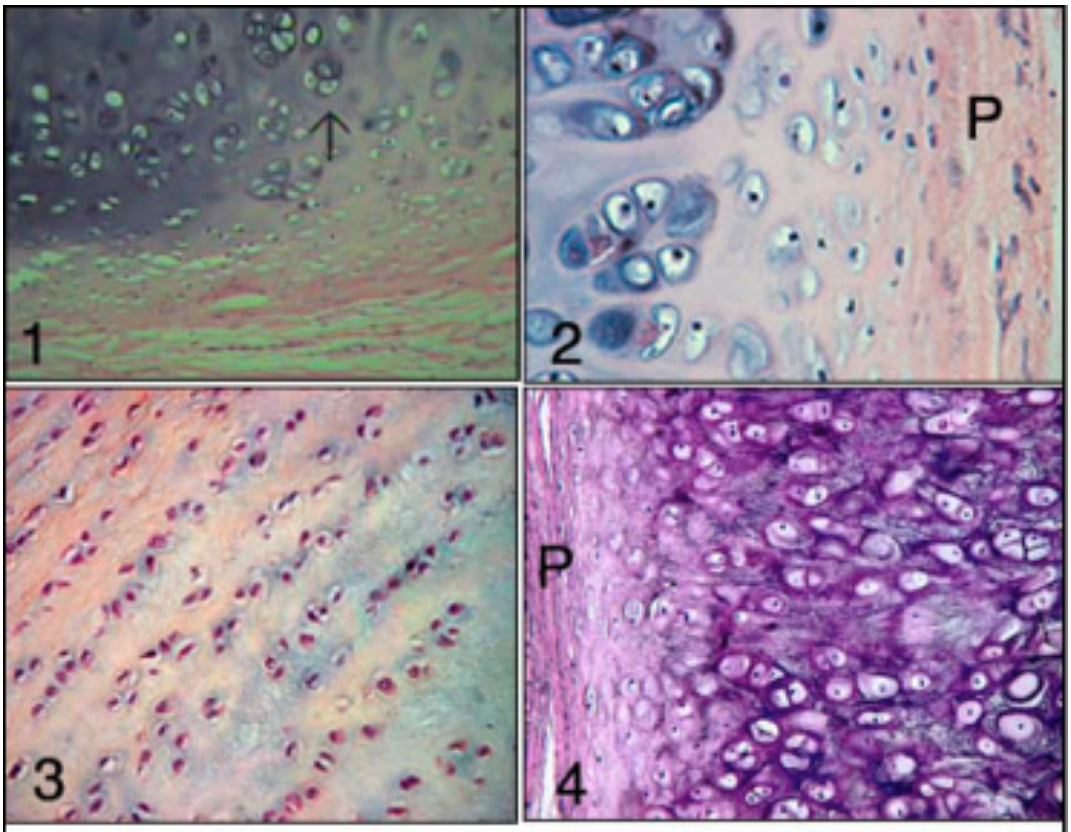
Cartilage



1. Hyaline cartilage. The arrow points to the cartilagenous matrix.
2. Hyaline cartilage. Chondrocytes lie within lacunae. The perichondrium (P) is to the right.
3. Fibrous cartilage. Note the scattered chondrocytes with lacunae.
4. Elastic cartilage. Elastic fibers stain dark. The perichondrium (P) is to the left.

Cartilage serves as a rigid yet lightweight and flexible supporting tissue. It forms the framework for the respiratory passages to prevent their collapse, provides smooth "bearings" at joints, and forms a cushion between the vertebrae, acting as a shock absorber for the spine. Cartilage is important in determining the size and shape of bones and provides the growing areas in many bones. Its capacity for rapid growth while maintaining stiffness makes cartilage suitable for the embryonic skeleton. About 75% of the water in cartilage is bound to proteoglycans, and these compounds are important in the transport of fluids, electrolytes, and nutrients throughout the cartilage matrix.

Although adapted to provide support, cartilage contains only the usual elements of connective tissue cells, fibers, and ground substance. It is the ground substance that gives cartilage its firm consistency and ability to withstand compression and shearing forces. Collagen and elastic fibers embedded in the ground substance impart tensile strength and elasticity. Together, the fibers and ground substance form the matrix of cartilage. Cartilage differs from other connective tissues in that it lacks nerves, blood and lymphatic vessels and is nourished entirely by diffusion of materials from blood vessels in adjacent tissues. Although relatively

rigid, the cartilage matrix has high water content and is freely permeable, even to fairly large particles. Classification of cartilage into hyaline, elastic, and fibrous types is based on differences in the abundance and type of fibers in the matrix.

Hyaline Cartilage

Hyaline cartilage is the most common type of cartilage and forms the costal cartilages, articular cartilages of joints, and cartilages of the nose, larynx, trachea, and bronchi. It is present in the growing ends of long bones. In the fetus, most of the skeleton is first laid down as hyaline cartilage.
The cells of cartilage are called chondrocytes and reside in small spaces called lacunae scattered throughout the matrix. The cells generally conform to the shape of the lacunae in which they are contained. Deep in the cartilage the cells and their lacunae usually appear rounded in profile, whereas at the surface, they are elliptical, with the long axis parallel to the surface. Chondrocytes often occur in small clusters called isogenous groups that represent the offspring of a single cell. In the usual preparations, the cells show an irregular outline and appear shrunken and pulled away from the walls of the lacunae. Electron microscopy reveals that each cell completely fills the lacunar space and sends short processes into the surrounding matrix, but neighboring cells do not touch one another. The nucleus is round or oval and contains one or more nucleoli. The cytoplasm shows the usual organelles as well as lipid and glycogen inclusions. In growing chondrocytes the Golgi complex and endoplasmic reticulum are well developed. In fresh cartilage and in routine histologic sections, the matrix appears homogeneous because the ground substance and the collagen fibers embedded within it have the same refractive index. The collagen in hyaline cartilage rarely forms bundles but is present as a feltwork of slender unit fibrils in which the banding pattern shows variable periodicities or even is lacking. Collagen in cartilage appears to be less polymerized than in other tissues and is classified as type II collagen. The ground substance consists mainly of proteoglycans, the specific glycosaminoglycans of cartilage being chondroitin-4- and chondroitin-6-sulfate, keratan sulfate, and a small amount of hyaluronic acid. The proteoglycans are responsible for the basophilic properties of the ground substance. Chondronectin, a glycoprotein within the ground substance, mediates the adhesion of type II collagen to chondrocytes. Chondrocalcin, a calcium-binding glycoprotein, also has been demonstrated in the ground substance of hyaline cartilage. The matrix around each lacuna and isogenous group stains more deeply than elsewhere, forming the territorial matrix. The less densely stained intervening areas form the interterritorial matrix. Except for the free surfaces of articular cartilages, hyaline cartilage is enclosed by a specialized sheath of connective tissue called the perichondrium. The outer layers of the perichondrium consist of a well vascularized, dense, irregular connective tissue that contains elastic and collagen fibers and fibroblasts. Where it lies against cartilage, the perichondrium is more cellular and passes imperceptibly into cartilage. The slender collagen unit fibrils of the cartilage matrix blend with the wider, type I collagen unit fibrils of the perichondrium. Perichondrial cells adjacent to the cartilage retain the capacity to form new cartilage.

Elastic Cartilage

Elastic cartilage is a variant of hyaline cartilage, differing chiefly in that it contains branched elastic fibers in the matrix. Collagen fibers of the type found in hyaline cartilage also are present but are masked. Deep in the cartilage, elastic fibers form a dense, closely packed

mesh that obscures the ground substance, but beneath the perichondrium, the fibers form a looser network and are continuous with those of the perichondrium. The chondrocytes are similar to those of hyaline cartilage and elaborate the elastic and collagen fibers. Elastic cartilage is more flexible than hyaline cartilage and is found in the external ear, auditory tube, epiglottis, and in some of the smaller laryngeal cartilages.

Fibrous Cartilage

Fibrous (or fibro-) cartilage represents a transition between dense connective tissue and cartilage. It consists of typical cartilage cells enclosed in lacunae, but only a small amount of ground substance is present in the immediate vicinity of the cells. The chondrocytes lie singly, in pairs, or in short rows between bundles of dense collagen fibers the unit fibrils of which that show the 64-nm banding pattern typical of type I collagen. Fibrous cartilage always lacks a perichondrium and merges into hyaline cartilage, bone, or dense fibrous connective tissue. It occurs in the intervertebral discs, in some articular cartilages, in the symphysis pubis, and at sites of attachment of certain tendons to bone.