Histology of BONE

Classifications of Tissues

- The human body is composed of four basic types of tissues;

- Epithelium
- Connective
- Muscular
- Nervous tissues

BONE

- Specialized connective tissue
- Highly vascular mineralized connective tissue consisting of cells and dense intercellular organic matrix with inorganic salts.
- Provide support & protection to the vital organs
- Forms skeletal framework

COMPOSITION

- **Cells:**
  - **Osteoprogenitor cells**
  - **Osteoblasts**
  - **Osteocytes**
  - **Osteoclasts**
- **Extracellular Matrix:**
  - **Fibers:** collagen type I
  - **Ground Substance:** Proteoglycans & glycoproteins

Osteoprogenitor cells

- Derived from mesenchymal cell
- All connective tissue is derived from

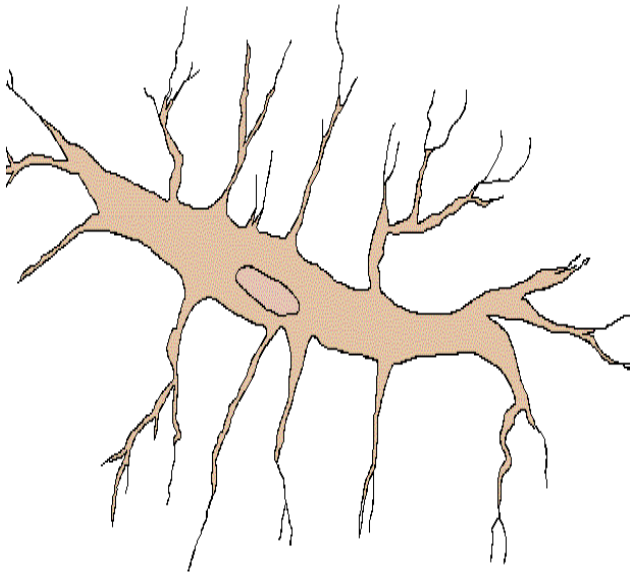
  unspecialized stem cells undergo mitosis and develop into osteoblast.
- Found on inner surface of periosteum and endosteum.
- Osteoprogenitor cells are inactive form of osteoblasts.

Osteoblasts:

- Bone forming cells
- No ability to mitotically divide
- Collagen secretors, synthesize organic components.

Osteocytes:

- Mature bone cells
- Derived form osteoblasts
- Do not secrete matrix material
- Lacunae communicate with each other by channels called *canaliculi*.

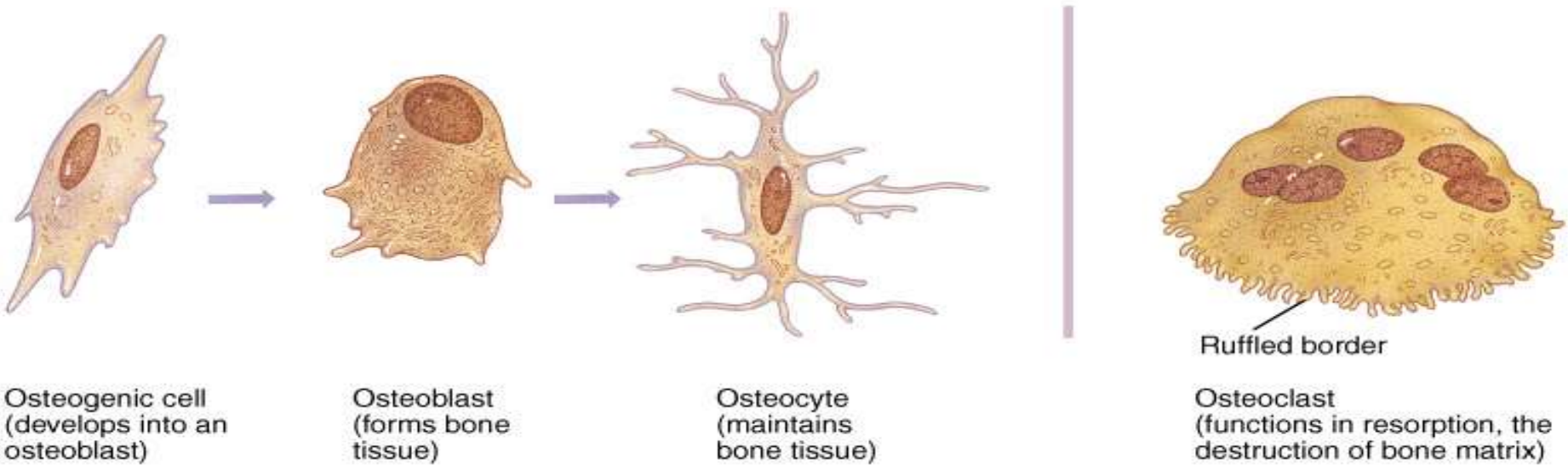


- Osteoclasts

➢ Bone resorbing cells

➢ They play a very important role in the remodelling and renewal of the bone.

Cells of Bone Tissue



Extracellular Matrix

Consist of Organic and Inorganic components

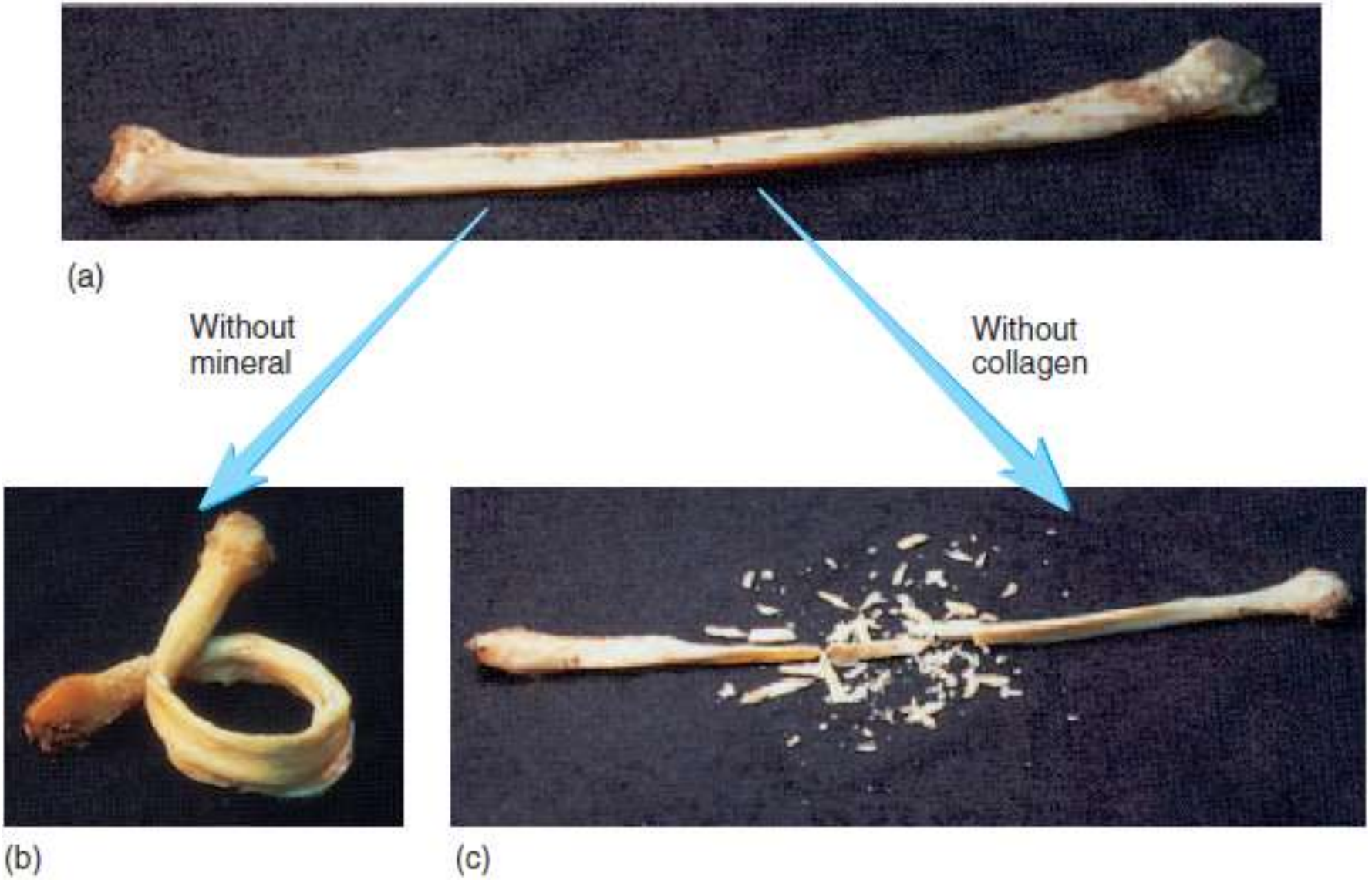
Organic:

- 35% of the dry weight of bone.
- Consist of collagen I , proteoglycans and glycoprotein.

Inorganic mineral salts:

- Calcium phosphate in crystalline form called **hydroxyapatite**
- Calcium Carbonate
- Sodium
- Magnesium Hydroxide

Effects of Changing the Bone Matrix (*a) Normal bone. (b) Demineralized bone, in which collagen is the primary remaining component, can be bent without breaking. (c) When collagen is removed,* mineral is the primary remaining component, thus making the bone so brittle it's easily shattered.



Periosteum and Endosteum

Periosteum consists of two layers:

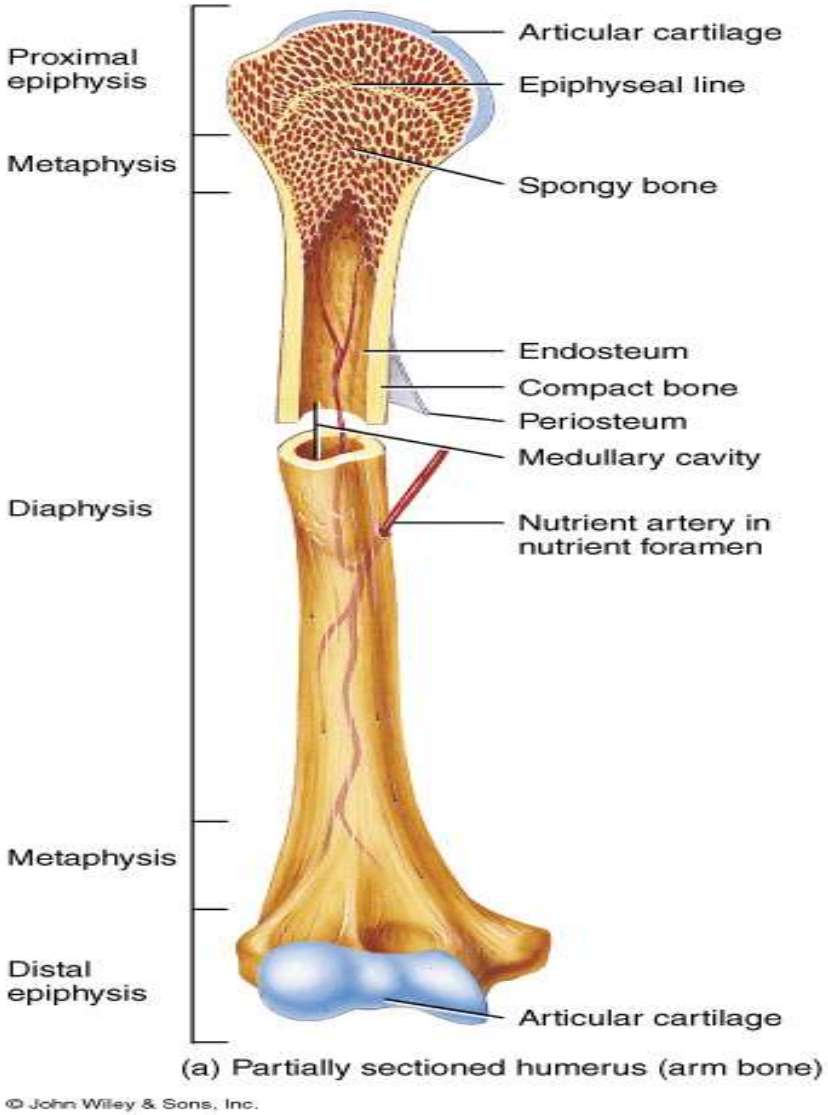
- Fibrous (Collagen fibers and fibroblasts)
- Cellular (Contains osteoprogenitor cells)

Endosteum :

The cavities within the bone are lined by a thin layer of connective tissue called endosteum. Also contains osteoprogenitor cells

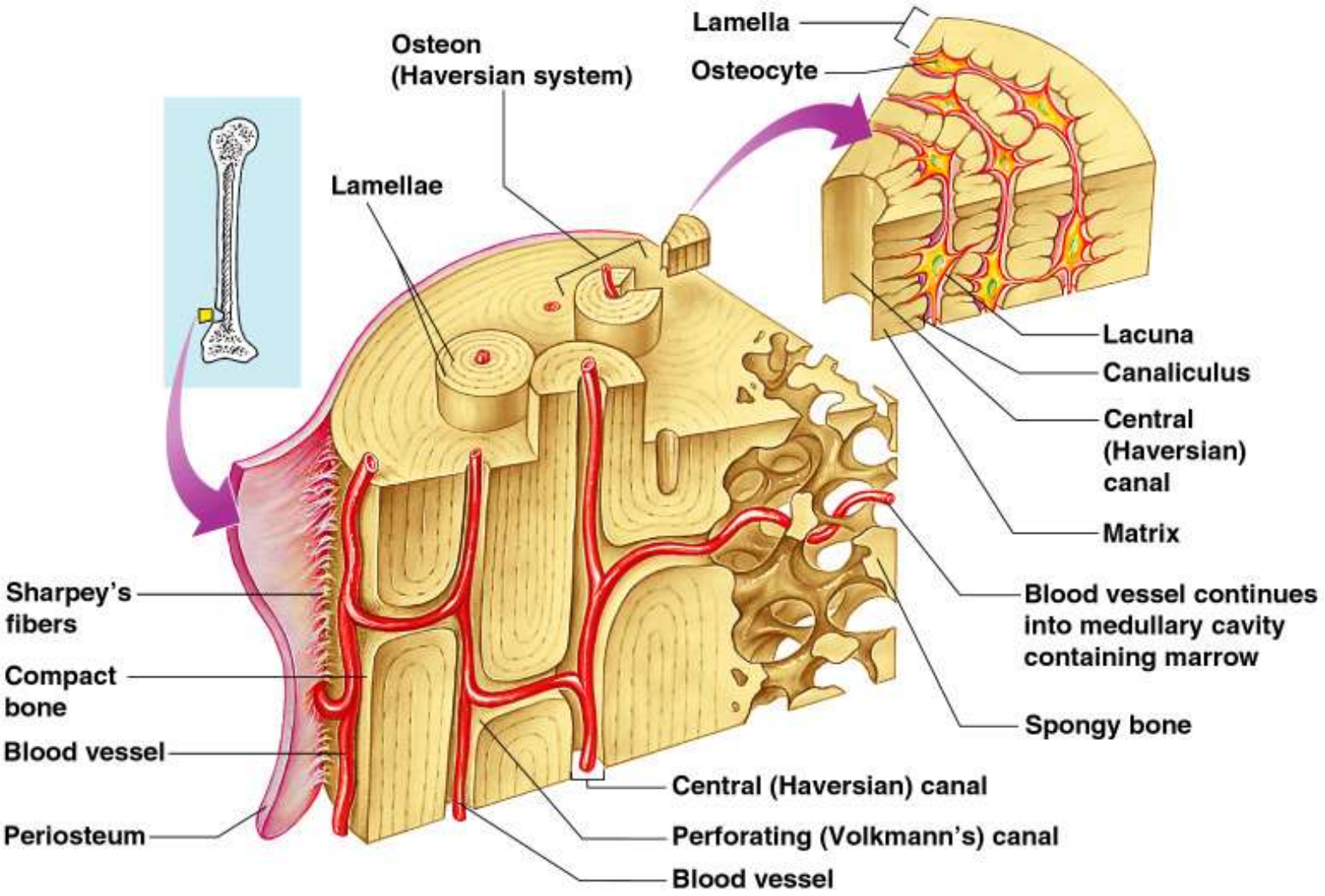
Macroscopic Structure

- Compact bone
- Spongy bone



(a) Partially sectioned humerus (arm bone)

MICROSCOPIC STRUCTURE OF BONE



LAMELLAR ARRANGEMENT

Lamellae

- Rings around the central canal
- Sites of lacunae

Lacunae

- Cavities containing bone cells (osteocytes)
- Arranged in concentric rings

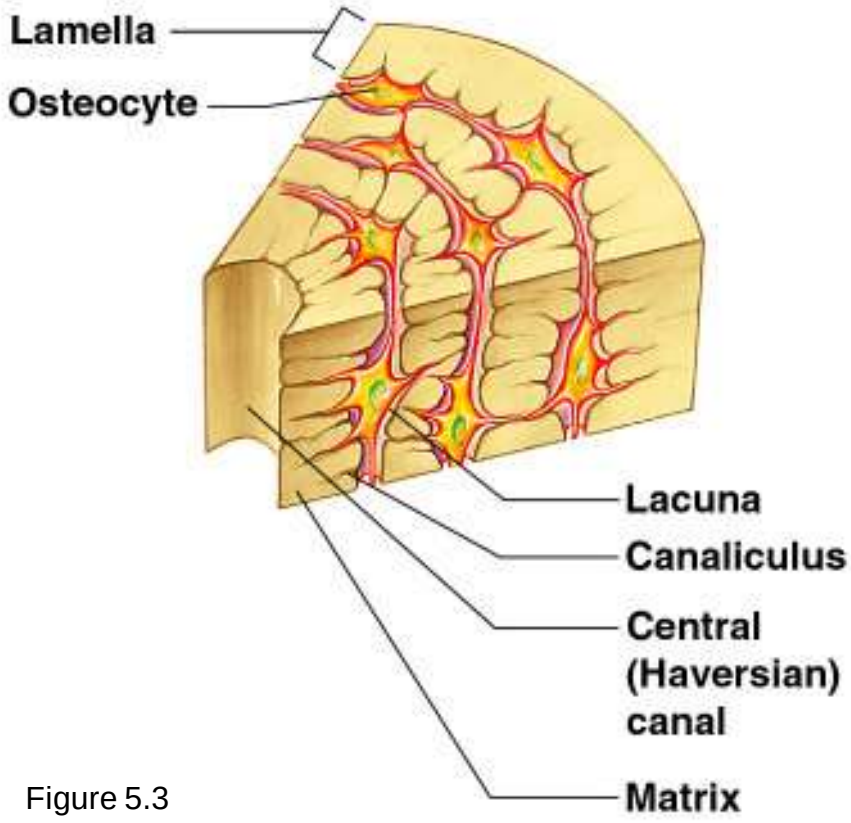
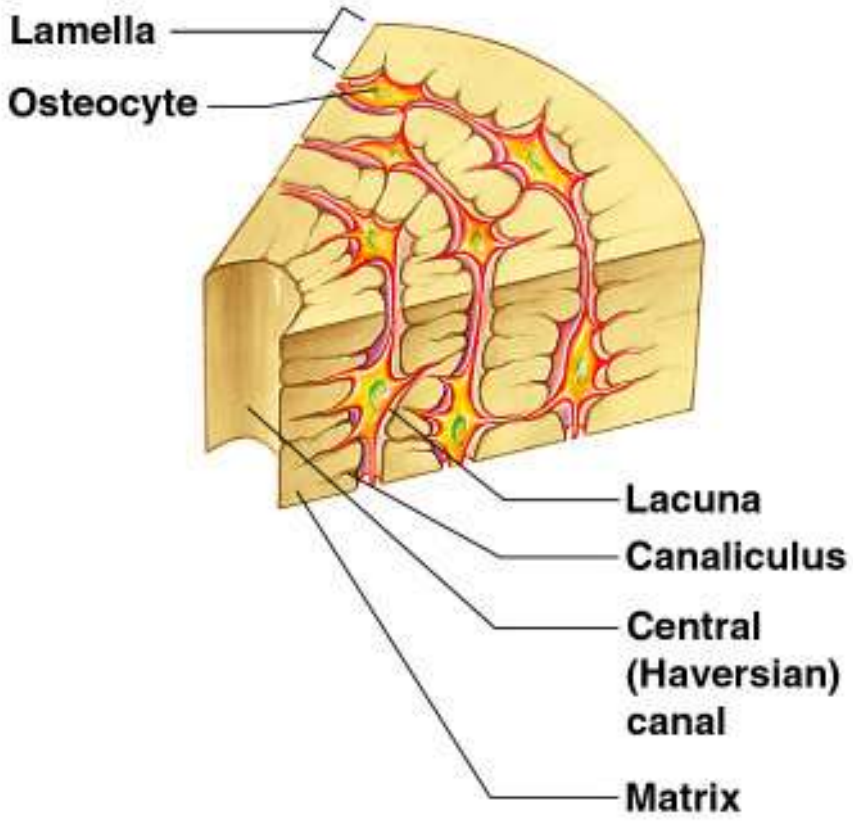


Figure 5.3

Canaliculi

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



Compact bone

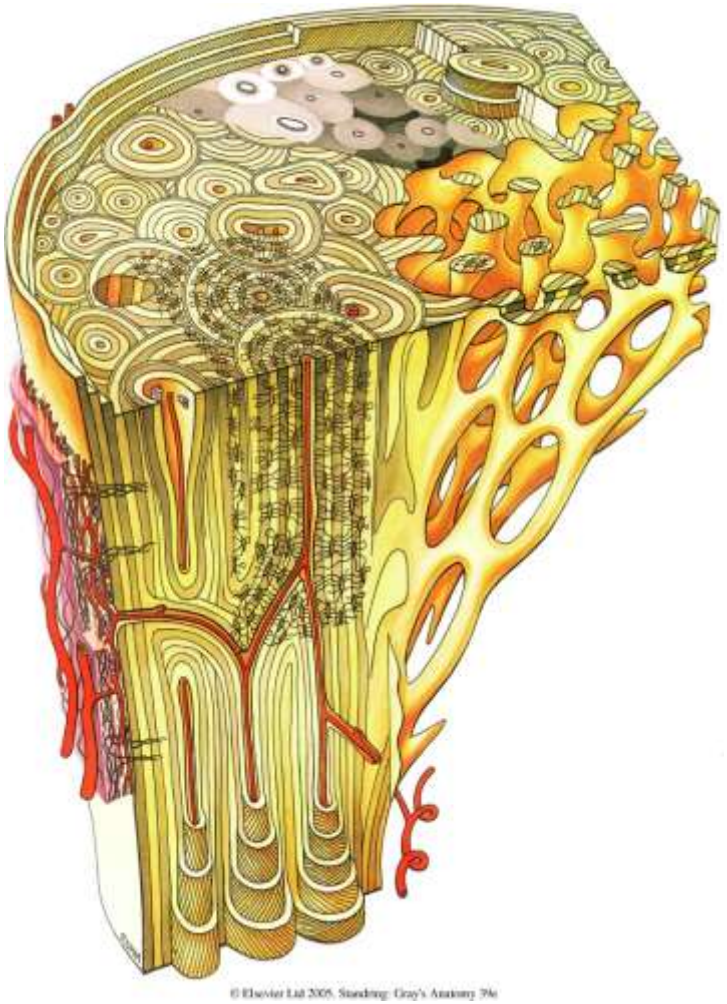
- The morphofunctional unit of the bone is **osteon,** or **Haversian system.**

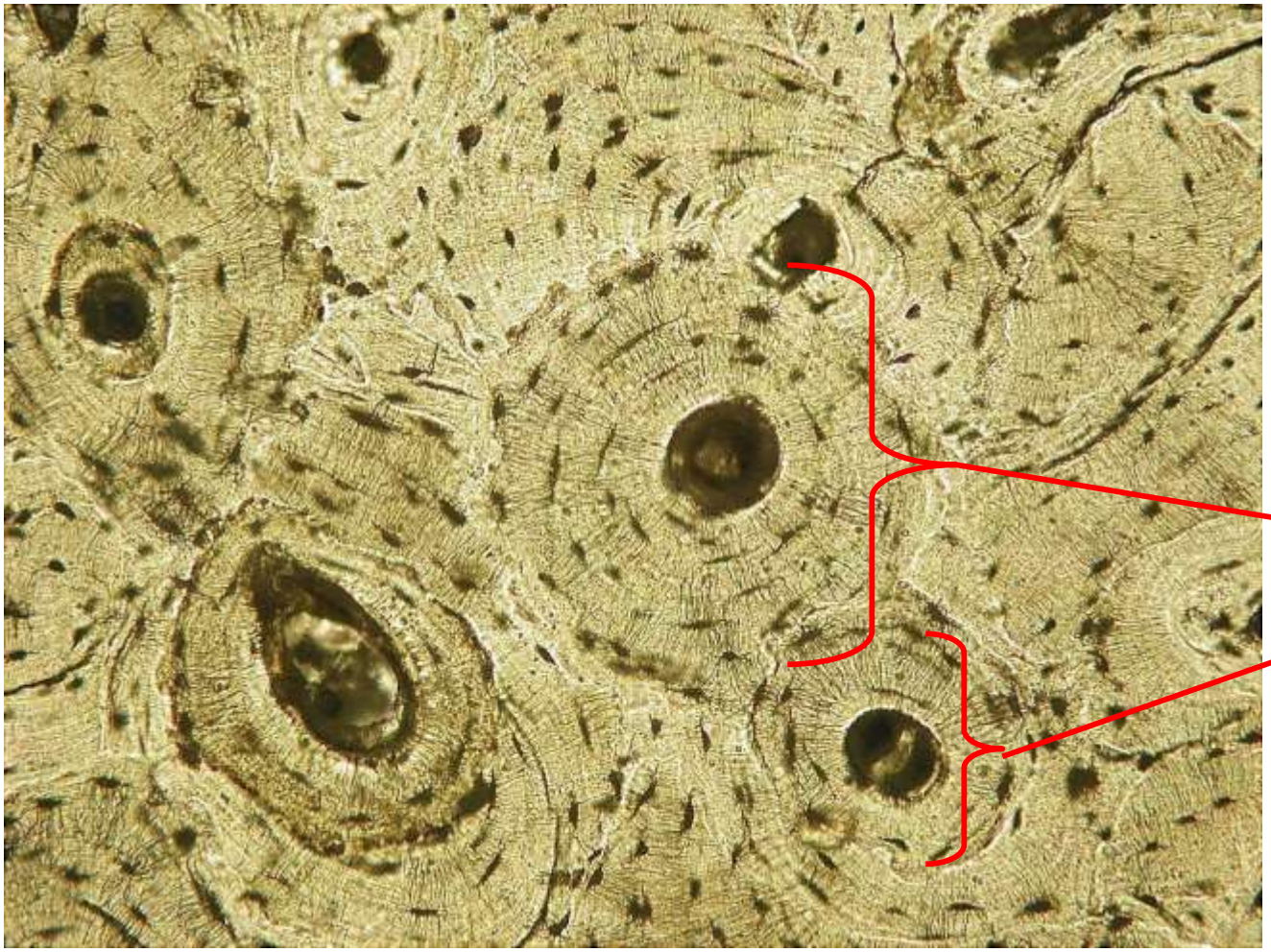
- Lamellar pattern of compact bone:

➢ Haversian lamellae

➢ Interstitial lamellae

➢ Circumferential lamellae

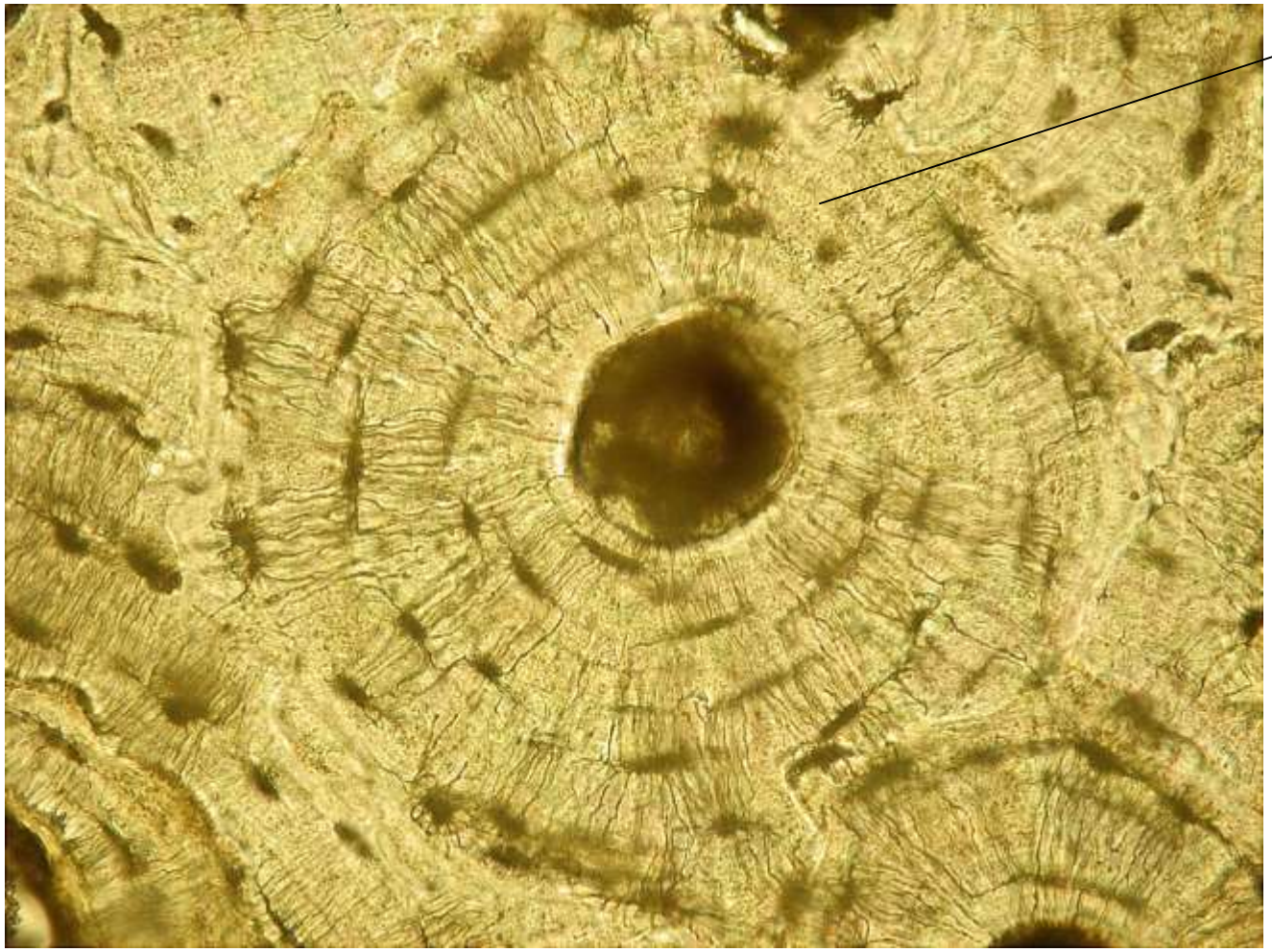




‘Haversian Systems’

Osteon contains

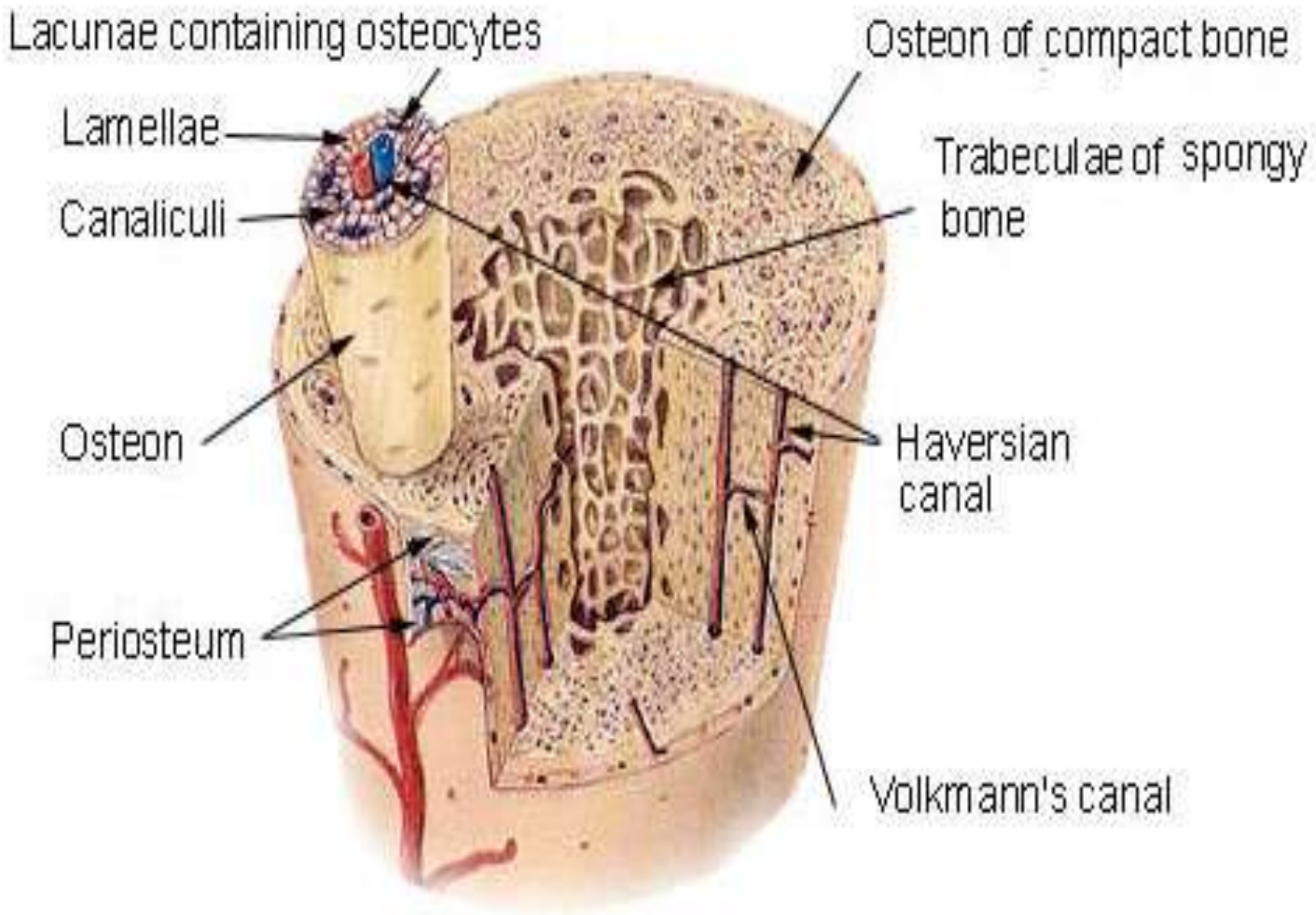
- Central canal
- Surrounding lamellae
- Lacunae
- Osteocytes
- Canaliculi



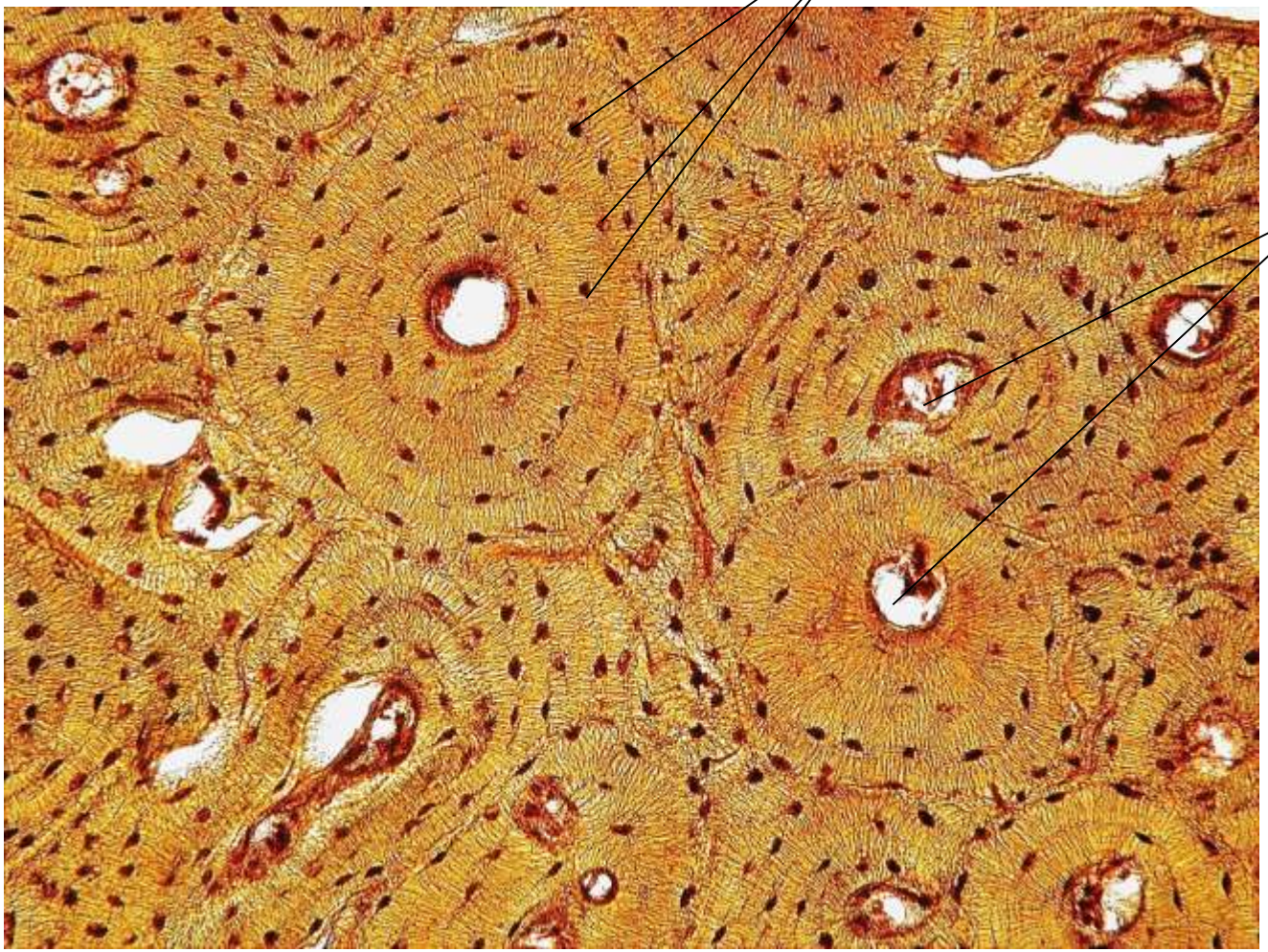
The matrix of bone is a mixture of organic (collagen) and inorganic (calcium phosphate)

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

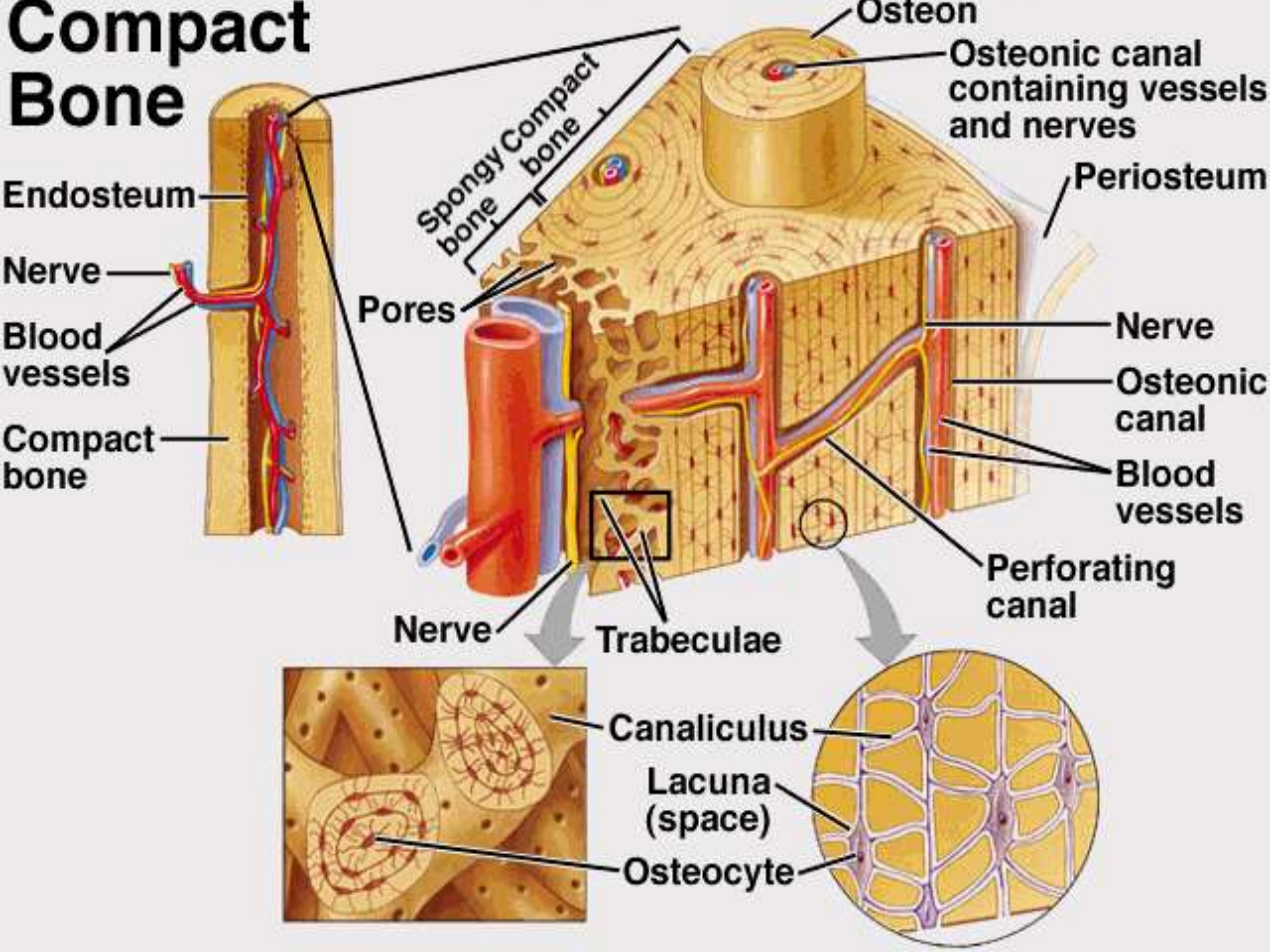
Compact Bone & Spongy (Cancellous Bone)



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



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


Compact Bone
Endosteum
Nerve
Blood vessels
Compact bone
Spongy bone
Compact bone
Osteon
Osteonic canal containing vessels and nerves
Periosteum
Pores
Nerve
Osteonic canal
Blood vessels
Perforating canal
Nerve
Trabeculae
Canaliculus
Lacuna (space)
Osteocyte

Spongy Bone

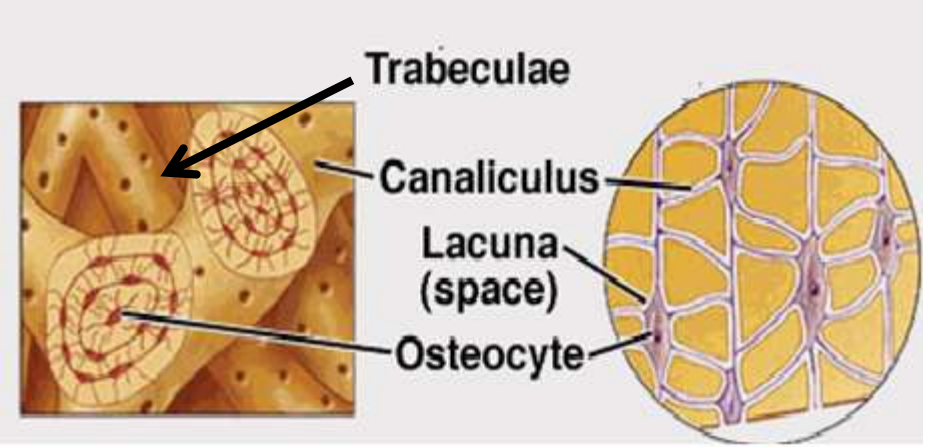
- Location :

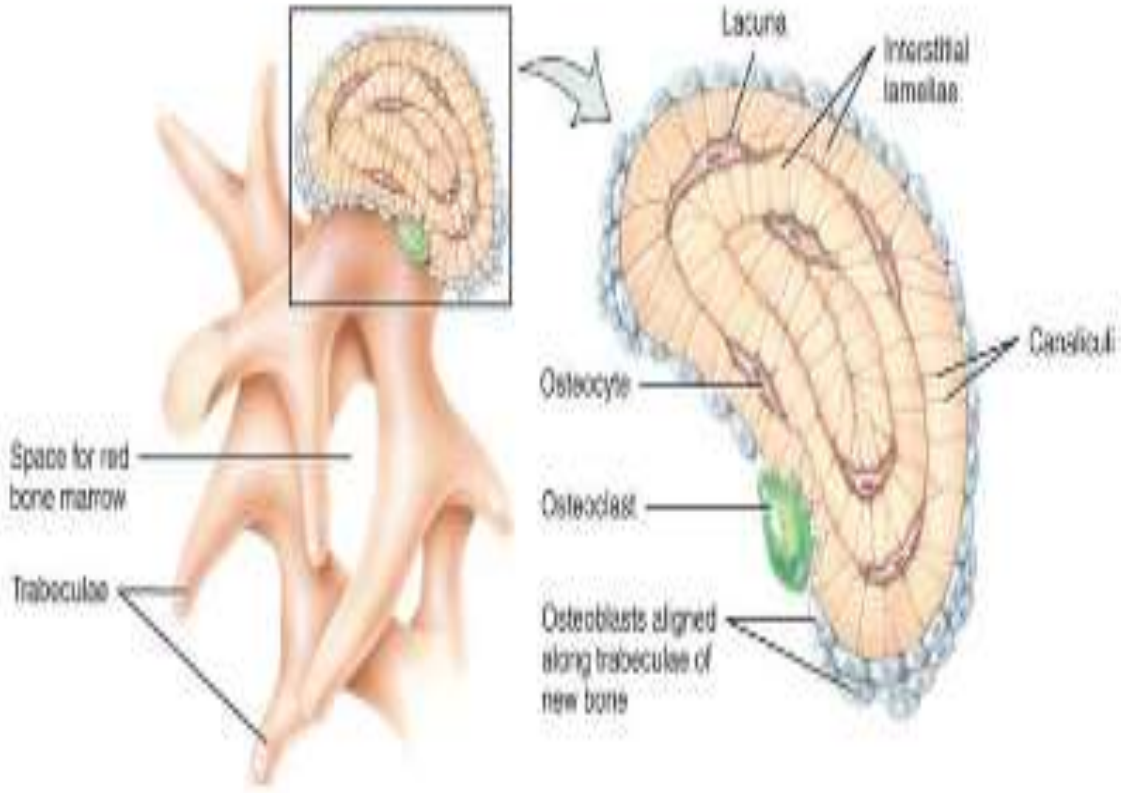
➢ Faces medullary cavity of diaphysis

➢ Form majority of epiphysis

Spongy Bone

- No osteons
- Lamellae are arranged in columns called **trabeculae.** (small beam)
- Cross section of a trabecula looks like an osteon with out central canal.
- **Trabeculae** contains osteocytes,matrix, canaliculi, and lamellae.
- Spaces between trabeculae are filled with Bone marrow.




Lacuna
Interstitial lamellae
Canaliculi
Osteocyte
Space for red bone marrow
Osteoclast
Trabeculae
Osteoblasts aligned along trabeculae of new bone

Spongy Bone

- Within each trabecula are lacunae that contain osteocytes
- Osteocytes are nourished from the blood circulating through the trabeculae within the red bone marrow.
- Interior bone tissue is made up primarily of spongy bone.

Ossification

- Bone formation (ossification) occurs in two ways
  1- Intramembranous ossification
  2- Endochondral ossification

Both methods above lead to the same bone formation but are different methods of getting there.

Ossification begins around the 6^{th} -7^{th} week of embryonic life. At this time the embryonic skeleton is made of fibrous membranes and hyaline cartilage.

Intramembranous Ossification

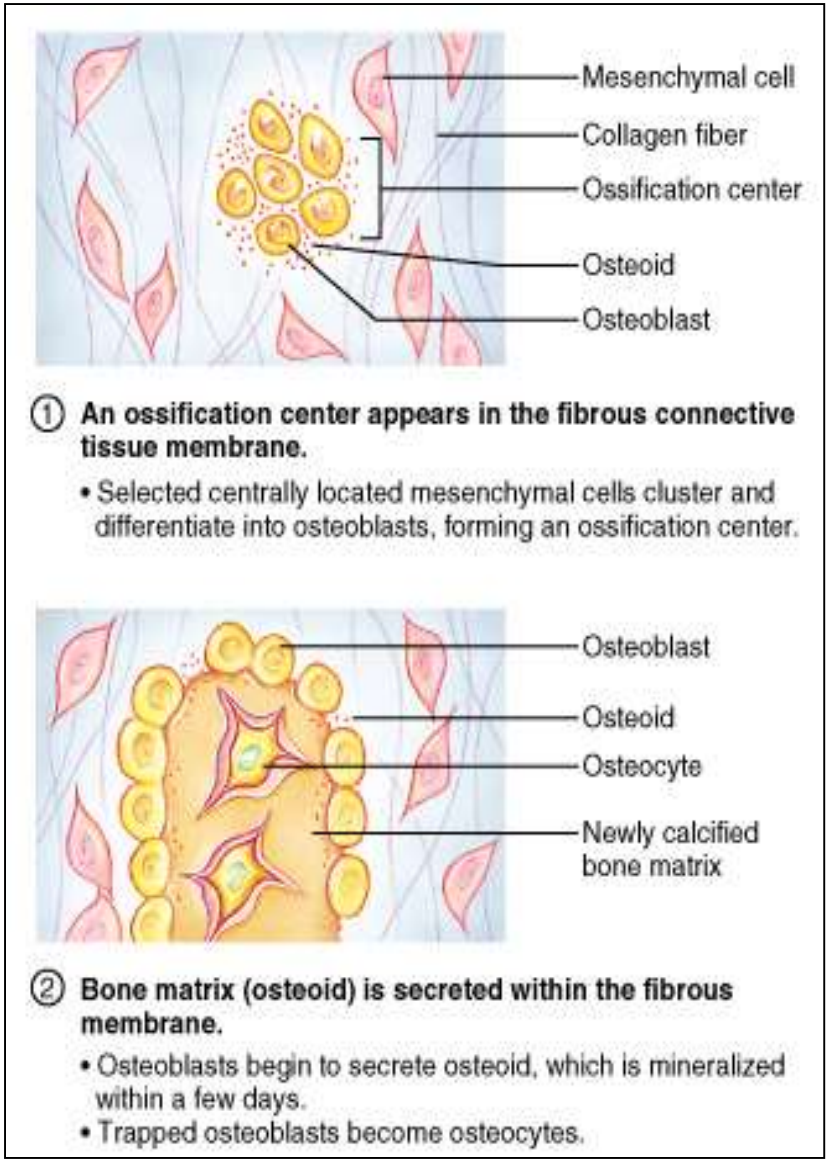
Bone develops by intramembranous ossification

- Flat bones of skull
- Bones of face
- Mandible
- Clavicles

Mesenchymal membrane become vascularized and the center of vascularized region called *primary center of ossification* differentiate into Osteoblast.

Intramembranous Ossification

- An ossification center appears in the fibrous connective tissue membrane
- Osteoblasts secrete bone matrix within the fibrous membrane called *Osteoid*.
- Osteoblasts mature into osteocytes



Endochondral ossification

Replacement of hyaline cartilage with bone is called **Endochondral (intracartilaginous) ossification**

Most bones are formed this way (i.e. long bones).

Primary Center of Ossification:

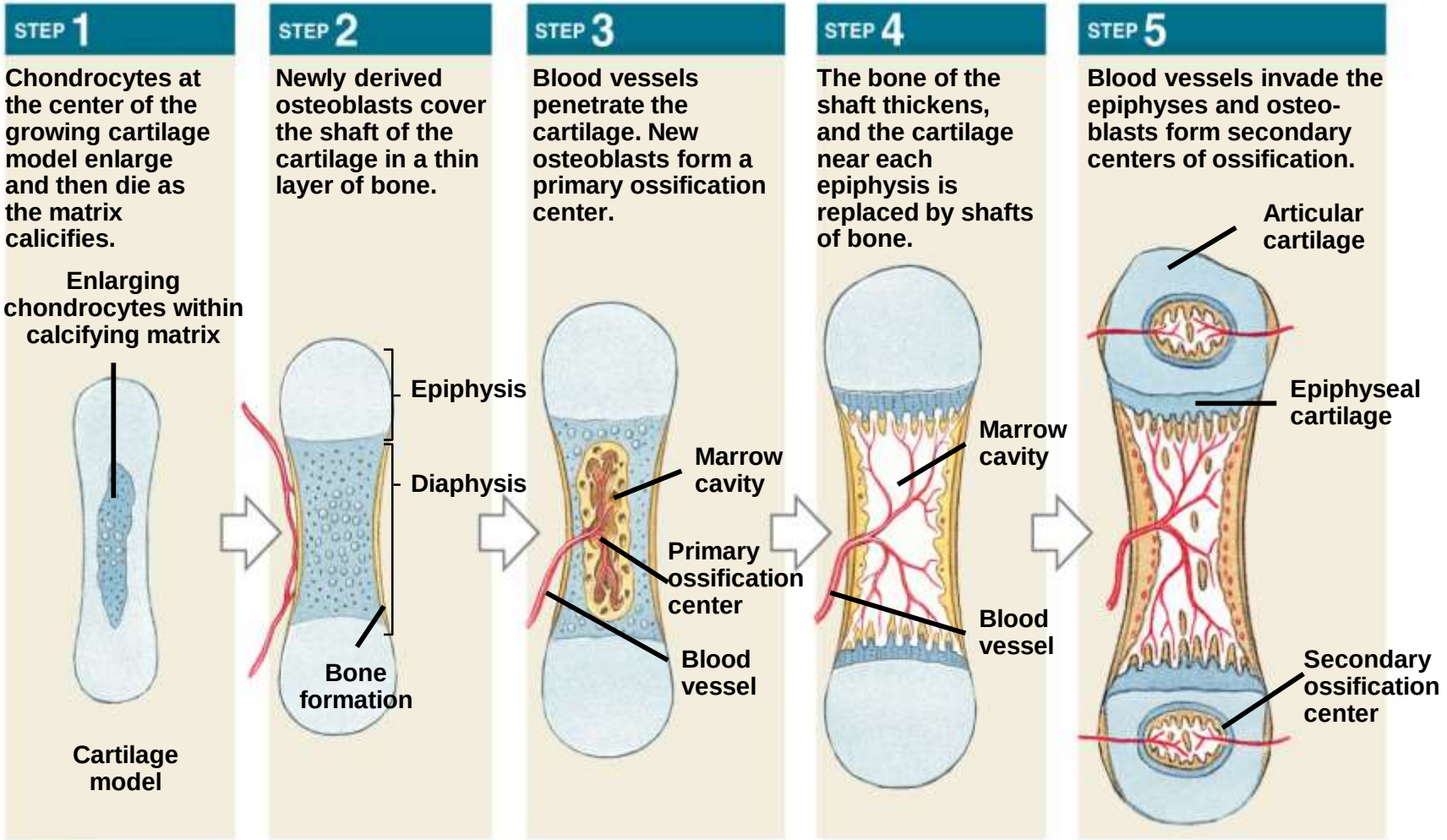
- Mesenchymal cells differentiate into chondroblasts (immature cartilage cells) which produces hyaline cartilage. Perichondrium develop around new cartilage.
- Chondrocytes undergo hypertrophy, swell and burst. pH of the matrix changes and calcification is occured. Ultimately, cartilage cells die. Lacunae are now empty.
- The perichondrium around the primary center of ossification changes into periosteum. The cells in its cellular layer transform into osteoblasts. These osteoblasts lay down a bone collar around the cartilage.

- The bony collar is invaded by capillaries from the periosteum which are accompained by mesenchymal cells.
- These mesenchymal cells transform into osteoclasts.
- In the middle of the bone, osteoclasts break down spongy bone trabeculae and form a cavity called the medullary cavity. This cavity will be filled with red bone marrow for hemopoiesis.
- The part of long bone which develop from *primary center of ossification* is known as *diaphysis*.

Secondary centers of Ossification

- These appear in the cartilaginous ends of the developing bone .
- The part of long bone which develop from secondary centers of ossification are known as *epiphyses*.

Endochondral Ossification



MCQ

1. Fibrous cartilage is present in:

a. Auricle

b. Nose

c. Tracheal rings

d. Intervertebral discs

MCQ

2. Elastic cartilage is present in:

a. Apices of arytenoid cartilage
b. Auricle
c. Tracheal rings
d. Temporomandibular joints

MCQ

3. Hyaline cartilage is present in:

a. Tracheal rings
b. External auditory meatus
c. Semilunar cartilages of knee joint
d. Intervertebral discs

MCQ

4. What are the small tunnels seen in bone?
   a. Canaliculi
   b. Sharpey's fibers
   c. Trabeculae
   d. Lacuna

MCQ

5. The blood vessels and nerves go inside the compact bone through:

a. Haversian canal
b. Volkman’s canal
c. Canaliculi
d. Interstitial lamellae

6. What forms the articular surface on bones?

a. Spongy bone

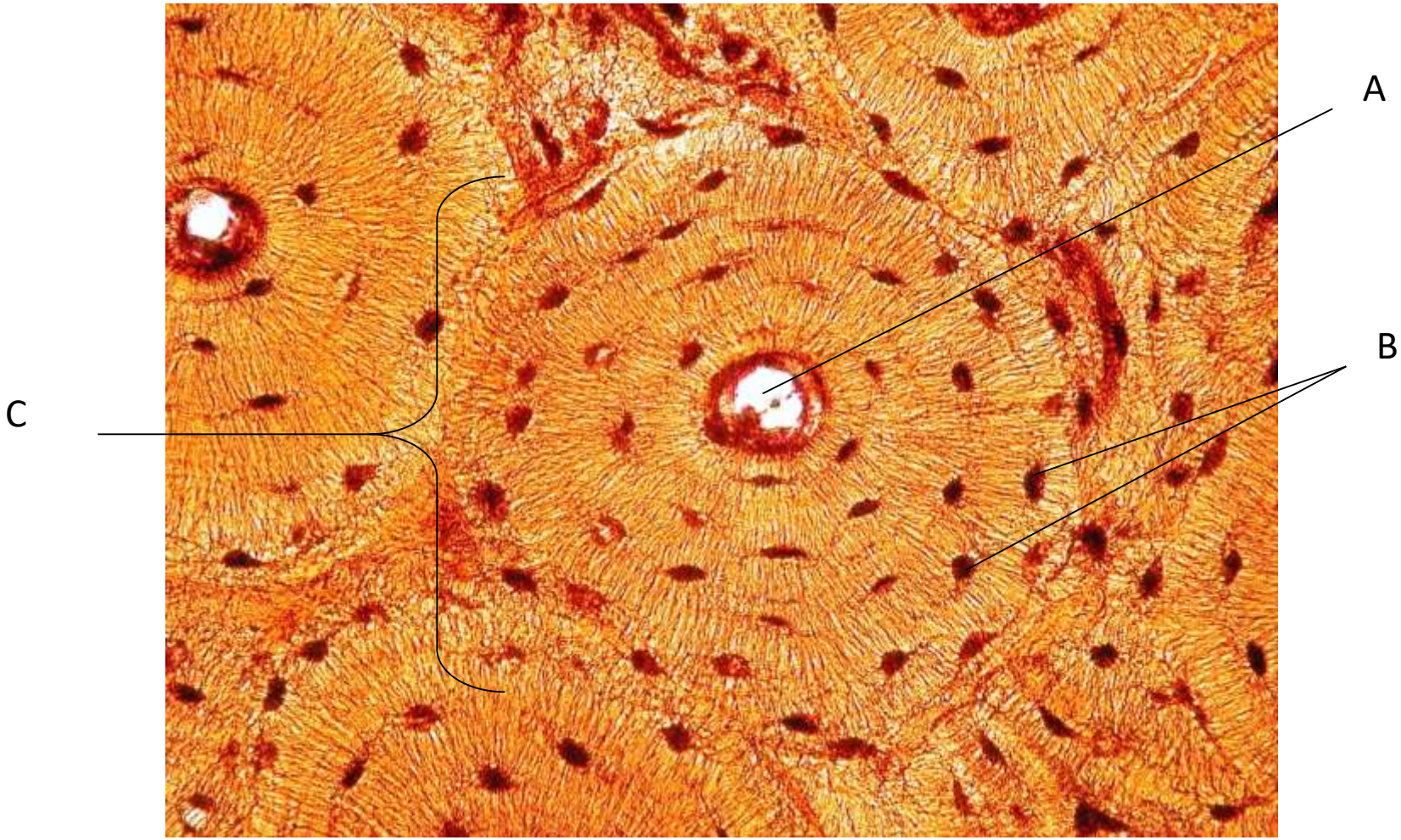
b. Compact bone

c. Hyaline cartilage

d. Elastic cartilage

e. Fibrocartilage

Label the following



Answer

1. D
2. B
3. A
4. A
5. A
6. C