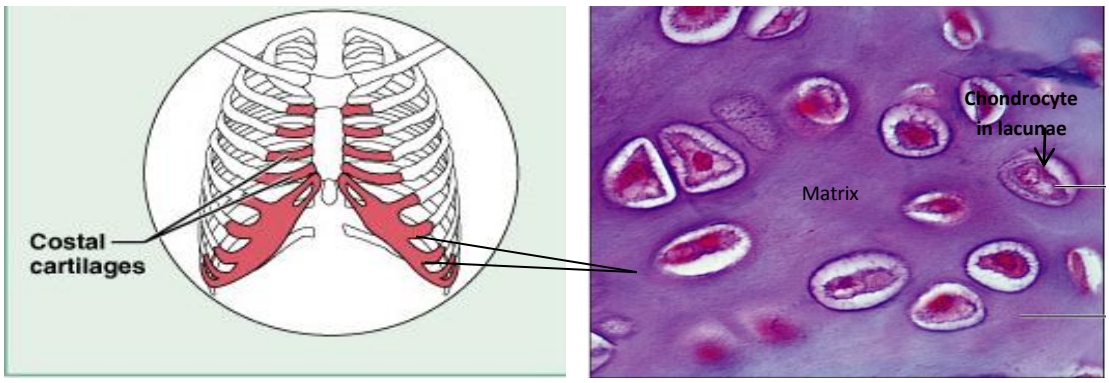


Lecture No – 3

Special tissues:- Bone and Cartilage

Cartilage: Introduction

Cartilage is characterized by an extracellular matrix enriched with glycosaminoglycans and proteoglycans, macromolecules that interact with collagen and elastic fibers. Variations in the composition of these matrix components produce three types of cartilage adapted to local biomechanical needs.

Cartilage is a specialized form of connective tissue in which the firm consistency of the extracellular matrix allows the tissue to bear mechanical stresses without permanent distortion. Another function of cartilage is to support soft tissues. Because it is smooth surfaced and resilient, cartilage is a shock-absorbing and sliding area for joints and facilitates bone movements. Cartilage is also essential for the development and growth of long bones both before and after birth .

Cartilage consists of cells called **chondrocytes** (Gr. *chondros,* cartilage, + *kytos,* cell) and an extensive **extracellular matrix** composed of fibers and ground substance. Chondrocytes synthesize and secrete the extracellular matrix, and the cells themselves are located in matrix cavities called **lacunae.** Collagen, hyaluronic acid, proteoglycans, and small amounts of several glycoproteins are the principal macromolecules present in all types of cartilage matrix. Elastic cartilage, characterized by its great pliability, contains significant amounts of the protein elastin in the matrix.

Because collagen and elastin are flexible, the firm gel-like consistency of cartilage depends on electrostatic bonds between collagen fibers and the glycosaminoglycan side chains of matrix proteoglycans. It also depends on the binding of water (solvation water) to the negatively charged glycosaminoglycan chains that extend from the proteoglycan core proteins.

As a consequence of various functional requirements, three forms of cartilage have evolved, each exhibiting variations in matrix composition. In the matrix of **hyaline cartilage,** the most common form, type II collagen is the principal collagen type . The more pliable and distensible **elastic cartilage** possesses, in addition to collagen type II, an abundance of elastic fibers within its matrix. **Fibrocartilage,** present in regions of the body subjected to pulling forces, is characterized by a matrix containing a dense network of coarse type I collagen fibers.

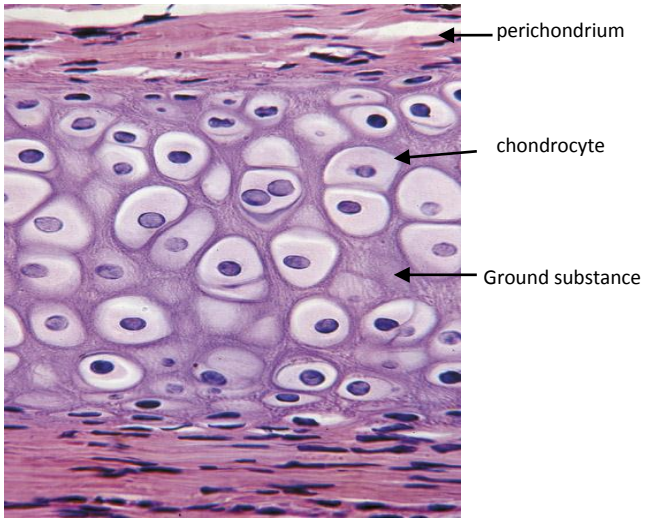
In all three forms, cartilage is avascular and is nourished by the diffusion of nutrients from capillaries in adjacent connective tissue (perichondrium) or by synovial fluid from joint cavities. In some instances, blood vessels traverse cartilage to nourish other tissues, but these vessels do not supply nutrients to the cartilage. As might be expected of cells in an avascular tissue, chondrocytes exhibit low metabolic activity. Cartilage has no lymphatic vessels or nerves.

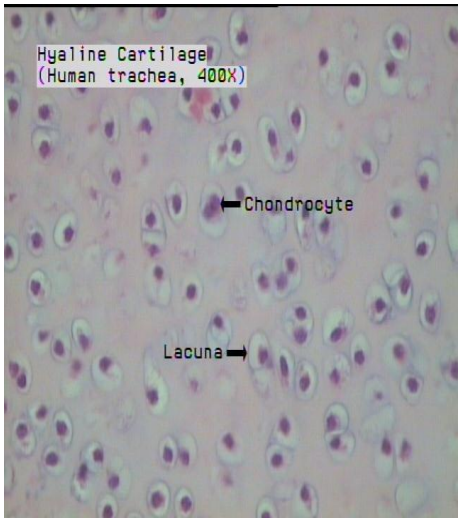
The **perichondrium** is a sheath of dense connective tissue that surrounds cartilage in most places, forming an interface between the cartilage and the tissue supported by the cartilage. The perichondrium harbors the vascular supply for the avascular cartilage and also contains nerves and lymphatic vessels. Articular cartilage, which covers the surfaces of the bones of movable joints, is devoid of perichondrium and is sustained by the diffusion of oxygen and nutrients from the synovial fluid.

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.

In adult mammals, 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 . Except in the articular cartilage of joints, all hyaline cartilage is covered by a layer of dense connective tissue, the perichondrium, which is essential for the growth and maintenance of cartilage . It is rich in collagen type I fibers and contains numerous fibroblasts. Although cells in the inner layer of the perichondrium resemble fibroblasts, they are chondroblasts and easily differentiate into chondrocytes.





Chondrocytes

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. These groups are called **isogenous** (Gr. *isos,* equal, + *genos,* family).

Cartilage cells and the matrix shrink during routine histological preparation, resulting in both the irregular shape of the chondrocytes and their retraction from the capsule. In living tissue, and in properly prepared sections, the chondrocytes fill the lacunae completely Chondrocytes synthesize collagens and the other matrix molecules.

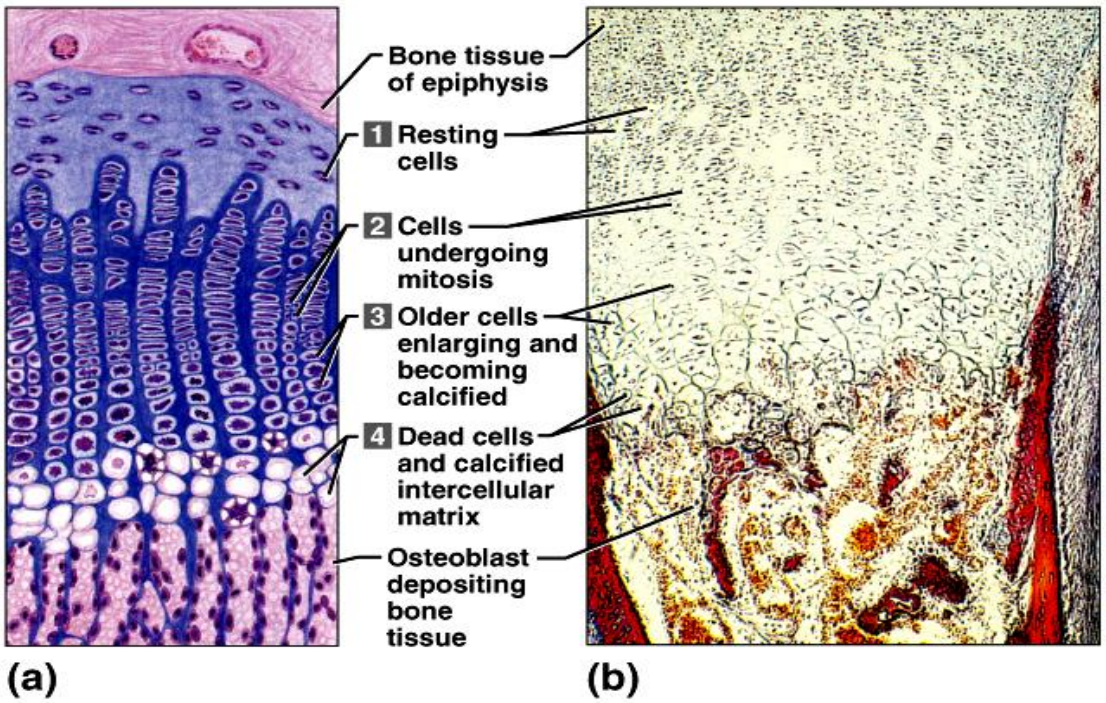
Because cartilage is devoid of blood capillaries, chondrocytes respire under low oxygen tension. Hyaline cartilage cells metabolize glucose mainly by anaerobic glycolysis to produce lactic acid as the end product. Nutrients from the blood cross the perichondrium to reach more deeply placed cartilage cells. Mechanisms include diffusion and transport of water and solute

promoted by the pumping action of intermittent cartilage compression and decompression. Because of this, the maximum width of the cartilage is limited.

Chondrocyte function depends on a proper hormonal balance. The synthesis of sulfated glycosaminoglycans is accelerated by growth hormone, thyroxin, and testosterone and is slowed by cortisone, hydrocortisone, and estradiol. Cartilage growth depends mainly on the hypophyseal growth hormone **somatotropin.** This hormone does not act directly on cartilage cells but promotes the synthesis of **somatomedin C** in the liver. Somatomedin C acts directly on cartilage cells, promoting their growth.

Growth

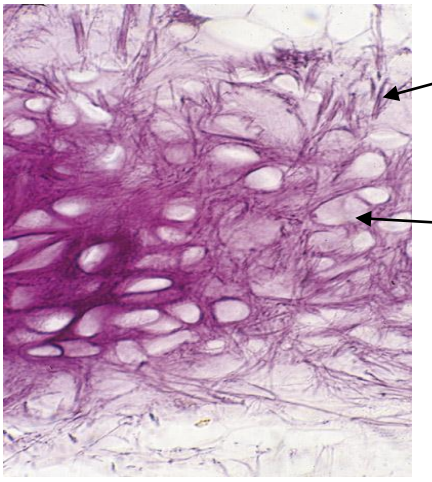
The growth of cartilage is attributable to two processes: **interstitial growth,** resulting from the mitotic division of preexisting chondrocytes, and **appositional growth,** resulting from the differentiation of perichondrial cells. In both cases, the synthesis of matrix contributes to the growth of the cartilage. Interstitial growth is the less important of the two processes. It occurs only during the early phases of cartilage formation, when it increases tissue mass by expanding the cartilage matrix from within. Interstitial growth also occurs in the epiphyseal plates of long bones and within articular cartilage. In the epiphyseal plates, interstitial growth is important in increasing the length of long bones and in providing a cartilage model for endochondral bone formation . In articular cartilage, as the cells and matrix near the articulating surface are gradually worn away, the cartilage must be replaced from within, since there is no perichondrium there to add cells by apposition. In cartilage found elsewhere in the body, interstitial growth becomes less pronounced, as the matrix becomes increasingly rigid from the cross-linking of matrix molecules. Cartilage then grows in girth only by apposition. Chondroblasts of the perichondrium proliferate and become chondrocytes once they have surrounded themselves with cartilaginous matrix and are incorporated into the existing cartilage .

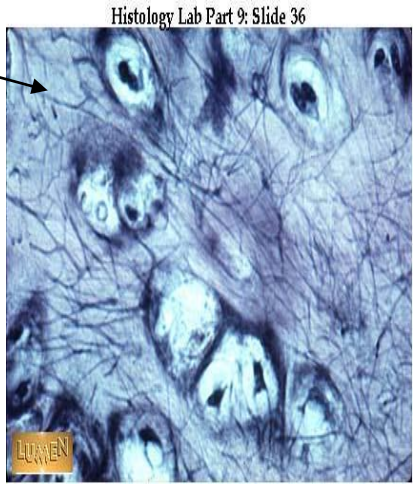


Elastic Cartilage

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.

Elastic cartilage is essentially identical to hyaline cartilage except that it contains an abundant network of fine elastic fibers in addition to collagen type II fibrils. Fresh elastic cartilage has a yellowish color owing to the presence of elastin in the elastic fibers Elastic cartilage is frequently found to be gradually continuous with hyaline cartilage. Like hyaline cartilage, elastic cartilage possesses a perichondrium.





Fibrocartilage

Fibrocartilage is a tissue intermediate between dense connective tissue and hyaline cartilage. It is found in intervertebral disks, in attachments of certain ligaments to the cartilaginous surface of bones, and in the symphysis pubis. Fibrocartilage is always associated with dense connective tissue, and the border areas between these two tissues are not clear-cut, showing a gradual transition. Fibrocartilage contains chondrocytes, either singly or in isogenous groups, usually arranged in long rows separated by coarse collagen type I fibers . Because it is rich in collagen type I, the fibrocartilage matrix is acidophilic. In fibrocartilage, the numerous collagen fibers either form irregular bundles between the groups of chondrocytes or are aligned in a parallel arrangement along the columns of chondrocytes . This orientation depends on the stresses acting on fibrocartilage, since the collagen bundles take up a direction parallel to those stresses. There is no identifiable perichondrium in fibrocartilage.