



Objective:

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| <ul style="list-style-type: none">• Bone Tissue and cartilage |
| <ul style="list-style-type: none">• Types of cartilage & Bone |

Cartilage and bone

- Cartilage and bone are types of supporting connective tissue, because they form a strong, durable framework that protects and supports the soft body tissues.
- In general, cartilage has a **semisolid** extracellular matrix; while bone has a **solid** extracellular matrix.

A. Cartilage

Cartilage is a specialized connective tissue with a firm extracellular matrix that allows it to resist mechanical stress and support soft tissues.

It consists of **chondrocytes** located in **lacunae** and a strong gel-like matrix made of fibers and ground substance. Chondrocytes produce this matrix. Collagen fibers provide tensile strength, making cartilage strong and resilient but more flexible than bone.

Cartilage is found in areas needing support and flexibility, such as the nose and external ear. Mature cartilage is **avascular** (has no blood vessels), so nutrients and waste products are exchanged by **diffusion**.

Most cartilage is surrounded by the **perichondrium**, which has two layers:

- An outer fibrous layer that provides protection and mechanical support.
- An inner cellular layer containing stem cells (chondroblasts) responsible for cartilage growth and maintenance.



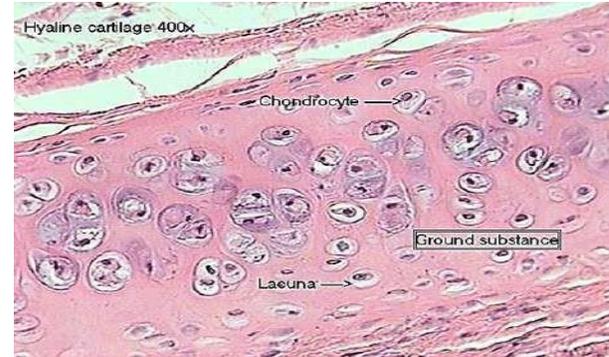
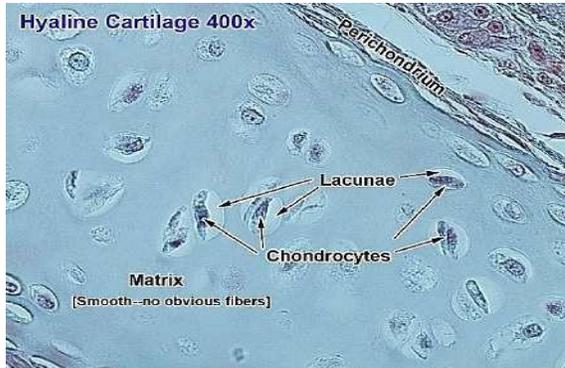
Types of Cartilage

- There are 3 major types of cartilage: **Hyaline** Cartilage, **Fibro** cartilage, and **Elastic** Cartilage.
- Each exhibits difference in density and the dispersal of chondrocytes within the extracellular matrix.

I. Hyaline Cartilage:

- The most common type of cartilage and also the weakest.
- It is named for its **clear glassy** appearance under microscope.
- The chondrocytes within their lacunae are **irregularly scattered** throughout the extracellular matrix.
- However, the collagen within the matrix is **not readily observed** by light microscopy because it is primarily in the form of submicroscopic fibrils.
- It provides support through flexibility and resilience.
- Hyaline cartilage is surrounded by a perichondrium
- Hyaline cartilage has many functions in addition to its primary one of supporting soft tissue.
- It forms most of the fetal skeleton and is the model for most future bone growth.

- Hyaline cartilage is found in many other areas of the body including the nose, the trachea, most of the larynx, costal cartilage (cartilage attached to ribs) and the articular ends of long bones.



II. Elastic cartilage:

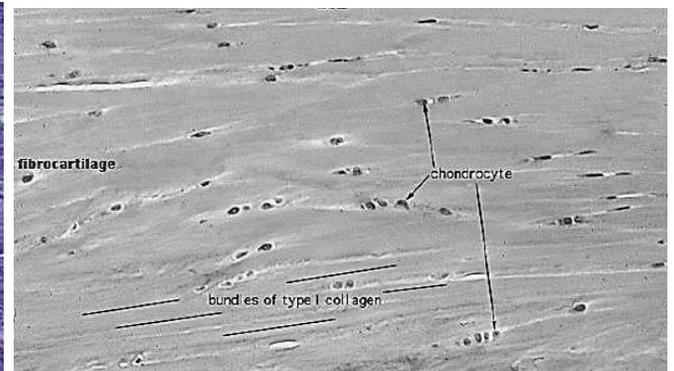
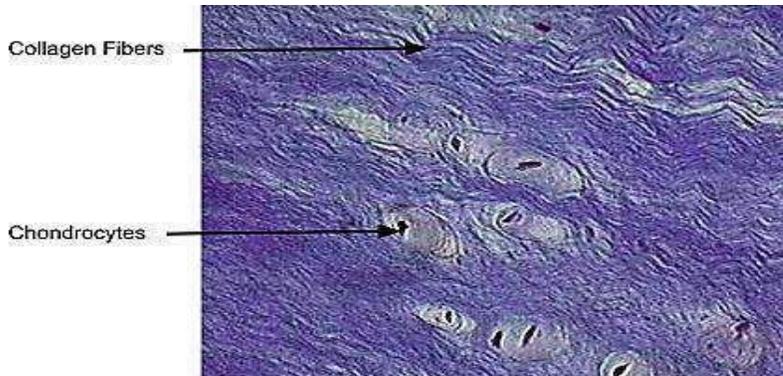
- It is so named because it has numerous **elastic fibers** in its matrix.
- The higher concentration of elastic fibers in this cartilage causes it to appear yellow in fresh sections.
- The chondrocytes of elastic cartilage are almost indistinguishable from those of hyaline cartilage.
- They are typically **closely packed** and surrounded by only a small amount of extracellular matrix.
- The elastic fibers are both denser and more highly branched in the central region of the extracellular matrix, where they form a web-like mesh around the chondrocytes within the lacunae.
- These fibers ensure that elastic cartilage is extremely resilient and flexible.
- Elastic cartilage is surrounded by perichondrium.
- Elastic cartilage is found in epiglottis and in the external ear





III. Fibrocartilage

- Fibrocartilage is a tissue intermediate between dense connective tissue and hyaline cartilage.
- the strongest type of cartilage; it has numerous coarse, readily visible fibers in its extracellular matrix.
- The fibers are arranged as **irregular bundles** between large chondrocytes.
- There is only a sparse amount of ground substance, and often the chondrocytes are **arranged in parallel long rows** separated by **coarse collagen type I fibers**
- The densely interwoven collagen fibers contribute to the extreme durability of this type of cartilage.
- There is no identifiable perichondrium in fibrocartilage
- Fibrocartilage is found in the intervertebral discs where it acts as a shock absorber and resists compression.



Growth Patterns of Cartilage

Cartilage grows in two ways: **Interstitial Growth and Appositional Growth.**

A. Interstitial Growth:

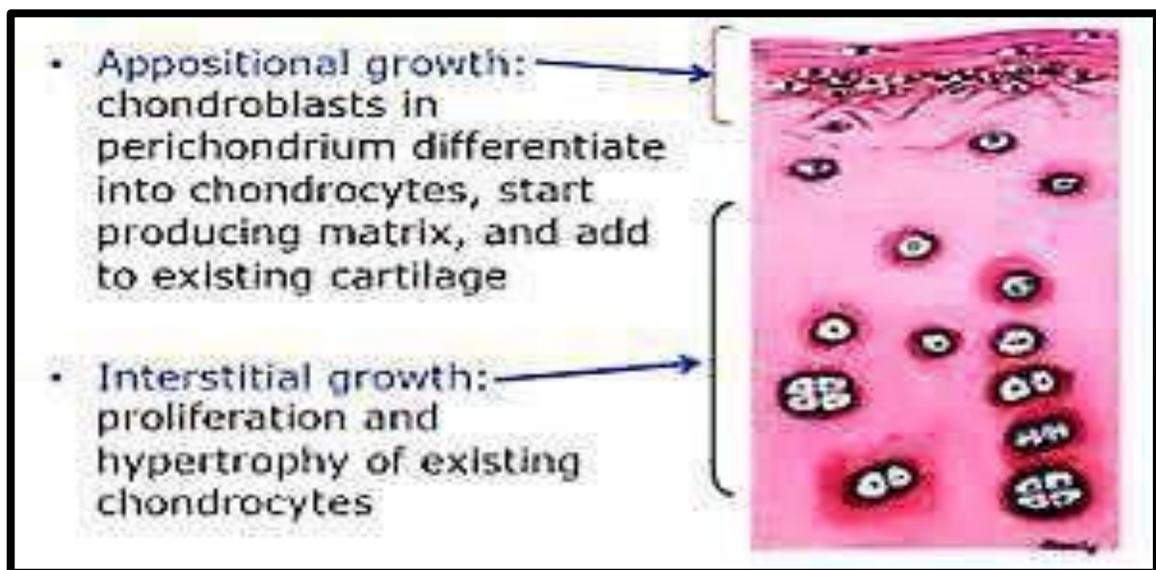
- a) Chondrocytes housed in lacunae undergo mitotic cell division.
- b) The two new cells occupy a single lacuna



- c) Cells synthesize and secrete new cartilage matrix; they are pushed apart and now reside in their own lacunae
- d) The new individual cells within their own lacunae are called chondrocytes. new matrix has been produced internally, and thus interstitial growth has occurred.

Appositional Growth:

- A. Occurs later in life, mainly after injury or healing.
- B. Happens only at the **periphery** of the cartilage.
- C. • Stem cells in the **perichondrium** divide and differentiate into **chondroblasts**.
- D. • Chondroblasts produce new matrix, become **chondrocytes**, and occupy their own lacunae.
- E. • Early in development, both **interstitial** and **appositional** growth occur together.
- F. • Interstitial growth decreases as cartilage matures and becomes semi-rigid.
- G. • After maturity, growth occurs mainly at the periphery and is limited.
- H. • Cartilage growth usually stops when fully mature and is limited after injury due to lack of blood vessels.





B. Bone:

- Bone is a specialized connective tissue composed of intercellular calcified material, the **bone matrix**, and three cell types: **osteocytes**, **osteoblasts** and **osteoclasts**.
- Because metabolites are unable to diffuse through the calcified matrix of bone, the exchanges between osteocytes with one another and with blood capillaries depend on communication through minute passageways in the matrix called **canaliculi** which are defined as thin, cylindrical spaces that perforate the matrix.

Functions of bone:

1. Support
2. Protection
3. Assistance in movement
4. Mineral homeostasis
5. Blood cell production
6. Triglyceride storage

Periosteum & Endosteum:

External and internal surfaces of bone are covered by layers of bone-forming cells and connective tissue called **periosteum**; consists of an outer layer of collagen fibers and fibroblasts. And an inner cellular layer, composed of fibroblast-like cells called **osteoprogenitor cells**. and endosteum which lines all internal cavities within the bone.

Composition of Bone Matrix:

- **Organic composition:** About 1/3 of bone mass is composed of organic components, including cells, collagen fibers, and ground substance. The collagen fibers give a bone tensile strength by resisting stretching and twisting, and contribute to its overall flexibility.
- **Inorganic composition:** about 2/3 of bone mass is hydroxyapatite (calcium phosphate + calcium hydroxide) deposited into the



framework formed by collagen fibers in a process called calcification. It is responsible for bone hardness and ability to resist compression.

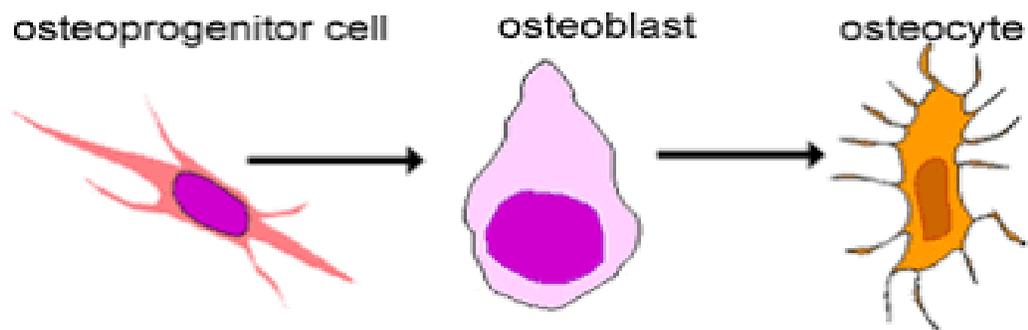
Cell Types of Bone:

1. Osteoprogenitor cells:

- Stem cells derived from mesenchyme.
- When they divide, they produce another stem cell and a "committed cell" that matures to become an osteoblast.
- These stem cells are located in both the periosteum and the endosteum.

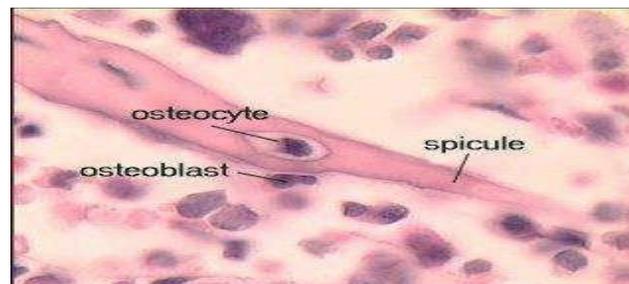
2. Osteoblasts:

- Derived from **osteoprogenitor stem cells**.
- Usually arranged side by side on bone surfaces.
- Active osteoblasts are **cuboidal in shape** with abundant rough ER and Golgi apparatus.
- They synthesize and secrete **osteoid**, the organic bone matrix.
- Osteoid later **calcifies** due to mineral (salt crystal) deposition.
- Once trapped in the mineralized matrix, osteoblasts differentiate into **osteocytes**.



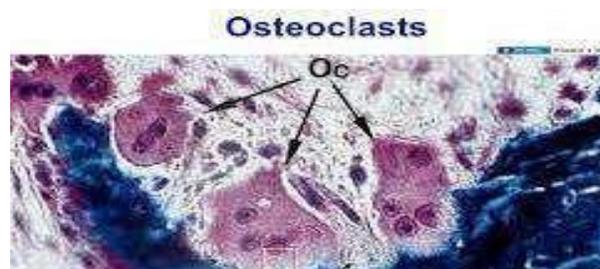
3. Osteocytes

- Mature bone cells derived from osteoblasts that have become entrapped in the matrix they secreted.
- They reside in small spaces within the matrix called lacunae
- Osteocytes maintain the bone matrix and detect mechanical stress on a bone.
- If stress is detected, osteoblasts are signaled, and it may result in the deposition of new bone matrix at the surface.



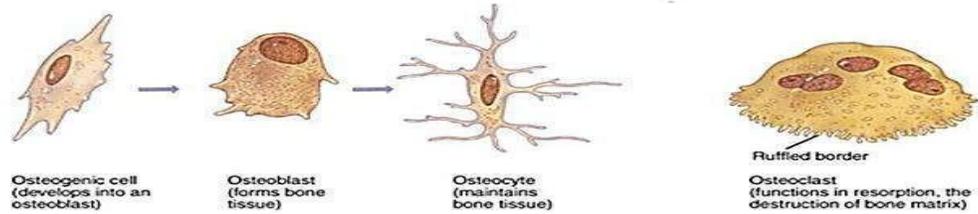
4. Osteoclasts

- Large, multinuclear, phagocytic cells.
- They appear to be derived from fused bone marrow cells similar to those that produce monocytes .
- These cells exhibit a ruffled border where they contact the bone, which increases their surface area exposure to the bone.
- An osteoclast is often located within or adjacent to a depression or pit on the bone surface called a **resorption lacuna (Howship's lacuna)**.





Bone Cell Types



- **Osteogenic cells-** stem cells.
- **Osteoblasts-** bone building cells, secrete matrix & collagen fibers.
- **Osteocytes-** mature bone cells that no longer secrete matrix.
- **Osteoclasts-** bone digestion.

There are 2 forms of bone connective tissue: **compact bone** and **spongy bone**.

A. Compact Bone:

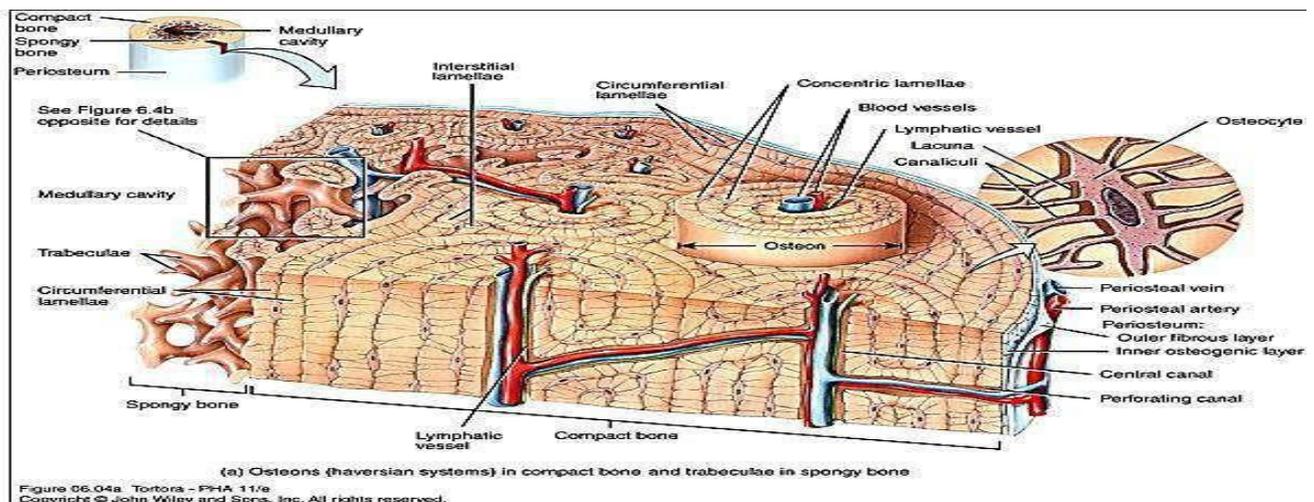
- Appears solid but is in fact perforated by a number of vascular canals.
- It usually forms the hard outer shell of the bone.
- A cylindrical osteon or Haversian system, is the basic functional and structural unit of mature compact bone.
- Osteons run parallel to the diaphysis of the long bone.

Compact Bone Microscopic Anatomy: An osteon composed of the following components:

- **The central canal** (Haversian canal) is a cylindrical channel that lies in the center of the osteon. Traveling within the central canal are the blood vessels and nerves that supply the bone.
- **Concentric lamellae** are rings of bone connective tissue that surround the central canal and form the bulk of the osteon. The numbers of concentric lamellae vary among osteons. Each lamella contains collagen fibers oriented in one direction; fiber direction gives bone part of its strength and resilience.
- **Osteocytes** are housed in lacunae and are found between adjacent concentric lamellae.
- **Canaliculi** are tiny, interconnecting channels within the bone connective tissue that extend from each lacuna, travel through the lamellae, and connect to other lacunae and the central canal. Canaliculi house osteocyte cytoplasmic projections that permit intercellular contact and communication. Thus, nutrients, minerals, gases, and wastes can travel through these passageways between the central canal and the osteocytes.



- **Perforating canals** (Volkmann canals) resemble central canals in that they also contain blood vessels and nerves. However, perforating canals run perpendicular to the central canals and help
- connect multiple central canals, thus creating a vascular and innervation connection among the multiple osteons.
- **Circumferential lamellae** are rings of bone immediately internal to the periosteum of the bone (external circumferential lamellae) or internal to the endosteum (internal circumferential lamellae). These two distinct regions appear during the original formation of the bone.
- **Interstitial lamellae** are the leftover parts of osteons that have been partially resorbed. They often look like a "bite" has been taken out of them. The interstitial lamellae are incomplete and typically have no central canal.



B. Spongy Bone

- Also called cancellous or trabecular bone).
- appears more porous, like a sponge, forms an open lattice of narrow plates of bone, called **trabeculae**.
- spongy bone is located internally, primarily within the epiphyses.



Spongy Bone Microscopic Anatomy:

- Spongy bone contains **no osteons**.
- Instead, the **trabeculae** of spongy bone are composed of **parallel lamellae**.
- Between adjacent lamellae are osteocytes resting in lacunae, with numerous canaliculi radiating from the lacunae.
- Nutrients reach the osteocytes by diffusion through canaliculi that open onto the surfaces of the trabeculae.
- The trabeculae often form a meshwork of crisscrossing bars and plates of bone pieces.
- This structure provides great resistance to stresses.

