**CARTILAGE:**

**Characterestic features of cartilages:**

1- Cartilage is a specialized form of connective tissue in which the firm consistency and characterized by an extracellular matrix (ECM) enriched with glycosaminoglycans and proteoglycans, macromolecules that interact with collagen and elastic fibers. 2-Variations in the composition of these matrix components produce three types of cartilage adapted to local biomechanical needs.

3-Cartilage consists of cells called **chondrocytes**  and an extensive **extracellular matrix** composed of fibers and ground substance. Chondrocytes synthesize and secrete the ECM and the cells themselves are located in matrix cavities called **lacunae. 4-**Collagen, hyaluronic acid, proteoglycans, and small amounts of several glycoproteins are the principal macromolecules present in all types of cartilage matrix.

**Chondrocytes:**

A)At the periphery of hyaline cartilage, young chondrocytes have an elliptic shape, with the long axis parallel to the surface. Farther in, they are round and may appear in groups of up to eight cells originating from mitotic divisions of a single chondrocyte. B) Chondrocytes synthesize collagens and the other matrix molecules.

**Perichondrium:**

A-The **perichondrium**  is a sheath of dense connective tissue that surrounds cartilage in most places, forming an interface between the cartilage and the tissue supported by the cartilage. B-The perichondrium harbors the vascular supply for the avascular cartilage and also contains nerves and lymphatic vessels.

**I-HYALINE CARTILAGE:**

Hyaline cartilage is the most common and best studied of the three forms. Fresh hyaline cartilage is bluish-white and translucent.In the embryo, it serves as a temporary skeleton until it is gradually replaced by bone.

**Sites of hyaline cartilage in adult mammals:** 1-Hyaline cartilage is located in the articular surfaces of the movable joints, in the walls of larger respiratory passages (nose, larynx,trachea, bronchi), in the ventral ends of ribs, where they articulate with the sternum, and in the **epiphyseal plate,** where it is responsible for the longitudinal growth of bone . 2-Except in the articular cartilage of joints, ***i***-All hyaline cartilage is covered by a layer of dense connective tissue, the **perichondrium**, which is essential for the growth and maintenance of cartilage . ***ii-***It consists largely of collagen type I fibers and contains numerous fibroblasts. ***iii***-The cells in the inner layer of the perichondrium resemble fibroblasts, they are precursors for chondroblasts which divide and differentiate into chondrocytes.

**II-ELASTIC CARTILAGE:**

1-Elastic cartilage is essentially very similar to hyaline cartilage except that it contains an abundant network of fine elastic fibers in addition to collagen type II

fibrils . 2- Fresh elastic cartilage has a yellowish color owing to the presence of elastin in the elastic fibers.

**Sites of elastic cartilage** : 1- Elastic cartilage is frequently found to be gradually continuous with hyaline cartilage. Like hyaline cartilage, elastic cartilage possesses a perichondrium.

2-Elastic cartilage is found in the auricle of the ear, the walls of the external auditory canals, the auditory (eustachian) tubes, the epiglottis, and the cuneiform

cartilage in the larynx.

**III-FIBROCARTILAGE:**

Fibrocartilage is a tissue intermediate between dense connective tissue and hyaline cartilage. It is found in intervertebral disks, in attachments of certain ligaments, and in the pubic symphysis.

**BONE:**

**Characterestic features of bone:**

1-Bone is a specialized connective tissue composed of calcified intercellular material, the **bone matrix,** and three cell types:

***i)Osteocytes .ii)Osteoblasts* .** ***iii)Osteoclasts* .** 2-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.

**Periosteum:** 1-The **periosteum** consists of a dense fibrous outer layer of collagen bundles and fibroblasts . Bundles of periosteal collagen fibers, called **perforating fibers,** penetrate the bone matrix, binding the periosteum to bone. 2-The innermost cellular layer of the periosteum contains mesenchymal stem cells called **osteoprogenitor cells,** with the potential to divide by mitosis and differentiate into osteoblasts. 3-Osteoprogenitor cells play a prominent role in bone growth and repair.

**Endosteum:** 1-The large internal marrow cavities of bone are lined by **endosteum** . Endosteum is a single very thin layer of connective tissue, containing flattened osteoprogenitor cells and osteoblasts, which covers the small spicules or trabeculae of bone that project into these cavities. 2-The endosteum is therefore considerably thinner than the periosteum.The principal functions of periosteum and endosteum are nutrition of osseous tissue and provision of a continuous supply of new osteoblasts for repair or growth of bone.

**BONE CELLS:**

**I-Osteoblasts:**

Osteoblasts are responsible for the synthesis of the organic components of bone matrix, consisting of type I collagen fibers, proteoglycans, and several glycoproteins including osteonectin. Osteoblasts have a cuboidal to columnar shape and basophilic cytoplasm. **Function of osteoblast. 1-**producing a layer of new (but not yet calcified) material called **osteoid** between the osteoblast layer and the bone formed earlier . 2-This process of bone appositional growth is completed by subsequent deposition of calcium salts into the newly formed matrix.

**II-Osteocytes:**

***i)***Individual osteoblasts are gradually surrounded by their own secretion and become **osteocytes** enclosed singly within spaces called **lacunae**. ***ii)***In the transition from osteoblasts to osteocytes the cells extend many long cytoplasmic processes, which also become surrounded by calcifying matrix. ***iii)***An osteocyte and its processes occupy each lacuna and the canaliculi radiating from it .

**III-Osteoclasts:**

1-Osteoclasts are very large, motile cells with multiple nuclei. The large size and multinucleated condition of osteoclasts is due to their origin from the fusion of bone marrow-derived cells.

***2-*** The osteoclast secretes collagenase and other enzymes and pumps protons, forming an acidic environment locally for dissolving hydroxyapatite and promoting the localized digestion of collagen.

**TYPES OF BONE:**

**I-Gross observation :** 1- **Compact bone**: bone in cross section shows dense areas generally without cavities. 2- **Cancellous** (**Spongy)** **bone** : areas with numerous interconnecting cavities. Under the microscope, however, both compact bone and the trabeculae separating the cavities of cancellous bone have the same basic histologic structure. 3-  **Long bones**: The bulbous ends,called **epiphyses ,**are composed of spongy bone covered by a thin layer of compact bone. The cylindrical part,the **diaphysis ,**is almost totally composed of compact bone, with a thin component of spongy bone on its inner surface around the bone marrow cavity. 4-**Short bones** : usually have a core of spongy bone surrounded completely by compact bone.

**5-The flat bones:**

The flat bones that form the calvaria (skullcap) have two layers of compact bone called **plates** (tables) .

A plate of epiphyseal cartilage is divided into five zones , starting from the epiphyseal side of cartilage:

A-The **resting zone** consists of hyaline cartilage with typical chondrocytes.

B. In the **proliferative zone,** chondrocytes begin to divide rapidly and form columns of stacked cells parallel to the long axis of the bone.

C-The **hypertrophic cartilage zone** contains swollen chondrocytes whose cytoplasm has accumulated glycogen. Hypertrophy compresses the matrix into thin

septa between the chondrocytes.

D-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.

E-In the **ossification zone,** bone tissue first appears. ***i)***Capillaries and osteoprogenitor cells originating from the periosteum invade the cavities left by the chondrocytes. Many of these cavities will be merged and become the marrow cavity. ***ii)***The osteoprogenitor cells form osteoblasts, which settle in a discontinuous

layer over the septa of calcified cartilage matrix. ***iii)***The osteoblasts deposit osteoid over the spicules of calcified cartilage matrix, forming woven bone.

**II-Microscopic examination** of bone shows two types: immature **primary bone** and mature **secondary bone.**

**1-Primary Bone Tissue.**

***i)***Primary bone is the first bone tissue to appear in embryonic development and in fracture repair. ***ii)***It is characterized by random disposition of fine collagen fibers and is therefore often called **woven bone** .

**2-Secondary Bone Tissue.**

Secondary bone tissue is the type usually found in adults. It characteristically shows multiple layers of calcified matrix and is often referred to as **lamellar bone**.