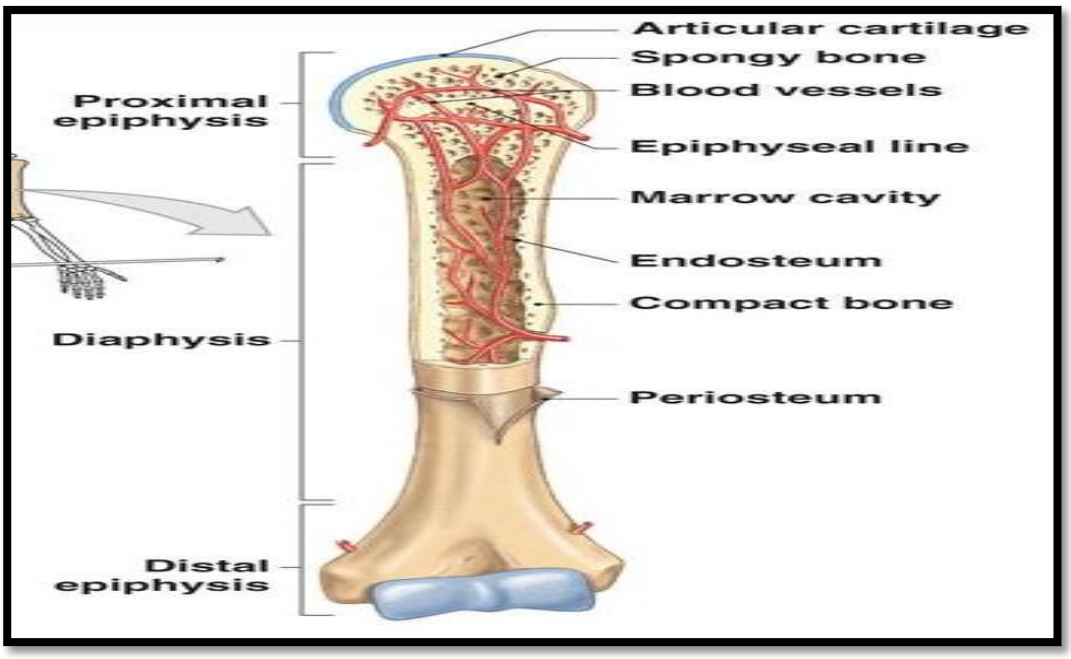
The Bone: is a specialized connective tissue composed of cells, fiber and calcified extracellular matrix **(**like other connective tissues),its forms the strong and rigid endoskeleton to which skeletal muscles are attached to permit movement.

Gross organization of bone

All bones are lined on both internal and external surfaces by layers of connective tissue containing osteogenic cells **endosteum** on the internal surface and **periosteum** on the external surface. Long bones have a shaft, called the **diaphysis**, and two expanded ends, each called an **epiphysis**. The flared portion of the bone between the diaphysis and the epiphysis is called the **metaphysis.** A large cavity filled with bone marrow, called the **marrow** or **medullary cavity**, forms the inner portion of the bone.

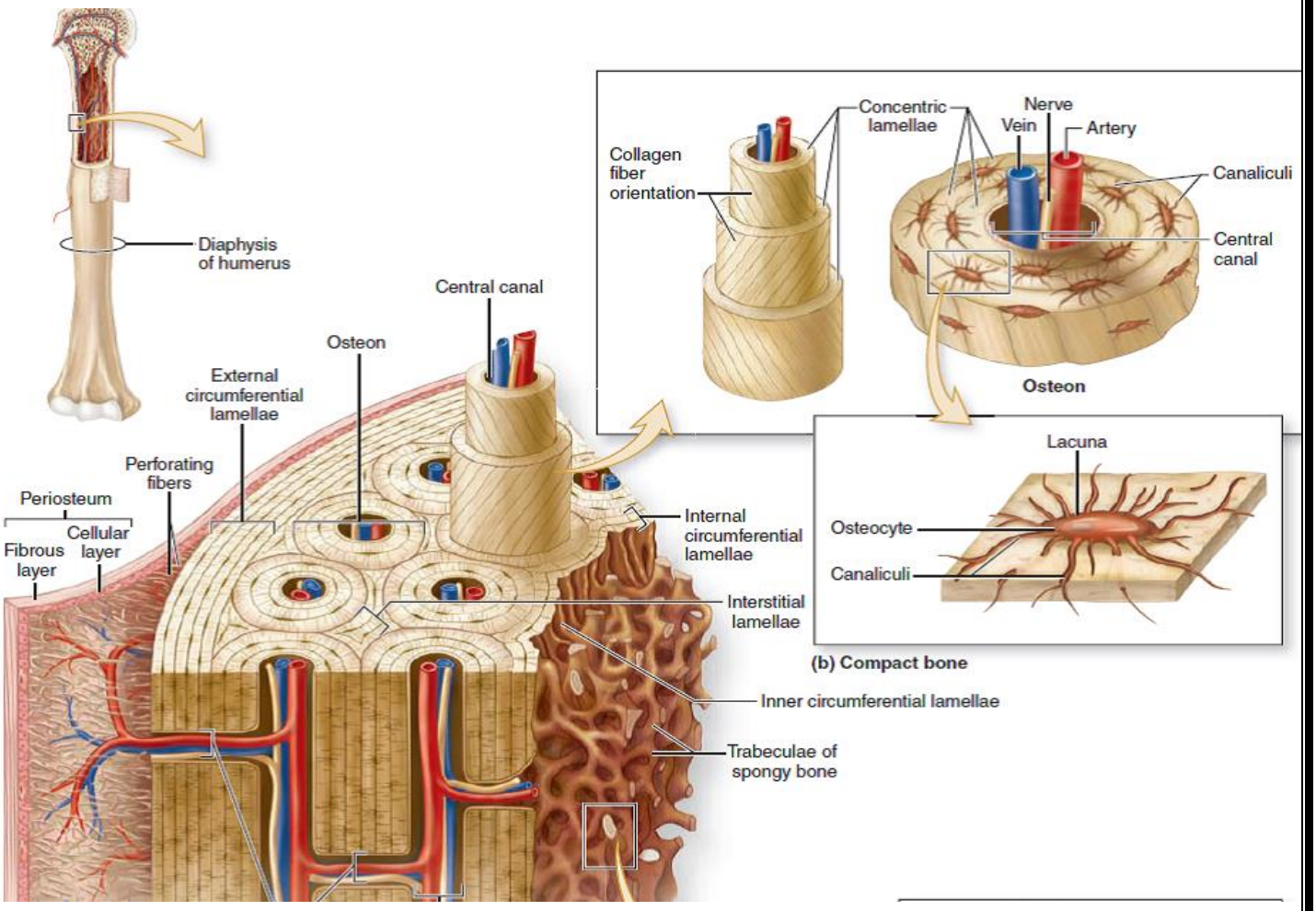


Bone classified according to the tissues

Typically, a bone consists of bone tissue and other connective tissues, including hematopoietic tissue, fat tissue, blood vessels, and nerves. If a bone is cut, two distinct structural arrangements of bone tissue can be recognized according to the degree of hardness two types:

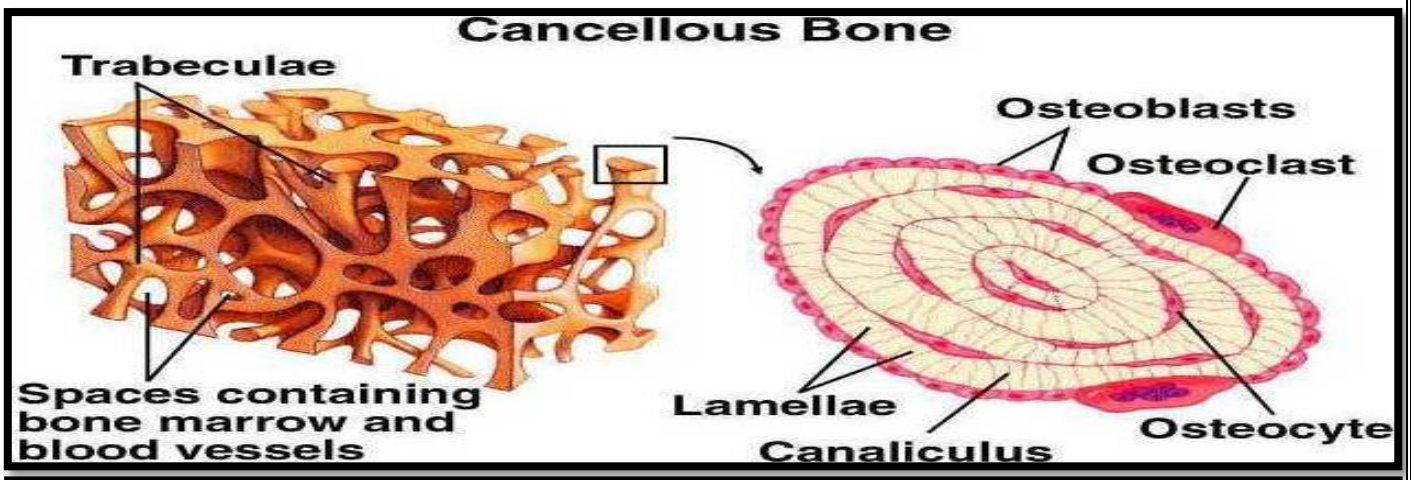
1-Compact, lamellar, denes or solid bone mature bone is largely composed of cylindrical units called **osteons** or **Haversian systems**. The osteons consist of **concentric lamellae** (sing., *lamella*) of bone matrix surrounding a central canal, the **osteonal (Haversian) canal**, which contains the vascular and nerve supply of the osteon. Canaliculi containing the processes of osteocytes are generally arranged in a radial pattern with

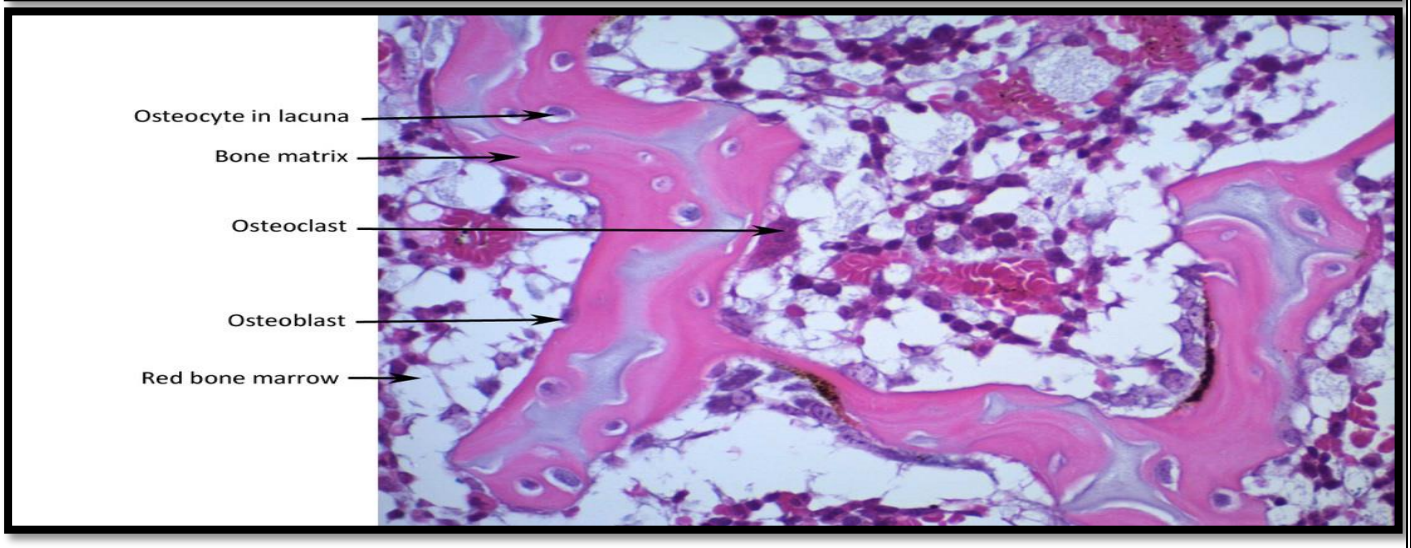
respect to the canal. The system of canaliculi that opens to the osteonal canal **(Haversian canal)** also serves for the passage of substances between the osteocytes and blood vessels. **Volkmann's canals,** also known as perforating holes or channels, are atomic arrangements in cortical bones. It found inside osteons. They interconnect the haversian canals with each other and the periosteum to provide energy and nourishing elements for osteons. Scattered among the intact osteons are numerous irregularly shaped groups of parallel lamellae called interstitial lamellae. In compact bone besides forming osteons, the lamellae also exhibit a typical organization consisting of multiple external circumferential lamellae and often some inner circumferential lamellae.



2-A spongy or cancellous bone: Cancellous bone has a higher surface area to mass ratio than cortical bone because it is less dense. This gives it softer, weaker, and more flexible characteristics. Cancellous bone is typically found at the ends of long bones, proximal to joints and within the interior of vertebrae. Cancellous bone is highly vascular and frequently contains red bone marrow where haematopoiesis, the

production of blood cells, occurs. The primary anatomical and functional unit of cancellous bone is the **trabecula.**

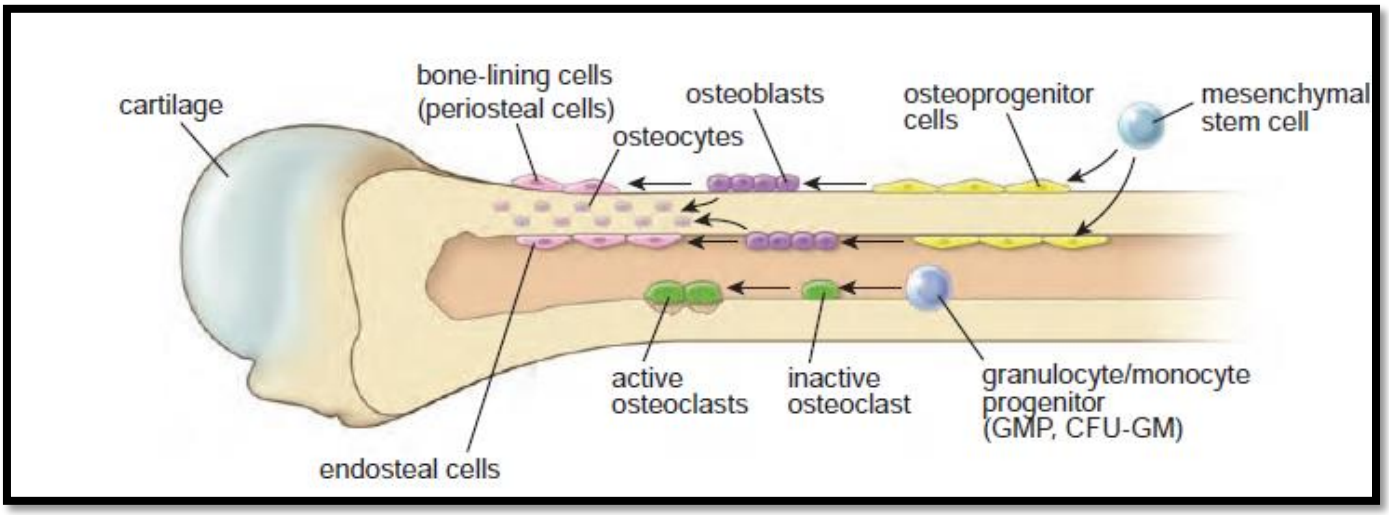




The cells of spongy bone: The bone cells composed from the following cells types:

1. **Osteoprogenitor cell:** mesenchmal stem cell found in periosteum, transform to osteoblast and formed bon matrix it have vital role in bone repair and growth.
2. **Osteoblasts** synthesis **osteoid** and mediate its mineralization, which responded of calcification, and may change to osteocytes. These are found lined up along bone surfaces.
3. **Osteocytes** represent largely inactive osteoblasts. Contain cytoplasm processes found within canaliculi. These may assist in the nutrition of bone.

4. **Osteoclasts** are phagocytic cells which are capable of eroding bone. These are important, along with osteoblasts, in the constant turnover and refashioning of bone.

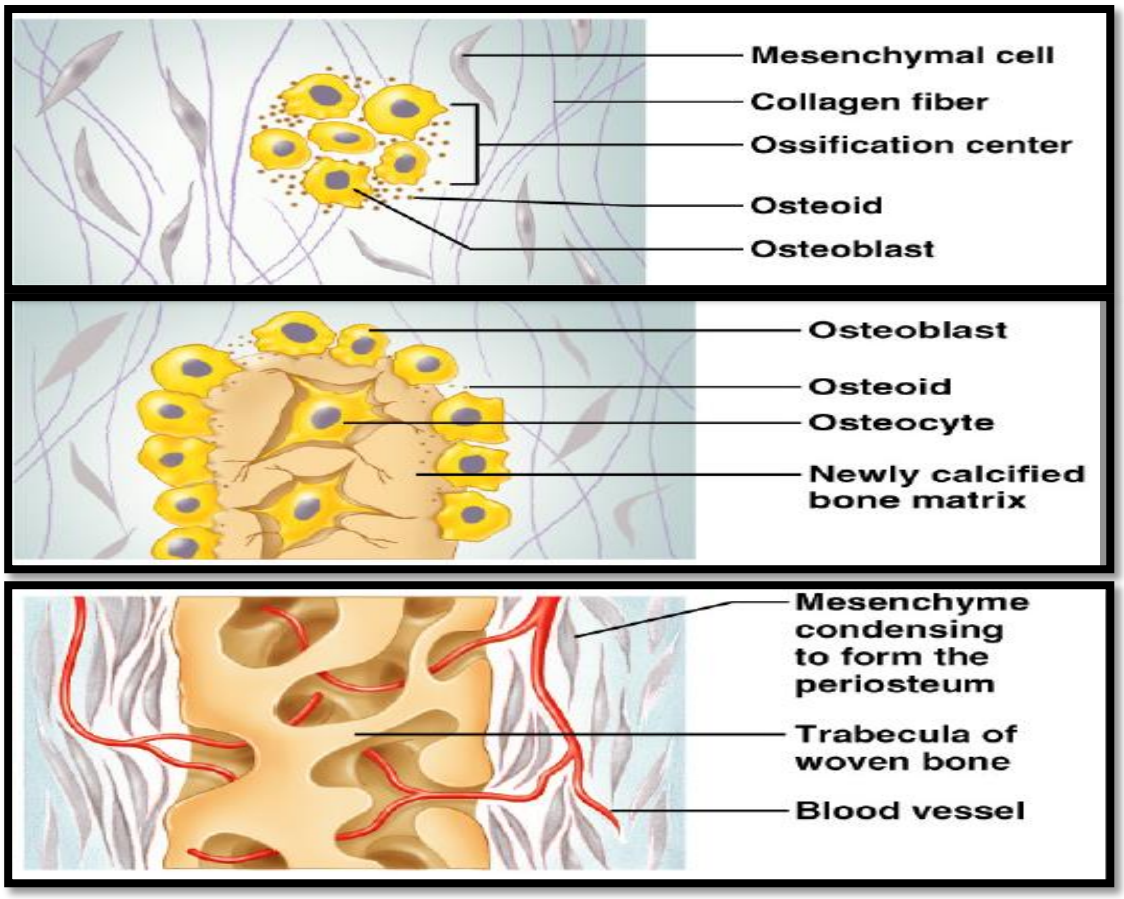


Development and growth of bone: There are two major processes that create bone during embryonic development, intramembranous and endochondral ossification.

Intramembranous Ossification is the embryonic development of flat bones from an embryonic tissue called the mesenchyme, such as formation of cranial bones of the skull (frontal, perietal, occipital, and temporal bones) and the clavicles.

1. Formation of **ossification centers**: centrally located stem cells within the mesenchyme differentiate (specialize) into osteoblasts, forming the ossification center
2. **Matrix formation**: osteoblasts start to secrete the fibers (proteins) that make up the bony matrix, called osteoid. Soon after the **osteoid** will combine with **calcium** to form calcified bone. This calcified bone will engulf the osteoblasts which will make them form into osteocytes.
3. **Periosteum and Weaving**: The osteoid is continually laid down randomly around blood vessels. Structures called **trabeculae** form around the vessels and pores are found where the blood vessels are located, thus forming **spongy bone**. Mesenchyme tissues on the outside of the spongy bone condense and form into the periosteum (vascular CT outside of bone)

4. **Compact bone formation**: as the trabeculae thicken within the spongy bone the osteoblasts on the periphery will continue to lay down osteoid. This osteoid will condense to form **lamellar bone (compact bone)** around the spongy bone (on both sides). As this process contines red bone marrow will start to appear where the blood vessels were located in the spongy spaces.



Endochondral Ossification (intracartilagenous Ossification)

This formation of all of the rest of the bones. Start with the second month of development. Uses hyaline cartilage as models for bone construction. Requires breakdown of hyaline cartilage prior to ossification. Formation begins at the primary ossification center.

Stages of Endochondral Ossification

1. Cavitation of the hyaline cartilage **primary ossification centers** form in diaphysis.
2. Invasion of internal cavities by the **periosteal bud**, and spongy bone formation

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3. Formation of the medullary cavity; appearance of **secondary ossification centers** in the epiphyses.
4. Ossification of the epiphyses. With the primary and secondary ossification centers, two regions of cartilage remain:

- The layer of articular cartilage within joints usually persists through adult life and does not contribute to bone growth.
- The specially organized epiphyseal cartilage (also called epiphyseal plate or growth plate), which connects each epiphysis to the diaphysis.

An epiphyseal growth plate shows distinct regions of cellular activity:-

1. The resting zone consists of hyaline cartilage with typical chondrocytes.
2. In the proliferative zone, chondrocytes begin to divide rapidly and form columns of stacked cells parallel to the long axis of the bone.
3. The hypertrophic cartilage zone contains swollen, degenerative chondrocytes whose cytoplasm has accumulated glycogen. This hypertrophy compresses the matrix into thin septa between the chondrocytes.
4. In the calcified cartilage zone, loss of the chondrocytes by apoptosis is accompanied by calcification of the septa of cartilage matrix by the formation of hydroxyapatite crystals
5. In the ossification zone, bone tissue first appears.

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