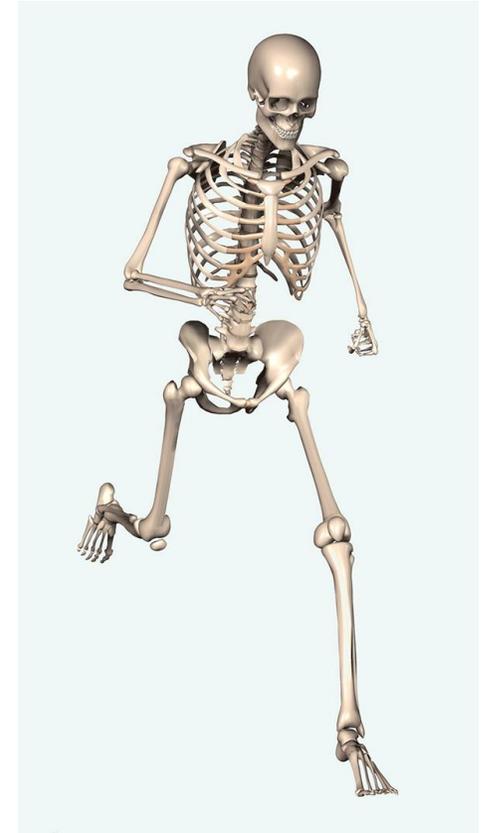


# HISTOLOGY OF BONE

part I

**Dr AMAL ALBTOOSH**



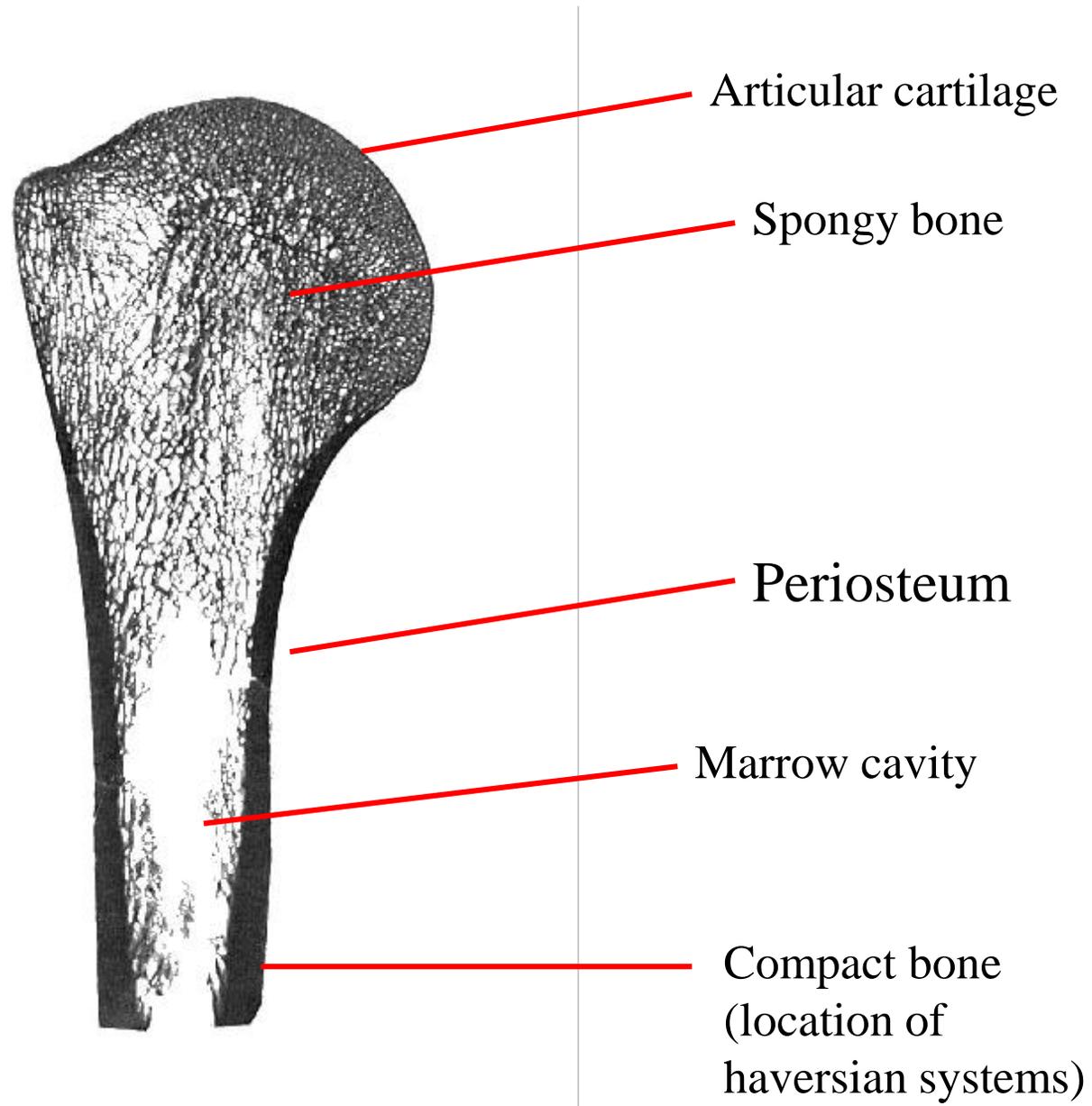
## Learning Objectives

- Understand the definition and function of bone
- Explain the composition of the bone matrix.
- Explain the bone cells.

# BONE

Bone is a specialized/ Modified connective tissue composed of calcified extracellular material, the **bone matrix** , and three major cell types

- Highly vascular mineralized connective tissue
- consisting of cells and dense intercellular organic matrix saturated with inorganic salts.
- Provide support & protection to the vital organs
- Forms skeletal framework
- a hematopoiesis organ[hematopoietic system, which includes organs and tissues such as the **bone marrow, liver, and spleen**]
- and to provide a storage site for phosphate and calcium (bone contains about 99% of the body's calcium).



Articular cartilage

Spongy bone

Periosteum

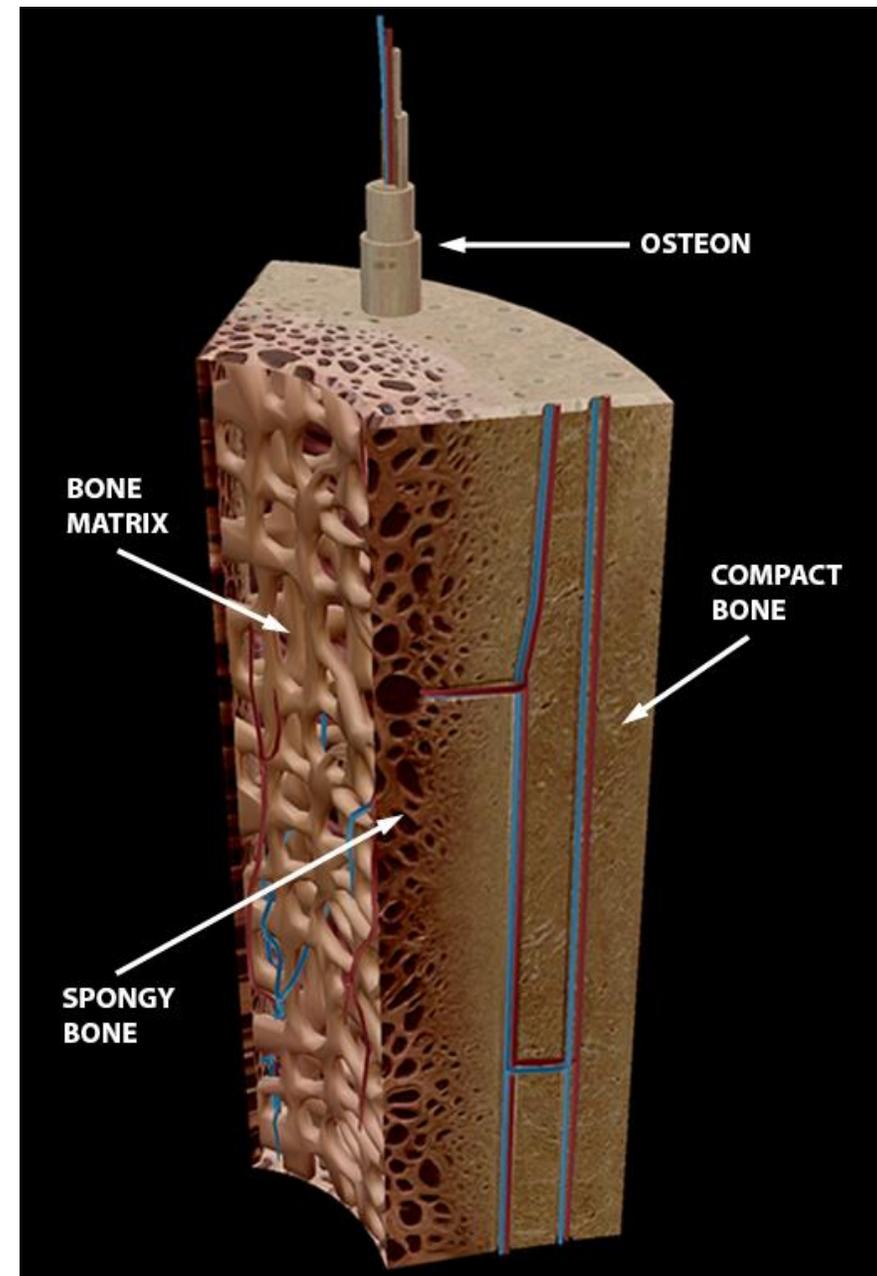
Marrow cavity

Compact bone  
(location of  
haversian systems)

Bone is divided into two types that are different structurally and functionally. Most bones of the body consist of both types of bone tissue:

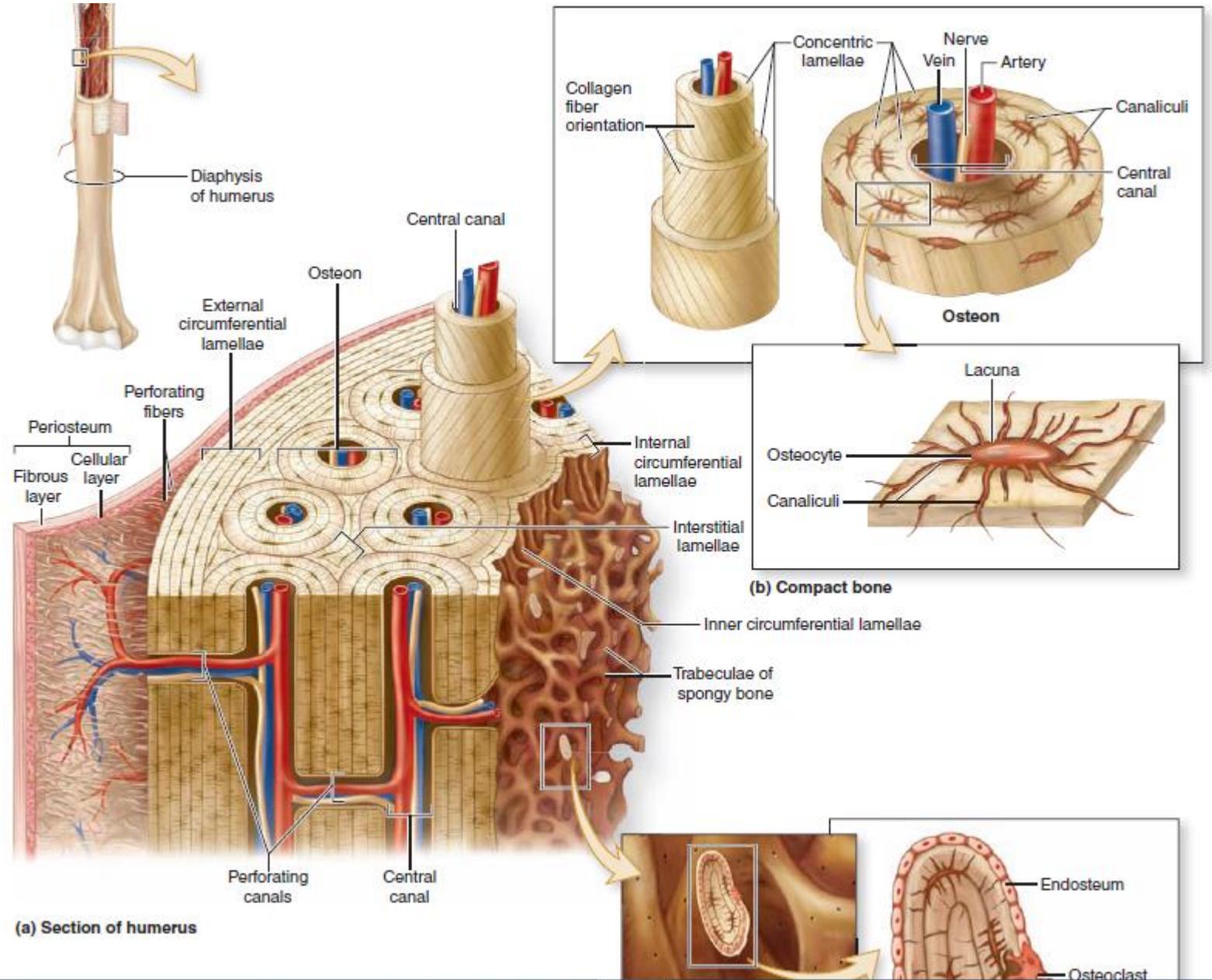
- **COMPACT BONE** [AKA cortical bone] mainly serves a mechanical function. This is the area of bone to which ligaments and tendons attach. It is thick and dense.

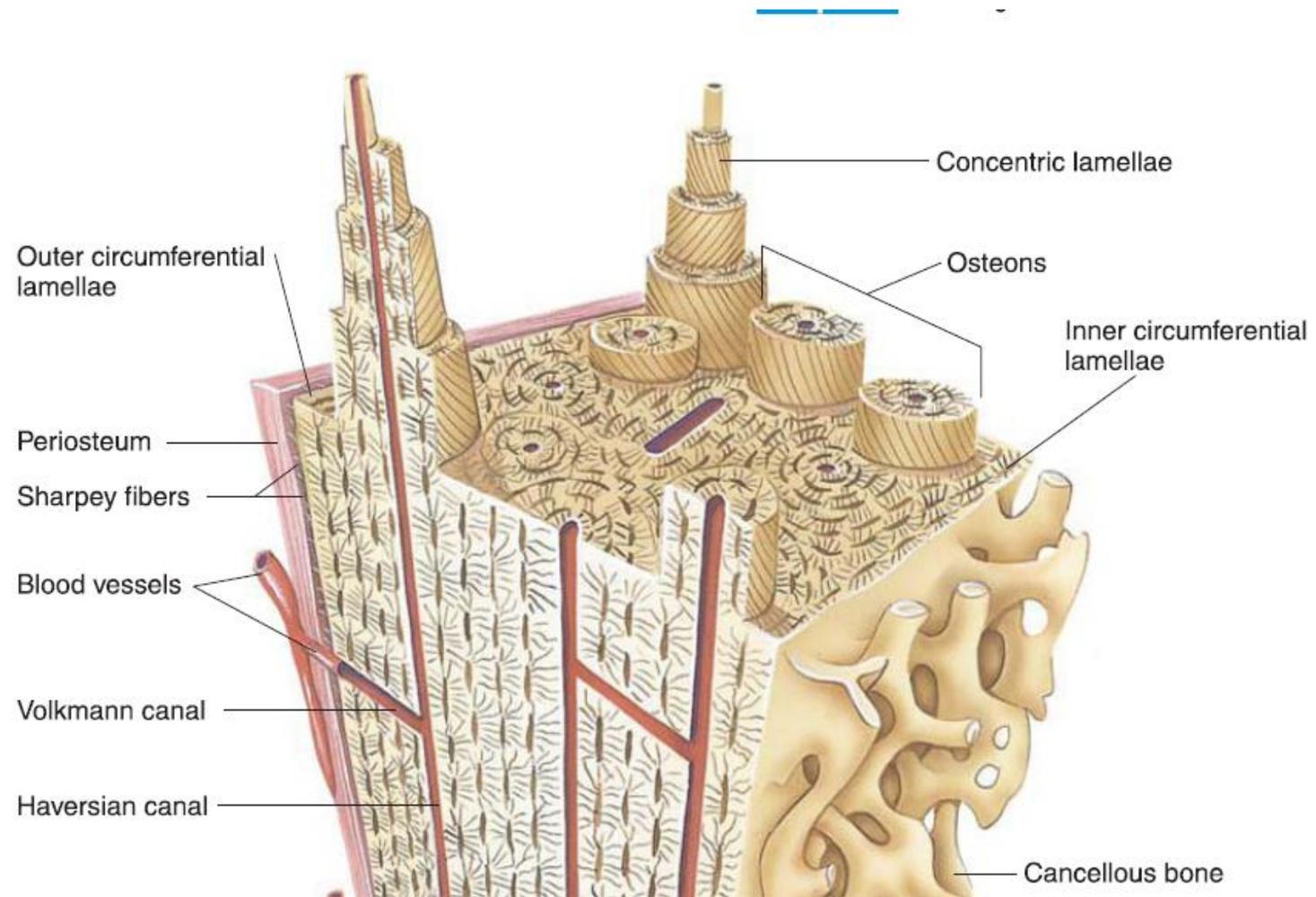
- **TRABECULAR BONE** [AKA cancellous bone or spongy bone], **mainly** serves a metabolic function. This type of bone is located between layers of compact bone and is thin and porous. Located within the trabeculae is the bone marrow.



# COMPACT BONE

- The **morphofunctional unit** of the bone is **osteon**, or **Haversian system**.
- Lamellar pattern of compact bone:
  - i. Haversian system
  - ii. Interstitial lamellae
  - iii. Circumferential lamellae





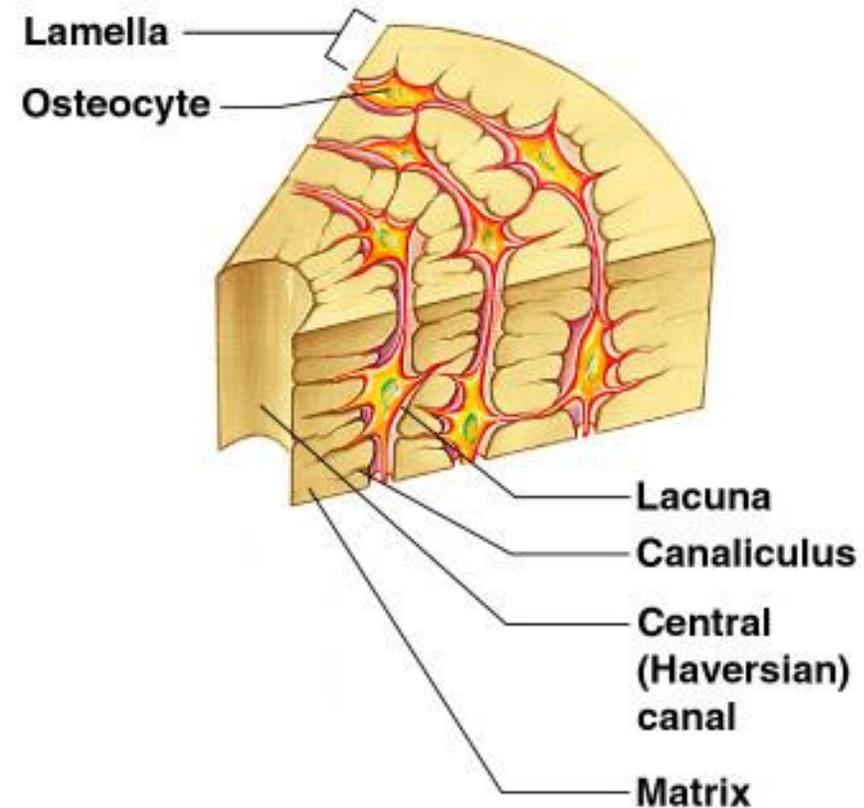
# T.S. THROUGH COMPACT BONE



'Haversian  
Systems'

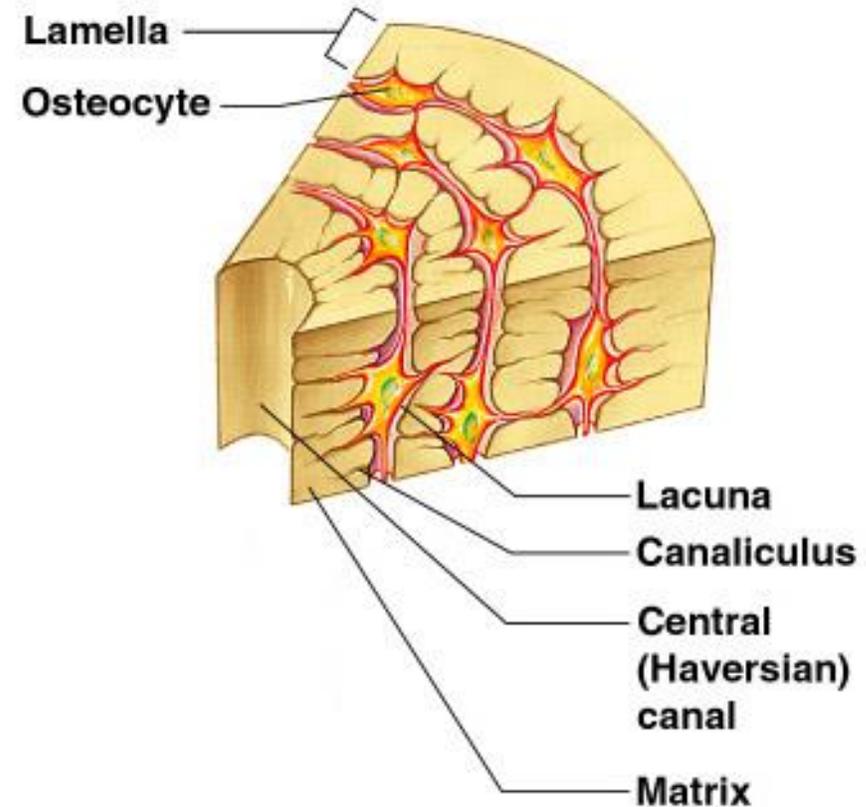
# LAMELLAR ARRANGEMENT

- Lamellae
  - Rings around the central canal
  - Sites of lacunae
- Lacunae
  - Cavities containing bone cells (osteocytes)
  - Arranged in concentric rings

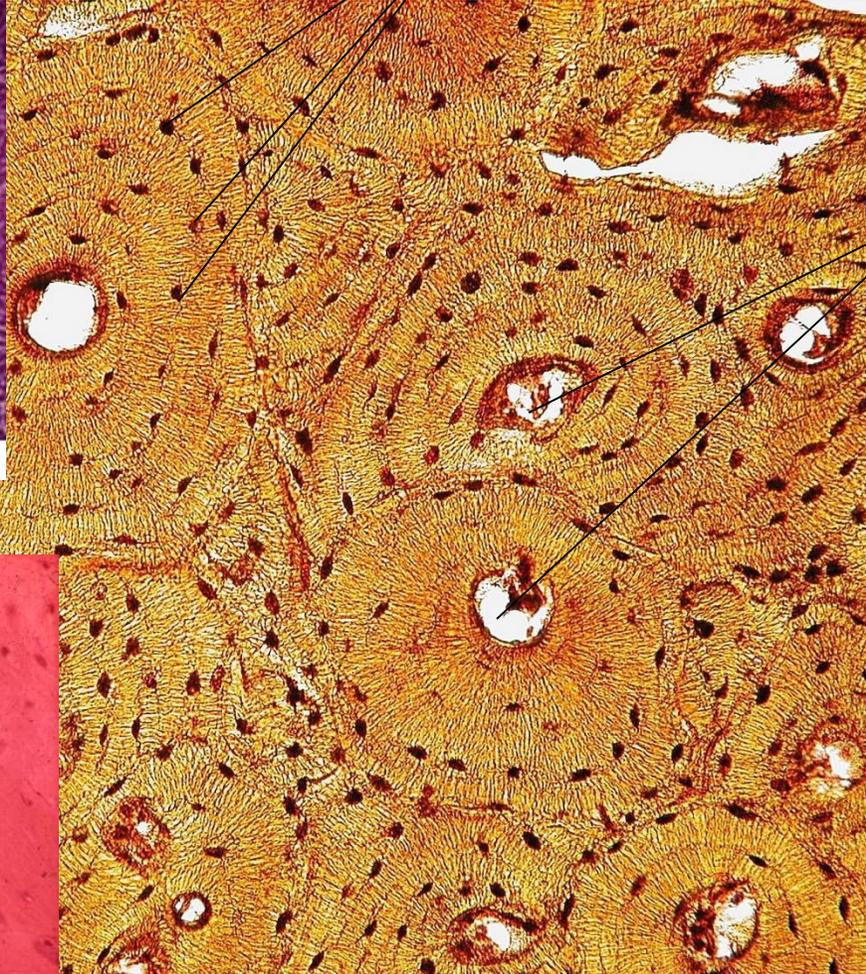


# LAMELLAR ARRANGEMENT

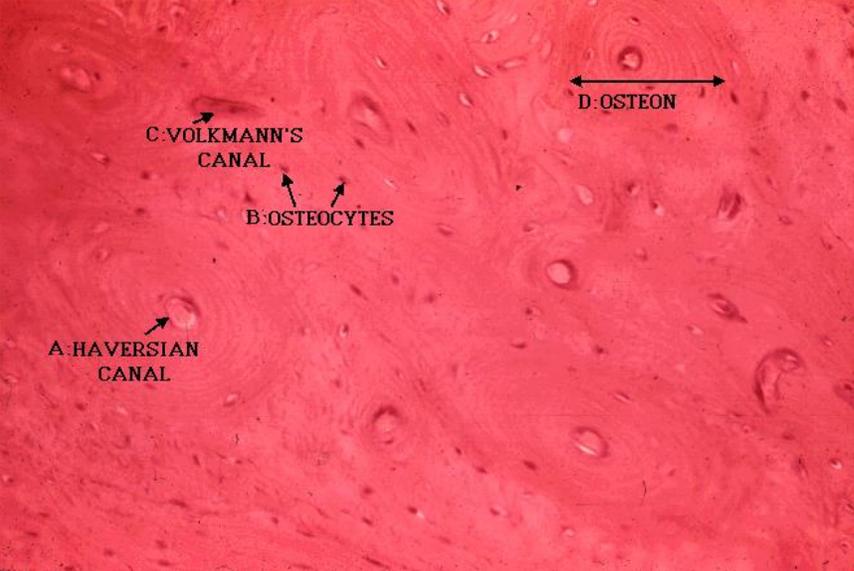
- **Canaliculi**
  - Tiny canals
  - Radiate from the central canal to lacunae
  - Form a transport system



Dark spots are called 'lacunae' and would contain osteocytes in living bone



Central canal containing an artery, vein, lymph vessel and nerves



# COMPOSITION

## 1. Bone matrix

a. The **inorganic (calcified) portion of the bone matrix** (about 65% of the dry weight) is composed of calcium, phosphate, bicarbonate, citrate, magnesium, potassium, and sodium.

It consists primarily of **hydroxyapatite crystals**.

b. The **organic portion of the bone matrix** (about 35% of the dry weight) consists primarily of type **I collagen** (95%) and a minor contribution of **type V collagen**.

It has a ground substance that contains **chondroitin sulfate**, **keratan sulfate**, and **hyaluronic acid** as well as the glycoproteins **osteocalcin**, **osteopontin**, and **bone sialoprotein**.



The matrix of bone is a mixture of organic (collagen) and inorganic (calcium phosphate)

90% of bone is matrix, with the remaining 10% made of osteocytes.

# COMPOSITION

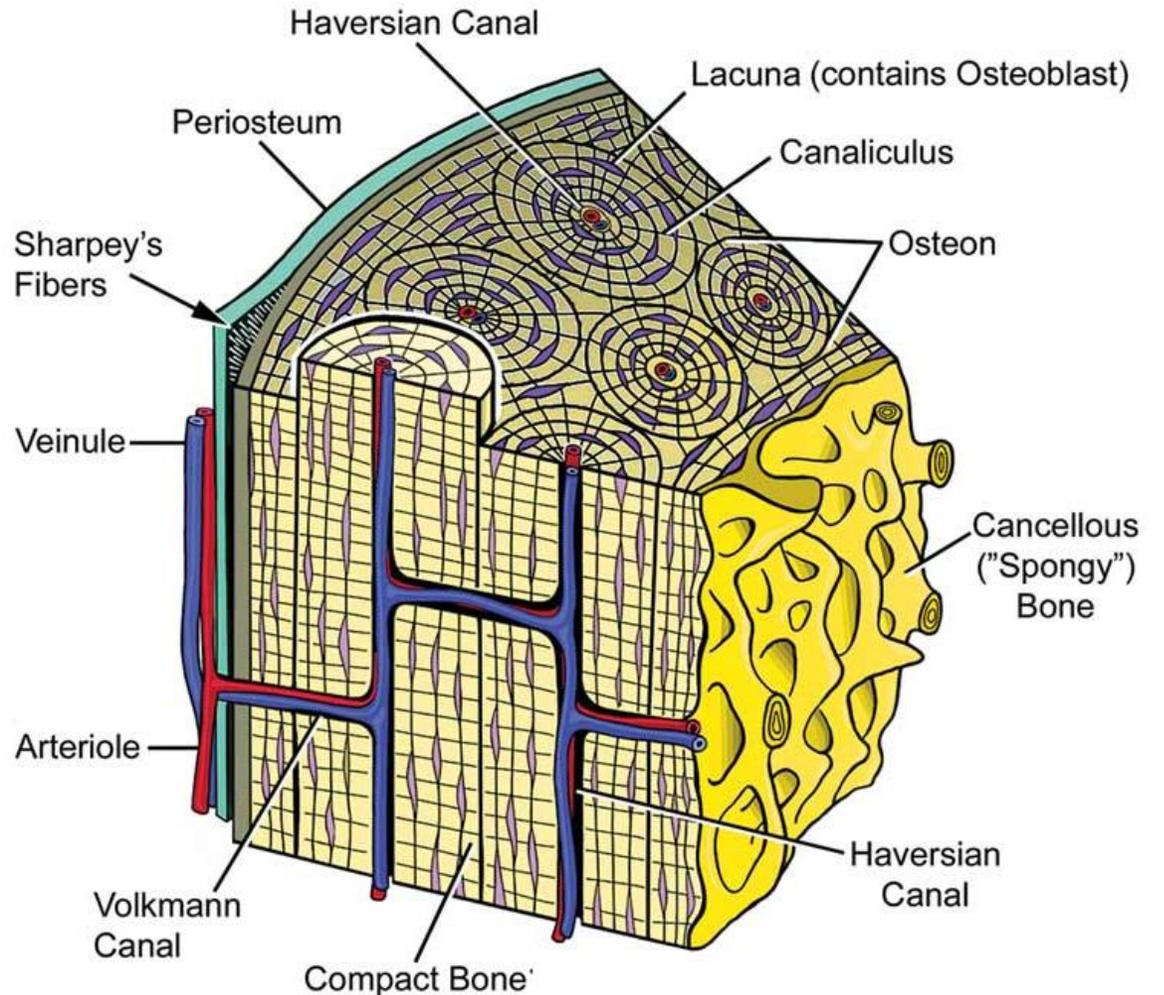
## 2. The periosteum

**DEFINITION:** a layer of **noncalcified** dense irregular collagenous connective tissue covering bone on its **external** surfaces ( except at synovial articulations and muscle attachments).

**FUNCTION:** to distribute blood vessels to bone.

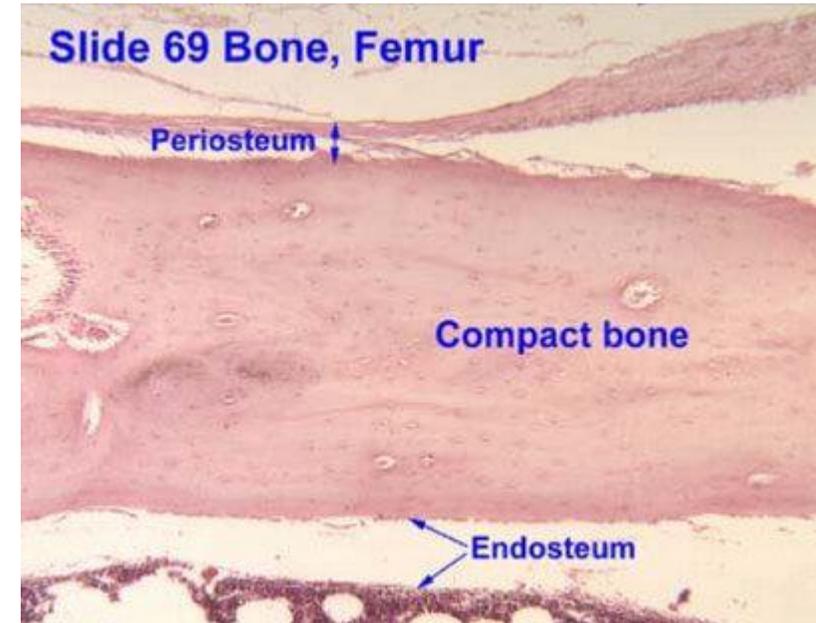
**COMPOSITION:** It is composed of:

- ✓ an outer dense **fibrous** collagenous layer
- ✓ and an inner cellular **osteoprogenitor ( osteogenic)** layer.
- ✓ **Sharpey fibers** ( type I collagen) attach the periosteum to the bone surface.



# COMPOSITION

3. The **ENDOSTEUM** is a thin specialized connective tissue that lines the **marrow cavities** and supplies **osteoprogenitor cells** and **osteoblasts** for bone growth and repair.



# COMPOSITION

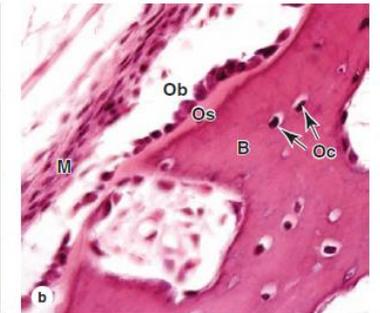
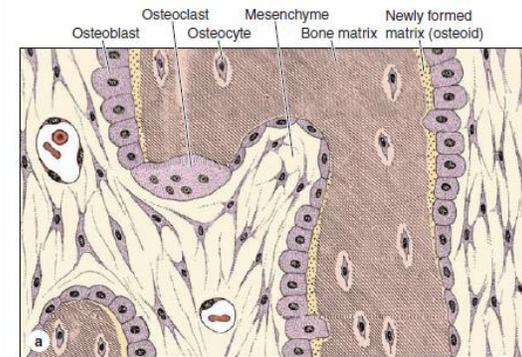
## ✓ Cells:

**Osteocytes** (Gr. *osteon* , bone + *kytos* , cell), which are found in cavities ( **lacunae** ) between bone matrix layers ( **lamellae** ), with cytoplasmic processes extending into small **canaliculi** (L. *canalis* , canal) between lamellae

■ **Osteoblasts** ( *osteon* + Gr. *blastos* , germ), which synthesize the organic components of the matrix

■ **Osteoclasts** ( *osteon* + Gr. *klastos* , broken), which are multinucleated, giant cells involved in the resorption and remodeling of bone tissue.

FIGURE 8-3 Osteoblasts and osteocytes.



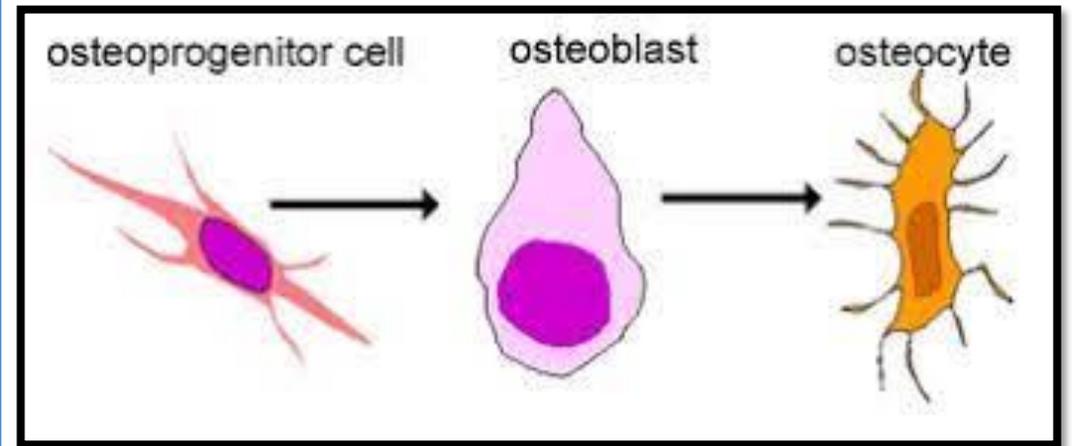
# COMPOSITION

## B. Bone cells

### 1. Osteoprogenitor cells

a. These spindle-shaped cells, derived from embryonic mesenchyme, are located in the **periosteum** and the **endosteum**. They persist throughout life as stem cells that can be activated as necessary to repair bone.

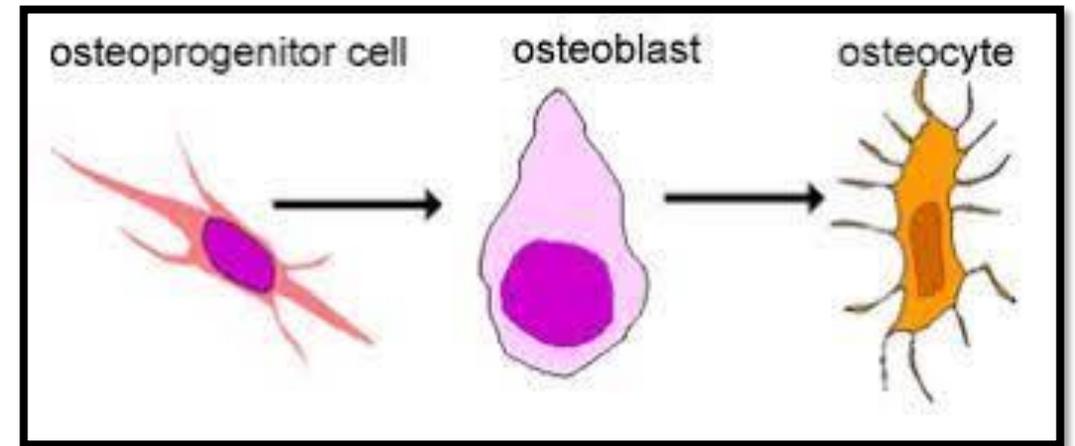
b. Under normal oxygen tension, they can differentiate into **osteoblasts**; however, at **low** oxygen tensions, they may change into **chondrogenic cells**.



# OSTEOBLASTS

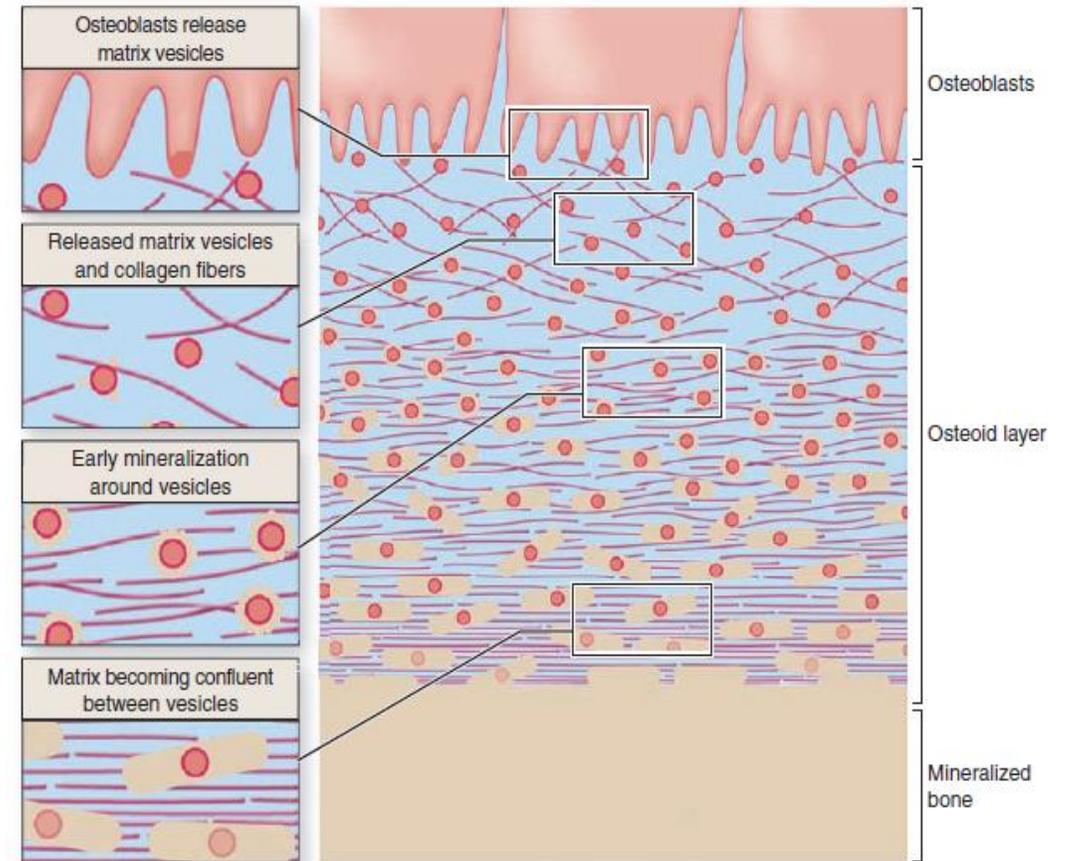
## 2. Osteoblasts

- **Osteoblasts** are derived from osteoprogenitor cells
- Osteoblasts are responsible for the synthesis of organic **protein components** of bone matrix, including:<sup>1</sup> type I (and a small amount of type V) collagen, <sup>2</sup> proteoglycans, and <sup>3</sup> glycoproteins, which they secrete as **osteoid (uncalcified bone matrix)**.



# OSTEOBLASTS

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

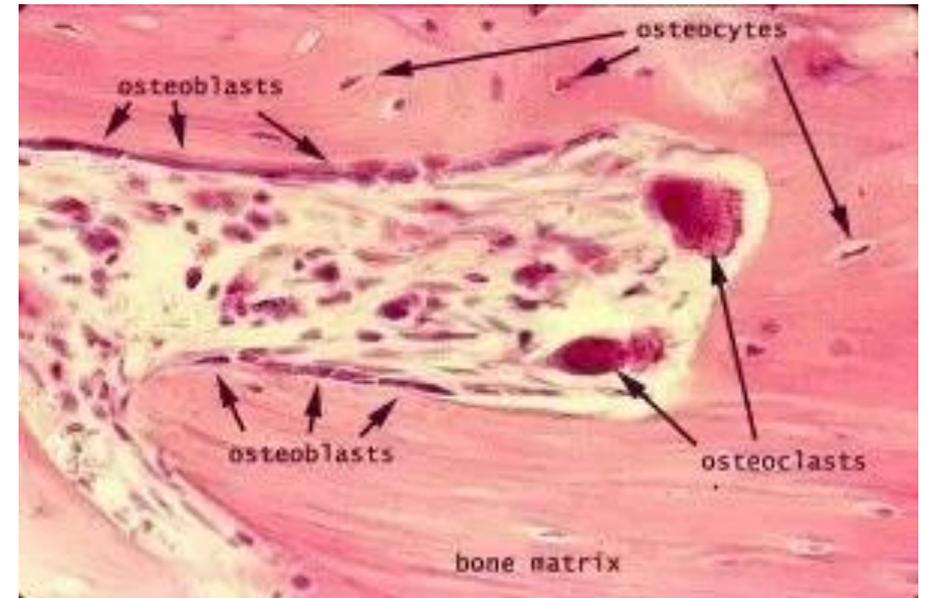


# OSTEOBLASTS

b. On bony surfaces, they appear as a layer of flat to high cuboidal, basophilic cells that become taller and increase their RER and Golgi as they secrete the organic matrix of bone.

c. They possess cytoplasmic processes with which they contact the processes of other osteoblasts and osteocytes and form **gap junctions**.

d. As they secrete matrix around themselves, osteoblasts become entrapped in **lacunae** but maintain contact with other cells via their cytoplasmic processes. Entrapped osteoblasts are known as osteocytes.



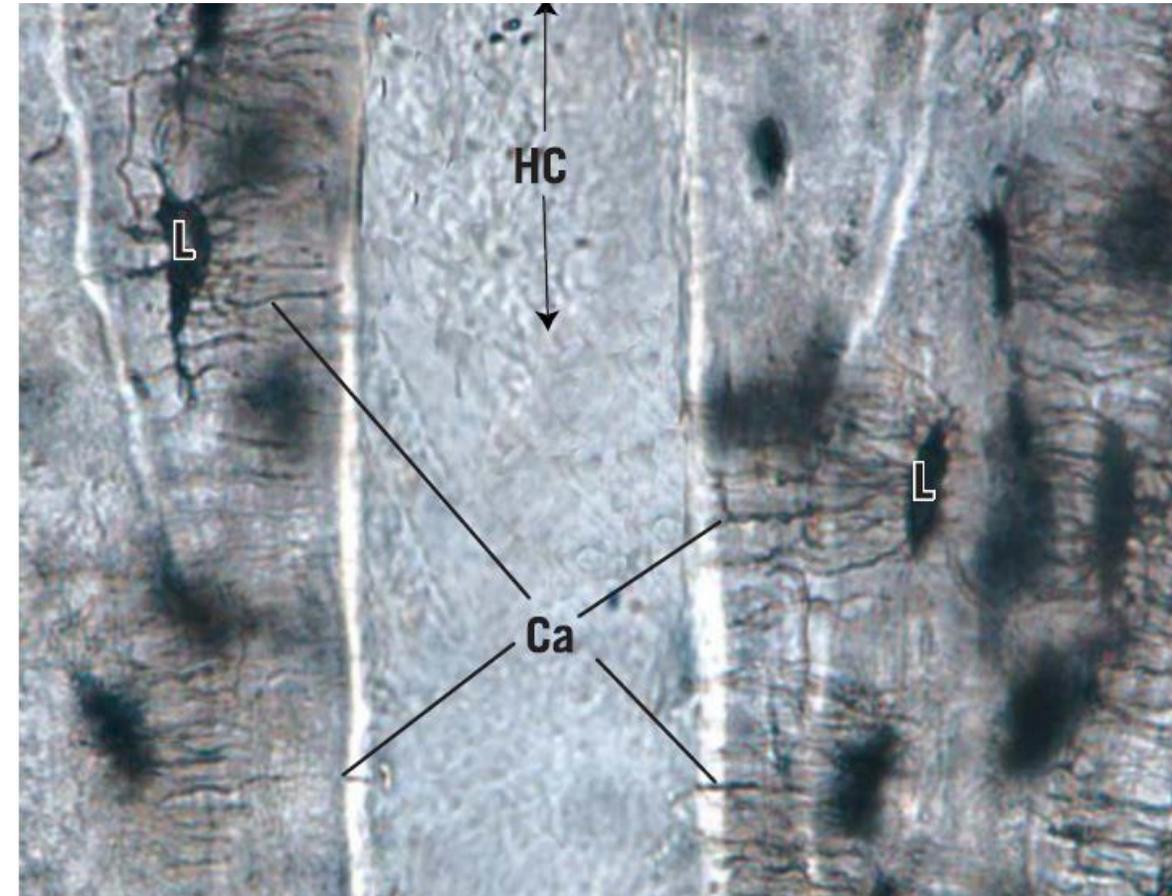
### 3. Osteocytes

#### a. Osteocytes, mature bone cells:

- ✓ housed in their own lacunae,
- ✓ contain abundant heterochromatin
- ✓ a paucity of RER, and a small Golgi complex.
- ✓ They have narrow cytoplasmic processes that extend through **canaliculi** in the calcified matrix
- ✓ and are nourished and maintained by nutrients, metabolites, and signal molecules carried by the extracellular fluid that flows through the lacunae and canaliculi. In addition, calcium released from bone enters the extracellular fluid located within these spaces.

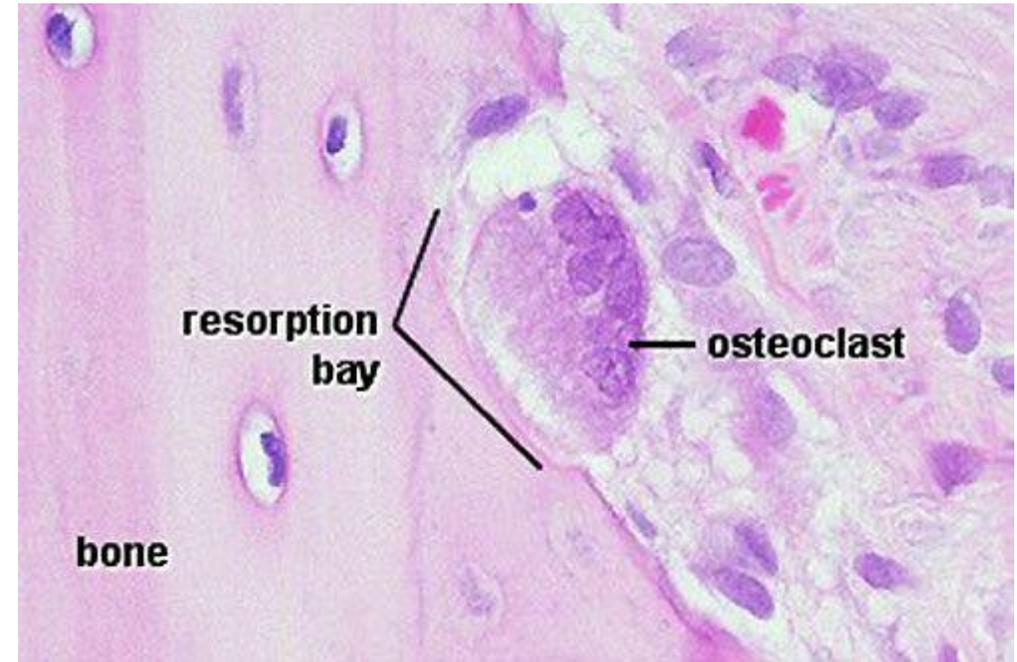
**b.** Osteocytes maintain communication with each other via **gap junctions** between their processes.

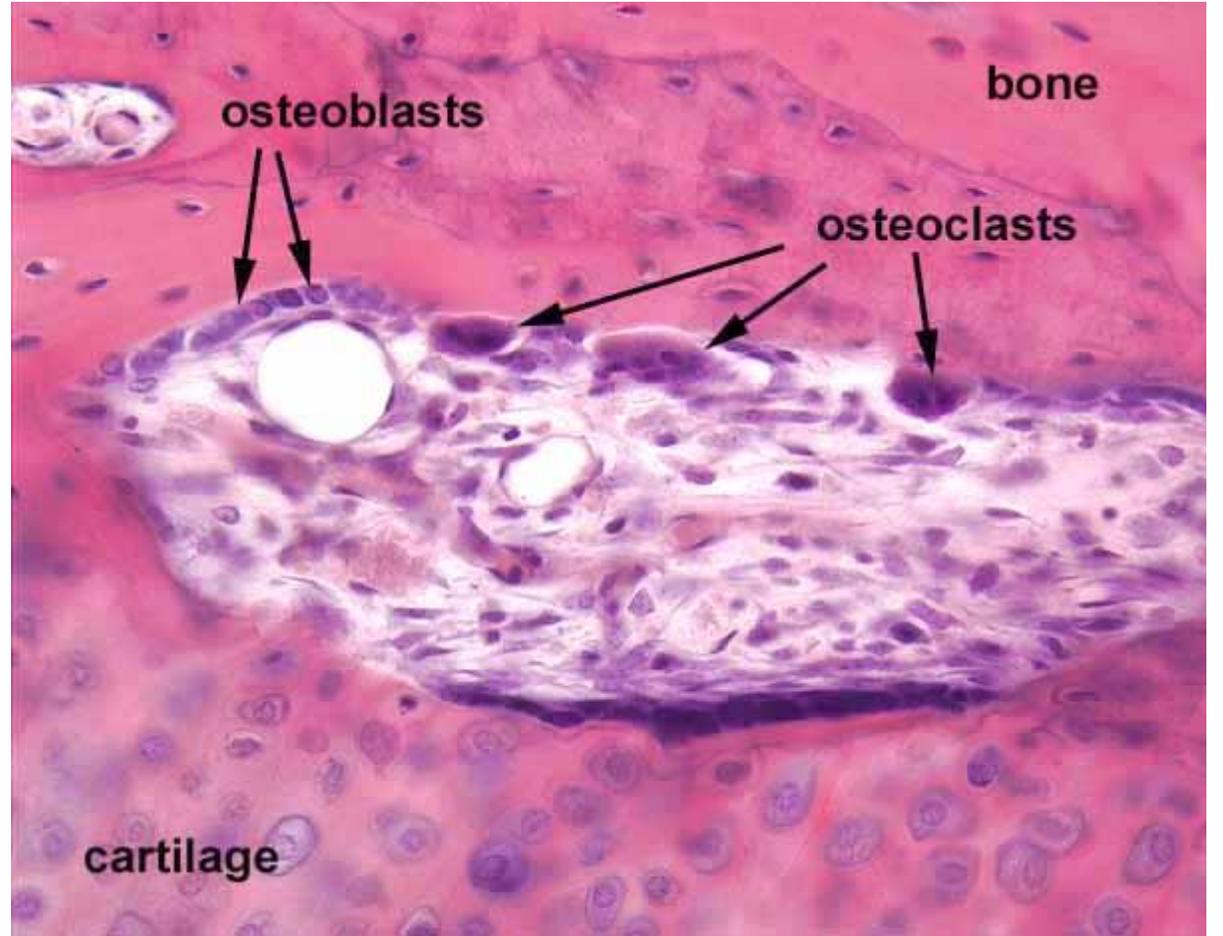
## OSTEOCYTES



# Osteoclasts

**Osteoclasts** are large, motile, multinucleated cells ( up to 50 nuclei) that resorb bone, a process known as **osteolysis**. They are derived from cells of the **mononuclear-phagocyte system**, blood-borne **monocytes** that enter the connective tissue spaces and there they differentiate into various types of macrophages and osteoclasts.





**TO BE  
CONTINUED**

