The bone

It is a specialized connective tissue which is characterized by its rigidity and hardness. In adult, its constitute most of the skeleton of the body.

General functions of bone

1- Support fleshy structures (as ribs)

2-To permit locomotion (as long bones)

3- Provide protection to vital organs such as brain, heart, and lungs (as skull).

4- Red blood cells are manufactured in the red bone marrow, which is situated in the spongy tissue at the ends of long bones.

5-It play a vital role in the mineral metabolism of the body. It considered as a reservoir for several minerals of the body such as calcium, and phosphate.

Bone like other types of connective tissue consist of cells and extracellular matrix but distinguish from other connective tissue is the matrix is mineralized. This matrix is calcified and acidophilic. The matrix is composed of approximately 35% organic and 65% inorganic components. The **organic components** include ground substance and type I collagen fibers. The ground substance is rich in proteoglycans with chondroitin sulfate and keratin sulfate, also found glycoprotein. The **inorganic components** include mineral salts which is responsible for the hardness and rigidity of bone, and these include calcium phosphate (85%), calcium carbonate (10%), and other salts (5%). All bones are lined on both internal and external surfaces by layers of tissue include endosteum on the internal surfaces and periosteum on the external surface.

Bone cells

There are different types of cells can be recognized:

1-Osteoprogenitor cells

They are found on the external and internal surfaces of bones. They form the inner layer of the periosteum and line the marrow cavities. These cells appear flattened or spindle- shaped, with elongated or ovoid nuclei (Figure 1). The cytoplasm is acidophilic or slightly basophilic. These cells can divide and proliferate, and transform into osteoblasts.

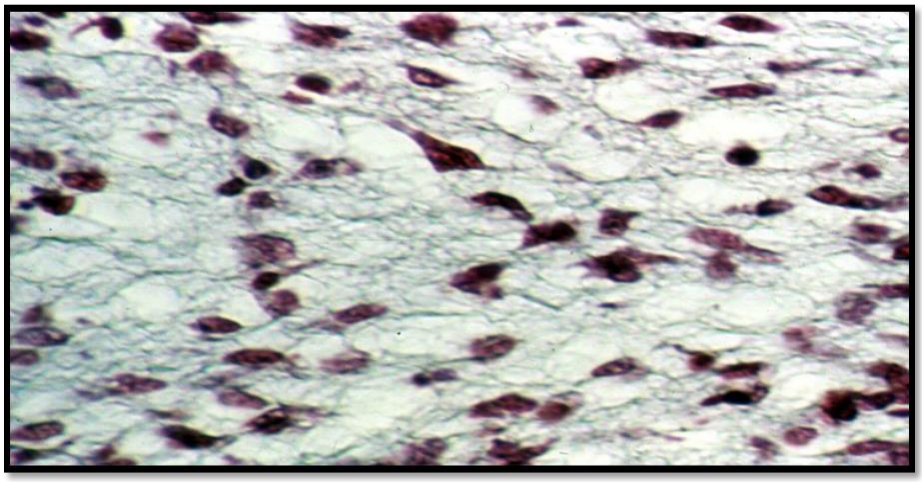

Figure (1): The shape of osteoprogenitor

2-Osteoblasts

These cells derived from Osteoprogenitor cells. They are located on the surface of the bone. It appears as continues single layer of cells, composed of cuboidal cells (Figure 2). The cytoplasm is basophilic with fine granules and large rounded nucleus. Osteoblasts are responsible for the synthesis of the organic components of the bon matrix, which called osteoid. It is not calcified matrix consist of type I collagen and porteoglycans and glycoprotiens. The bone deposition is completed by subsequent deposition of calcium salts into the newly formed matrix.

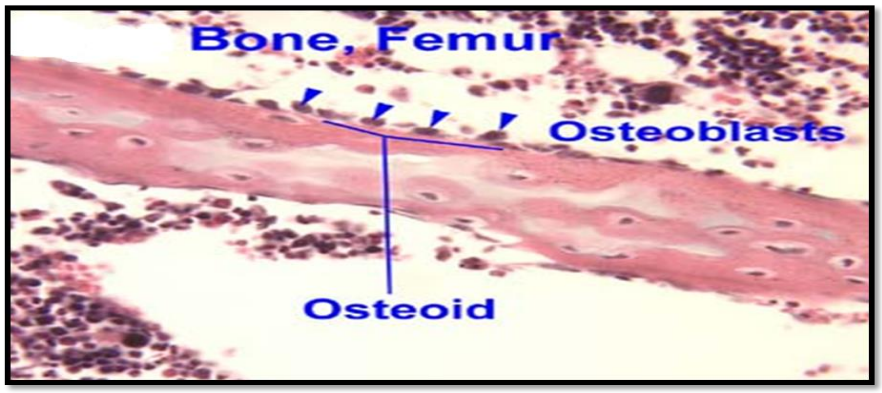

Figure (2): The shape of osteoblasts

3- Osteocytes

These are mature bone cells derived from osteoblasts that become lie within a space or lacunae situated between lamellae of calcified bone matrix. The osteocytes have flat, or almond-shape with faintly basophilic cytoplasm and flattened darkly staining nucleus (Figure 3). These cells have numerous slender cytoplasm processes called filopoidal processes extend into the canaliculi which radiate out from the lacuna in the matrix (Figure 4). These processes make contact with similar process of neighboring osteocytes via gap junction through which ions and small molecules can move between the cells. This provide mechanism for nutrients and exchange of metabolites between blood stream and osteocytes. These cells are actively involved in the maintenance of the bone matrix.

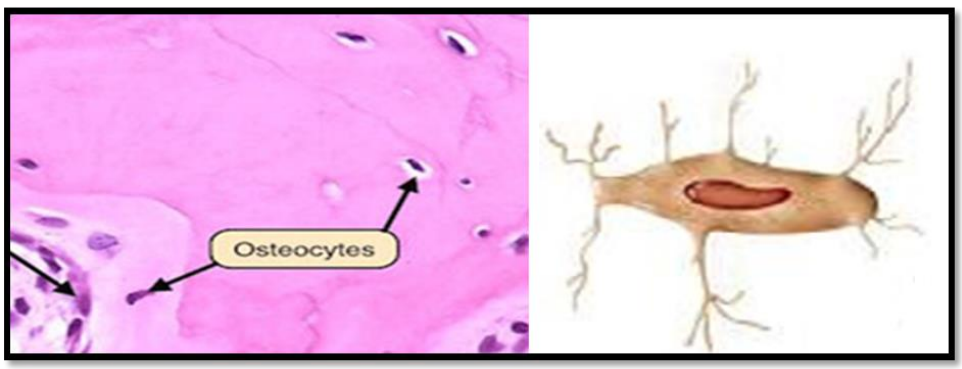

Figure (3): The shape of osteocytes.

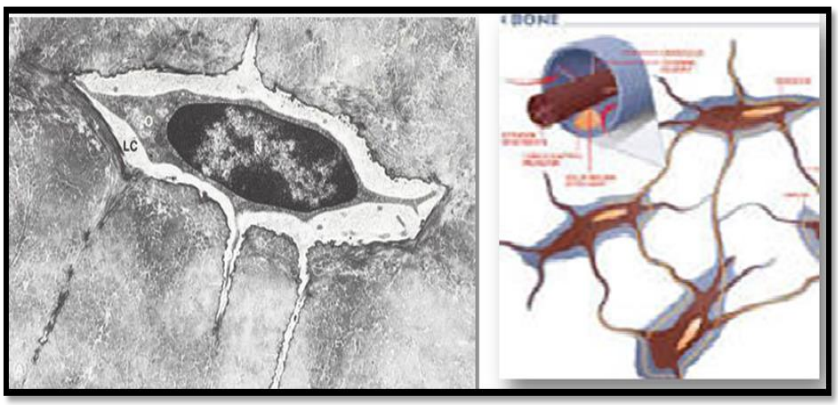

Figure (4): The canaliculi of lacunae of osteocytes.

4-Osteoclasts

These cells originate from bone marrow. They are very large cells which called giant cells and multinucleated, where they contain 5-50 nuclei in each cell (Figure 5). The cytoplasm is acidophilic, granular, and vacuolated in appearance, some of these vesicles are lysosomal in nature. The osteoclasts secrete collagenase and other enzymes promoting the localized digestion of collagen and dissolving calcium salts. Osteoclasts are found attached to the bone surface, often in shallow depressions called **Howships lacunae**. These cells play an important role in resorption and remodeling of bone tissue.

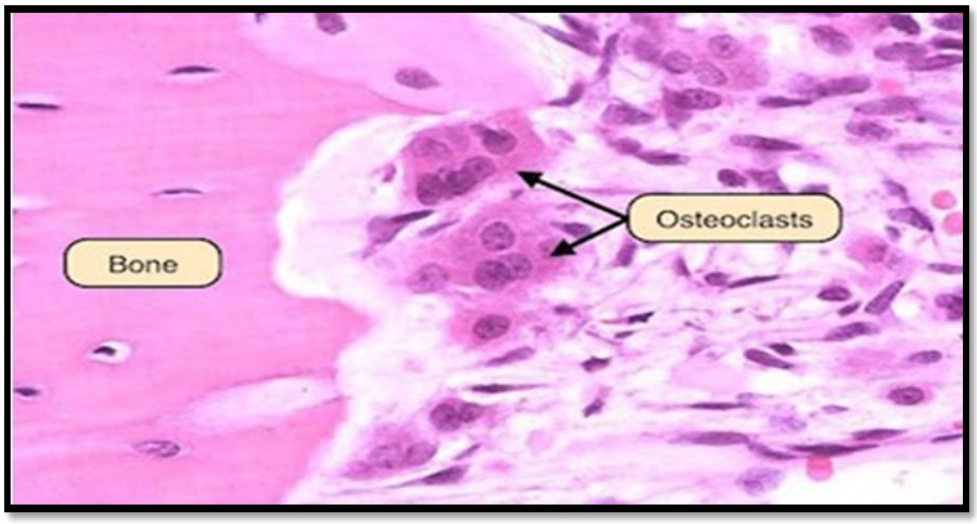

Figure (5): The shape of osteoclasts.

Periosteum

It is fibrous sheath covered the external surfaces of bone. It is consist of two layer, the **outer layer** is dense irregular connective tissue with fibroblasts and containing a network of blood vessels and nerves. The **inner layer**, more cellular layer of the periosteum is composed of loose connective tissue which is less vascular and highly cellular contain flattened cells called osteoprogenitor cells. These cells have potential to divide and differentiate into osteoblasts. Osteoprogenitor cells (osteogenic cells) play important role in bone growth and repair.

Endosteum

It is thin sheath that lines the of internal cavities within the bone. It is composed of a single layer of flattened osteoprogenitor cells and very small amount of connective tissue. The endosteum is thinner than the periosteum. The principle function of periosteum and endosteum are nutrition of bone tissue and for repair and growth of bone.

Types of bone

Bones are classified according to their shape into: long bones, short bones, flat bones and irregular bones. Also bones tissue is classified into compact or spongy bone (Figure 6).

A long bone such as the femur, consists of a center piece, the shaft called diaphysis, and a thickened head each called epiphysis at each end. The articular surface of the epiphysis is covered with a thin layer of hyaline cartilage. The remainder of the bone is covered membrane, the periosteum which is richly supplied with blood vessels. Beneath the periosteum is a layer of compact bone which is thicker in the shaft than in the two heads. The shaft

encloses a hollow, the marrow cavity, which is lined with a thin soft membrane known as the endosteum The marrow cavity contains a soft tissue richly supplied with fat cells and blood corpuscles, the yellow marrow. The epiphysis of a long bone consists of spongy (or cancellous) bone covered with a thin layer of compact bone (Figure 7). If a bone is cut, the cross section shows the epiphysis composed of spongy bone covered by a thin layer of compact bone. The diaphysis is composed of compact bone, with small amount of spongy bone on its inner surface around the marrow cavity.

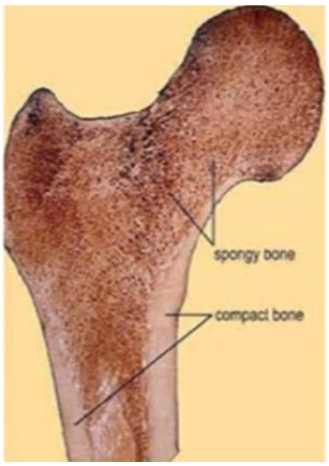

Figure (6): Type of bones

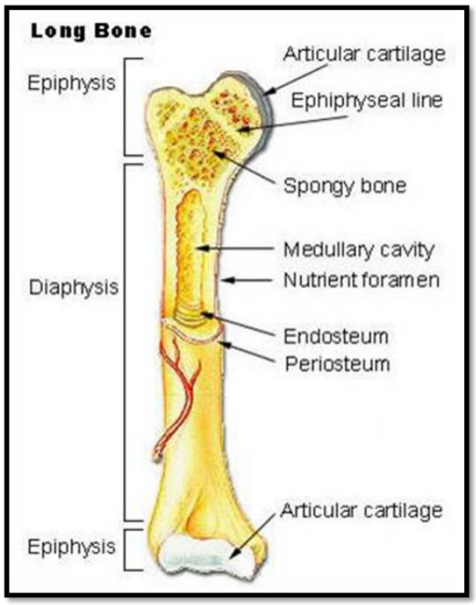

Figure (7): The structure of long bone

Under the microscope, the bone consist of two distinct structural arrangement of bone tissue can be recognized:

1- Spongy bone (cancellous)

Consist of slender, irregular trabeculae or bars which branch and unite with one another to form network (Figure 8). These trabeculae consist of several lamellae in which the lacunae containing osteocytes. These trabeculae surround spaces called marrow cavities which filled with bone marrow (Figure 9). There are two types of bone marrow, red bone marrow which

contains primitive stem cells that responsible of forming blood cells and yellow bone marrow which composed mainly of fat cells.

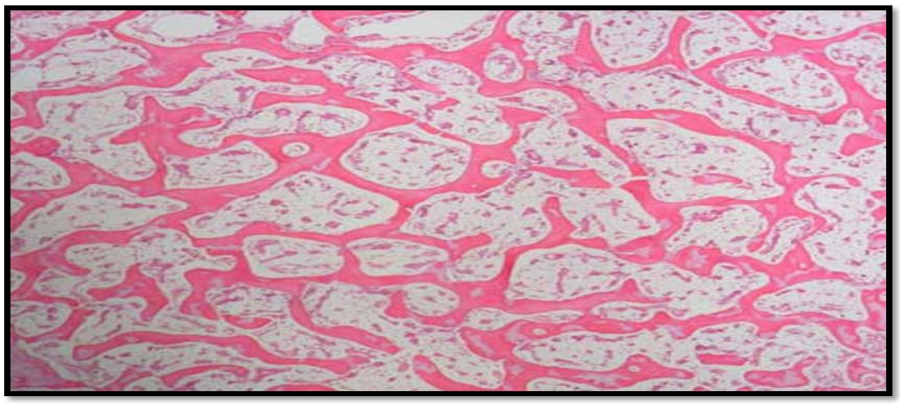

Figure (8): The shape of spongy bone.

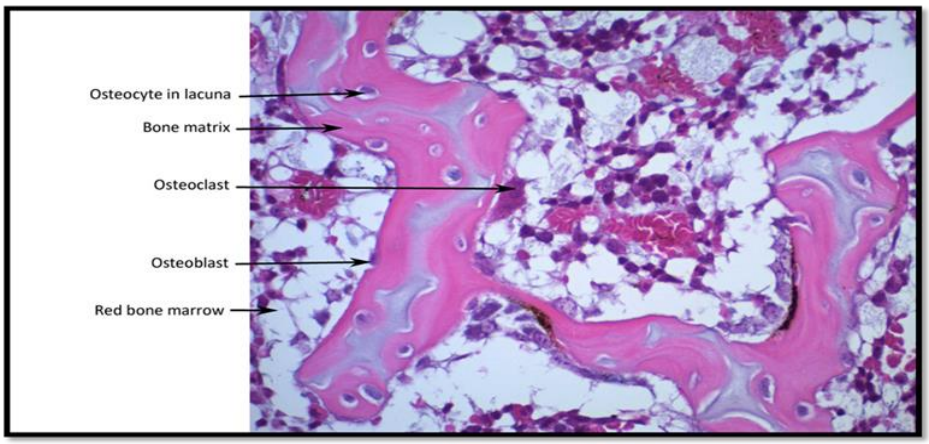

Figure (9): The structure of spongy bone.

2- Compact bone (lamellar bone)

It is composed of structural units called osteon or Haversion system, where the calcified bone matrix organized into lamellae. The osteon consists of concentric lamellae of bone matrix surrounding a central canal called Haversian canal (osteonal canal), which contains the blood vessels, nerves and loose connective tissue. The function of Haversian system is to bring nutrients to compact bone.

In Haversian system, the Haversian canal is surrounded by varying number of concentric lamellae. Each Haversian canal lined by osteoblasts, osteoprogenitor cells and loose connective tissue in addition to blood vessels and nerves. In each lamella, collagen fibers are parallel to each other (Figure 10).Within the lamellae there are small cavities called lacunae that have numerous narrow channels called canaliculi containing the processes of osteocytes which penetrate adjacent lamellae to join with canaliculi of neighboring lacunae, which serves for the passage of substances between the osteocytes and blood vessels. The Havresian canals communicate with each other and with marrow cavity and periosteum through transverse or oblique canals called Volkmanns canals (Figure 11).

The intervals between Haversian system are filled with interstitial or intermediate lamellae, which act as packing between adjacent Haversian system. Also there are inner circumferential lamellae, located around the marrow cavity. Also outer circumferential lamellae located beneath the periosteum (Figure 12). These structures are lamellae left by previous Haversian system destroyed during growth and remodeling of bone.

Microscopic examination of bone shows two types:

1-Primary bone, immature bone, or woven bone

It is the first bone tissue to appear in embryonic development and in fracture repair and other repair processes. It is temporary and is replaced in adults by secondary bone, except in a very few places in the body, e.g. near the sutures of the flat bones of the skull and in tooth sockets.

The type of bone is characterized by irregular array of collagen fibers in the matrix therefore this bone nonlamellar. Smaller content of minerals and contains higher proportion of osteocytes than in secondary bone. These cells tend to be randomly arranged.

1-Secondary bone, mature bone, or lamellar bone

It found in adults and its characterized by collagen fibers arranged in lamellae that are parallel to each other or concentrically organized around a vascular canal. The whole complex of concentric lamellae of bone called Haversian system. The features of this type of bone as mention in compact bone.

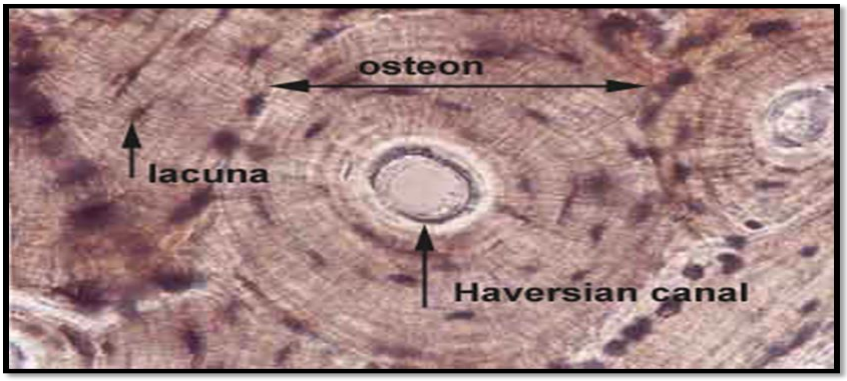

Figure (10): The structure of compact bone.

Figure (11): The structure of Volkmann canal.

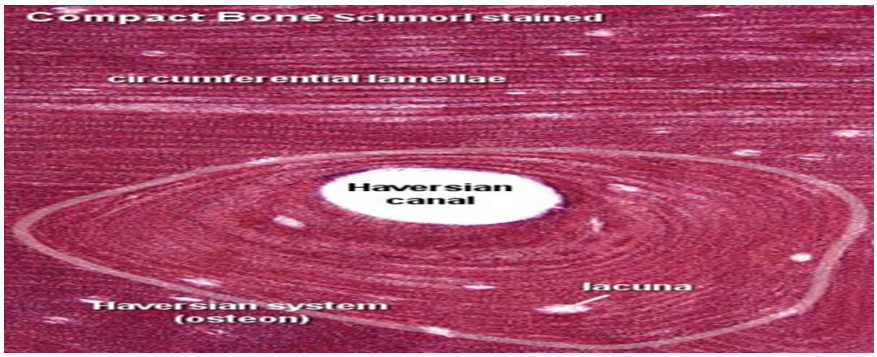

Figure (12): The arrangement of lamellae within bone.