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CARTILAGE

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CARTILAGE

Cartilage is a specialized form of connective tissue in which the firm consistency of the ECM allows the tissue to bear mechanical stresses without permanent distortion. Cartilage provides 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 is characterized by an extracellular matrix (ECM) 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 hyaline cartilage, fibrocartilage, and elastic cartilage adapted to local biomechanical needs .

Cartilage consists of cells called chondrocytes and extracellular matrix composed of fibers and ground substance.

- **Chondrocytes** synthesize and secrete the ECM and the cells 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.

Chondrocyte function is hormone dependent. Synthesis of sulfated GAGs is accelerated by growth hormone, thyroxin, and testosterone and is slowed by cortisone, hydrocortisone, and estradiol. Cartilage growth depends mainly on the pituitary-derived growth hormone somatotropin. This hormone does not act on cartilage cells directly but promotes the endocrine release in the liver of insulin-like growth factor-1 (IGF-1), sometimes called somatomedin C. IGF-1 acts directly on cartilage cells, promoting their growth

- **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 in movable joints, is devoid of perichondrium and is sustained by the diffusion of oxygen and nutrients from the synovial fluid.

In all three forms, cartilage is avascular and is nourished by the diffusion of nutrients from capillaries in adjacent connective tissue (perichondrium) or from synovial fluid in joint cavities. In some instances, large 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 also lacks lymphatic vessels and nerves.

1- 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 .

- **Matrix**

Forty percent of the dry weight of hyaline cartilage consists of collagen embedded in a firm, hydrated gel of proteoglycans and structural glycoproteins. Hyaline cartilage contains primarily type II collagen, although small amounts of collagen types VI and IX are also present.

- **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 aggregates . Chondrocytes synthesize collagens and the other matrix molecules. As matrix is produced, cells in the aggregates are moved apart and occupy separate lacunae.

Because cartilage is devoid of blood capillaries, chondrocytes respire under low oxygen tension. The maximum width of the cartilage is limited and cartilage usually is found as small, thin plates of tissue.

- **Perichondrium**

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 consists largely of collagen type I fibers and contains numerous fibroblasts. Although cells in the inner layer of the perichondrium resemble fibroblasts, they are precursors for chondroblasts which divide and differentiate into chondrocytes.

2- ELASTIC CARTILAGE

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 . 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.

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.

3- 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 . Fibrocartilage is always associated with dense connective tissue and the border between these two tissues is not clear-cut .

Fibrocartilage contains chondrocytes, either singly or in isogenous aggregates, usually arranged axially, in long rows separated by coarse collagen type I fibers and less proteoglycans than other forms of cartilage. Because it is richer in collagen type I, the fibrocartilage matrix is more acidophilic.

CARTILAGE FORMATION,GROWTH AND REPAIR

All cartilage derives from the embryonic mesenchyme in the process of chondrogenesis. The first indication of cell differentiation is the rounding up of the mesenchymal cells, which retract their extensions, multiply rapidly, and form cellular condensations. The cells formed by this direct differentiation of mesenchymal cells, now called chondroblasts, have a ribosome-rich basophilic cytoplasm. Synthesis and deposition of the matrix then begin to separate the chondroblasts from one another. During embryonic development, the differentiation of cartilage takes place primarily from the center outward; therefore, the more central cells have the characteristics of chondrocytes, whereas the peripheral cells are typical chondroblasts. The superficial mesenchyme develops into the perichondrium.

- Chondrocytes in growing fibrocartilage.

. RER is abundant in the cells, which are actively secreting their collagen-rich matrix. Fine collagen fibers, sectioned in several orientations, are prominent around the chondrocytes of fibrocartilage. Growing chondrocytes in hyaline and elastic cartilage have more prominent Golgi complexes and synthesize abundant proteoglycans in addition to collagens.

Further 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 greatly to the growth of the cartilage. Interstitial growth is the less important of the two processes postnatally. It occurs during the early phases of cartilage formation, when it increases tissue mass by expanding the cartilage matrix from within. 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 increases in girth only by appositional growth. Chondro-blasts differentiate in the inner layers of the perichondrium, proliferate, and become chondrocytes once they have surrounded themselves with cartilaginous matrix and are incorporated into the existing cartilage . Except in young children, damaged cartilage undergoes slow and often incomplete regeneration, by activity of cells in the perichondrium which invade the injured area and generate new cartilage. In extensively damaged areas—and occasionally in small areas—the perichondrium produces a scar of dense connective tissue instead of forming new cartilage. The poor regenerative capacity of cartilage is due in part to the avascularity of this tissue.