position of most bones

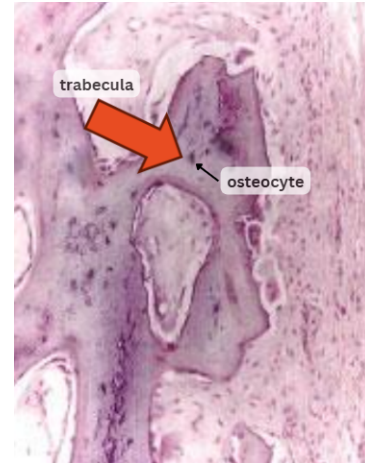


Figure 19. Trabecula (red arrow)

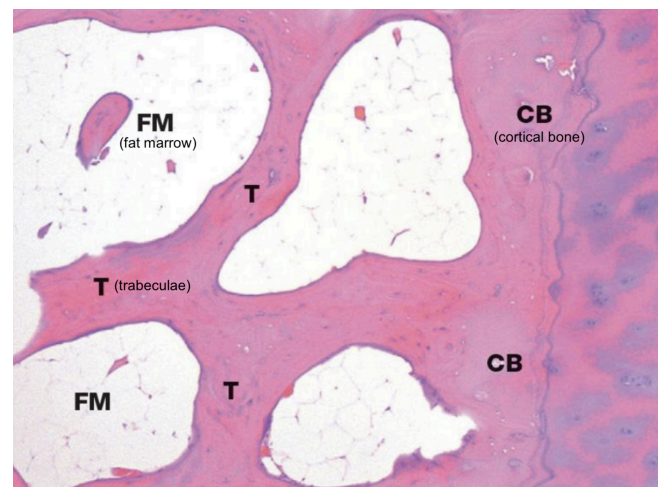


Figure 20. Cortical and Trabecular Bone

- Yung cortical bone (CB) wala siyang space, dikit-dikit/compact siya
- Once you see spaces, nasa trabeculae (T) or spongy bone ka na. In this figure, yung nakikita sa spaces ay adipose tissues or **Fat Marrow (FM)**

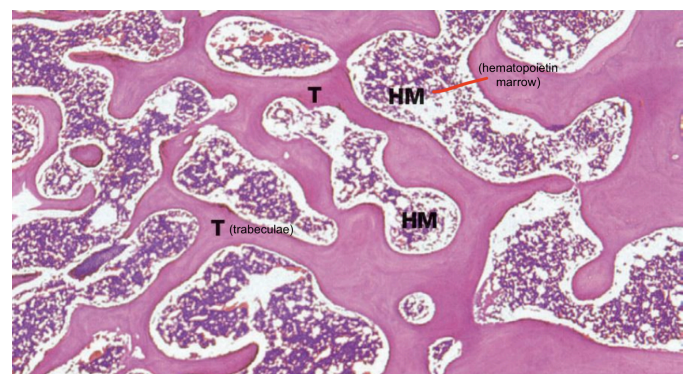


Figure 21. Trabecular Bone

- 🧑 Yung spaces in between dito sa figure presents to be dark. It contains the **Hematopoietin Marrow (HM)**. Usually makukuha sa younger patients.
- 🧑 | ! Fatty Marrow = Light; Hematopoietin Marrow = Dark

WOVEN BONE

- 🧑 Woven Bone and Lamellar Bone - depende sa pagkakalayout ng collagen fibers
- A.k.a. **Immature** or **primary bone**
- First bone tissue that forms during ossification process.
- Newly formed bone with **randomly arranged collagen fibers**.
- Found in the fetus during initial skeletal development and in repair of bone fractures
- Temporary – replaced by lamellar bone

LAMELLAR BONE

- A.k.a. **Secondary** or **mature bone**
- Forms through remodeling of the woven bone.
- Exhibits multiple parallel or concentric layers of calcified matrix arranged in an orderly manner around the central canals
- Found in adult bone

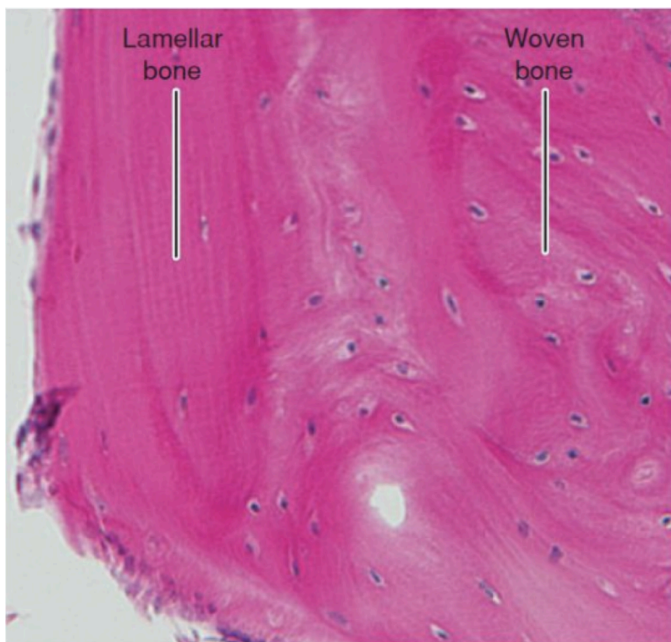


Figure 22. Lamellar vs Woven Bone

BONE GROWTH

APPOSITIONAL (RADIAL) BONE GROWTH

Bones increase in diameter as new bone tissue is added beneath the periosteum. During radial bone growth, new bone is formed at the periosteal (outer) surface while bone is simultaneously removed at the endosteal (inner) surface, enlarging the medullary (marrow) cavity without greatly increasing bone weight.

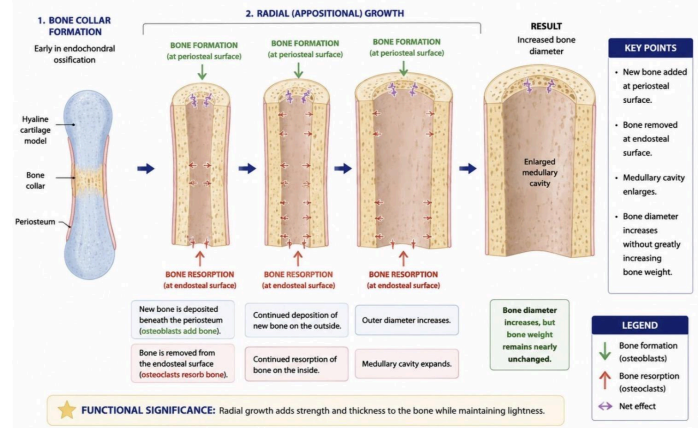


Figure 23. Appositional Bone Growth

CLINICAL CORRELATION: OSTEOPOROSIS

- **HISTOLOGY PEARL**
- Osteoporosis does not primarily mean "soft bone."
- It is characterized by reduced bone mass and compromised bone microarchitecture, resulting in increased bone fragility.
- Bone remodeling is essential for maintaining bone strength — but when resorption persistently exceeds formation, bone mass and microarchitecture deterioration
- ↓ Bone Mass + Deterioration of Bone Microarchitecture
- Osteoclast-mediated resorption > Osteoblast-mediated formation

Histologic Change	Clinical Consequence
↑ Bone resorption	↓ Bone mass
Thinning of trabeculae	Loss of structural support
Loss of trabecular connections	↓ Mechanical strength
↑ Cortical porosity	Increased fragility
Altered remodeling balance	↑ Fracture susceptibility



Figure 24. Osteoporosis

Table 1. Summary of Types of bone.

Type	Key Histologic Feature	Main Location
Compact Bone <i>Cortical</i>	- Densely packed - Osteons + lamellae - Strong structural support	Outer Cortex of bones
Cancellous Bone <i>Spongy / Trabecular</i>	- Thin trabeculae - Endosteum-lined - Marrow spaces between trabeculae	- Inner bone - Adjacent marrow cavities
Woven Bone <i>Immature / Primary</i>	- Random collagen arrangement - Loosely organized - Lightly mineralized	- Developing bone - Fracture callus
Lamellar Bone <i>Mature / Secondary</i>	- Organized collagen in lamellae - Regularly arranged osteocytes - Highly mineralized	All normal adult bone