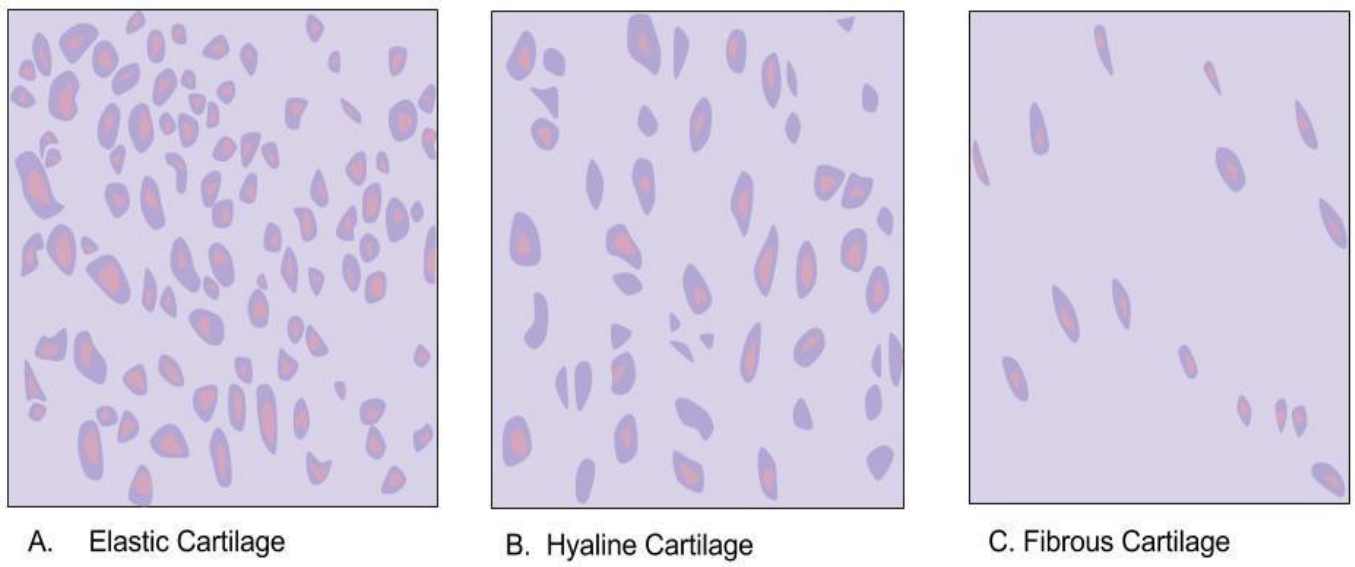
What is Cartilage?

Cartilage is a flexible connective tissue that differs from bone in several ways. For one, the primary cell types are chondrocytes as opposed to osteocytes. Chondrocytes are first chondroblast cells that produce the collagen extracellular matrix (ECM) and then get caught in the matrix. They lie in spaces called lacunae with up to eight chondrocytes located in each.

Chondrocytes rely on diffusion to obtain nutrients as, unlike bone, cartilage is avascular, meaning there are no vessels to carry blood to cartilage tissue. This lack of blood supply causes cartilage to heal very slowly compared with bone.

The base substance of cartilage is chondroitin sulfate, and the microarchitecture is substantially less organized than in bone. The cartilage fibrous sheath is called the perichondrium. The division of cells within cartilage occurs very slowly, and thus growth in cartilage is usually not based on an increase in size or mass of the cartilage itself.

Articular cartilage function is dependent on the molecular composition of its ECM, which consists mainly of proteoglycans and collagens. The remodeling of cartilage is predominantly affected by changes and rearrangements of the collagen matrix, which responds to tensile and compressive forces experienced by the cartilage.



Cartilage types: Images of microscopic views of the different types of cartilage: elastic, hyaline, and fibrous. Elastic cartilage has the most ECM; hyaline a middle amount; and fibrous cartilage has the least amount of ECM.

Types of Cartilage

There are three major types of cartilage: hyaline cartilage, fibrocartilage, and elastic cartilage.

Hyaline Cartilage

Hyaline cartilage is the most widespread cartilage type and, in adults, it forms the articular surfaces of long bones, the rib tips, the rings of the trachea, and parts of the skull. This type of cartilage is predominately collagen (yet with few collagen fibers), and its name refers to its glassy appearance.

In the embryo, bones form first as hyaline cartilage before ossifying as development progresses. Hyaline cartilage is covered externally by a fibrous membrane, called the perichondrium, except at the articular ends of bones; it also occurs under the skin (for instance, ears and nose).

Hyaline cartilage is found on many joint surfaces. It contains no nerves or blood vessels, and its structure is relatively simple.

If a thin slice of cartilage is examined under the microscope, it will be found to consist of cells of a rounded or bluntly angular form, lying in groups of two or more in a granular or almost homogeneous matrix. These cells have generally straight outlines where they are in contact with each other, with the rest of their circumference rounded.

They consist of translucent protoplasm in which fine interlacing filaments and minute granules are sometimes present. Embedded in this are one or two round nuclei with the usual intranuclear network.

Fibrocartilage

Fibrous cartilage has lots of collagen fibers (Type I and Type II), and it tends to grade into dense tendon and ligament tissue. White fibrocartilage consists of a mixture of white fibrous tissue and cartilaginous tissue in various proportions.

It owes its flexibility and toughness to the fibrous tissue, and its elasticity to the cartilaginous tissue. It is the only type of cartilage that contains type I collagen in addition to the normal type II.

Fibrocartilage is found in the pubic symphysis, the annulus fibrosus of intervertebral discs, menisci, and the temporal mandibular joint.

Elastic Cartilage

Elastic or yellow cartilage contains elastic fiber networks and collagen fibers. The principal protein is elastin.

Elastic cartilage is histologically similar to hyaline cartilage but contains many yellow elastic fibers lying in a solid matrix. These fibers form bundles that appear dark under a microscope. They give elastic cartilage great flexibility so it can withstand repeated bending.

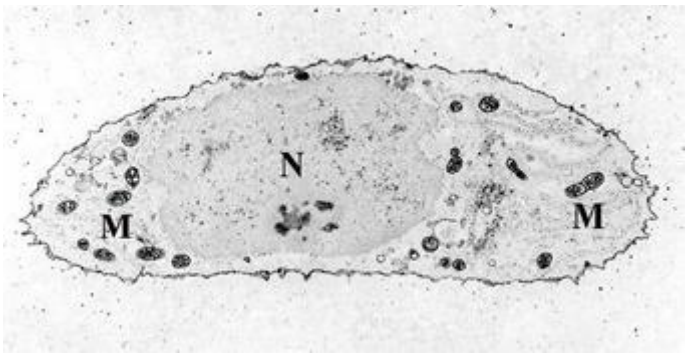
Chondrocytes lie between the fibers. Elastic cartilage is found in the epiglottis (part of the larynx) and the pinnae (the external ear flaps of many mammals, including humans).

Cartilage Growth

Chondrification is the process by which cartilage is formed from condensed mesenchyme tissue.

Formation

Chondrification (also known as chondrogenesis) is the process by which cartilage is formed from condensed mesenchyme tissue.



A chondrocyte: A chondrocyte, stained for calcium, showing its nucleus (N) and mitochondria (M).

Mesenchyme tissue differentiates into chondroblasts and begins secreting the molecules that form the extracellular matrix (ECM). Mesenchymal stem cells (MSCs) are undifferentiated, meaning they can give rise to different cell types. Under the appropriate conditions and at sites of cartilage formation, they are referred to as chondrogenic cells.

During cartilage formation, undifferentiated MSCs are highly proliferative and form dense aggregates of chondrogenic cells at the center of chondrification. These condrogenic cells then differentiate to chondroblasts, which will then synthesize the cartilage ECM.

Cartilage: Hyaline cartilage showing chondrocytes and organelles, lacunae and matrix.

The extracellular matrix consists of ground substance (proteoglycans and glycosaminoglycans) and associated fibers, such as collagen. The chondroblasts then trap themselves in lacunae, small spaces that are no longer in contact with the newly created matrix and contain extracellular fluid. The chondroblast is now a chondrocyte, which is usually inactive but can still secrete and degrade the matrix depending on the conditions.

Growth

The majority of body cartilage is synthesized from chondroblasts that are largely inactive at later developmental stages compared to earlier years (pre-pubescence). The division of cells within cartilage occurs very slowly.

Therefore, growth in cartilage is usually not based on an increase in size or mass of the cartilage itself. Remodeling of cartilage is predominantly affected by changes and rearrangements of the collagen matrix, which responds to tensile and compressive forces experienced by the cartilage. Cartilage growth thus mainly refers to matrix deposition, but can include both growth and remodeling of the ECM.

Early in fetal development, the greater part of the skeleton is cartilaginous. This temporary cartilage is gradually replaced by bone (endochondral ossification), a process that ends at puberty. In contrast, the cartilage in the joints remains permanently unossified during life.

Repair

Once damaged, cartilage has limited repair capabilities because chondrocytes are bound in lacunae and cannot migrate to damaged areas. Also, because cartilage does not have a blood supply, the deposition of new matrix is slow.

Damaged hyaline cartilage is usually replaced by fibrocartilage scar tissue. Over the last few years, surgeons and scientists have elaborated a series of cartilage repair procedures that help to postpone the need for joint replacement.

These include marrow stimulation techniques, including surgeries, stem cell injections, and grafting of cartilage into damaged areas.

However, due to the extremely slow growth of cartilage and its avascular properties, regeneration and growth of cartilage post-injury is still very slow.