BONE & CARTILAGE

(Structure, Function, Classification of BONE & CARTILAGE)

BY

Suman Kalyan Khanra

SACT

DEPARTMENT OF PHYSIOLOGY

NARAJOLE RAJ COLLEGE

Narajole; Paschim Medinipur

BONE

- **Definition:**

A bone is a somatic structure that is comprised of calcified connective tissue. Ground substance and collagen fibers create a matrix that contains osteocytes. These cells are the most common cell found in mature bone and responsible for maintaining bone growth and density. Within the bone matrix both calcium and phosphate are abundantly stored, strengthening and densifying the structure.

Each bone is connected with one or more bones and are united via a joint (only exception: hyoid bone). With the attached tendons and musculature, the skeleton acts as a lever that drives the force of movement. The inner core of bones (medulla) contains either red bone marrow (primary site of hematopoiesis) or is filled with yellow bone marrow filled with adipose tissue.

The main outcomes of bone development are endochondral and membranous forms. This particular characteristic along with the general shape of the bone are used to classify the skeletal system. The main shapes that are recognized include:

- long
- short
- flat
- sesamoid
- irregular

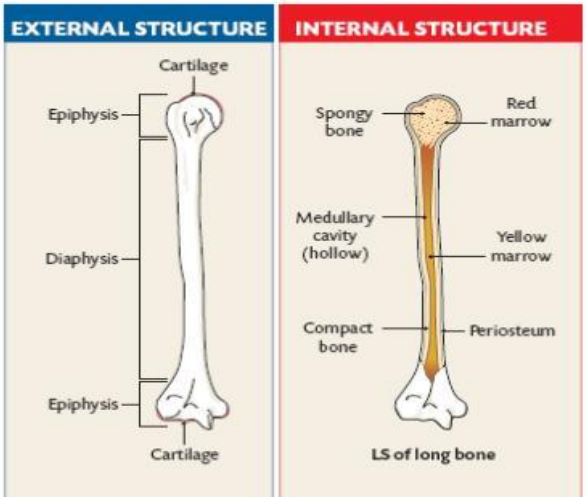
Types of bone

Long bones

These bones develop via endochondral ossification, a process in which the hyaline cartilage plate is slowly replaced. A shaft, or diaphysis, connects the two ends known as the epiphyses (plural for epiphysis). The marrow cavity is enclosed by the diaphysis which is thick, compact bone. The epiphysis is mainly spongy bone and is covered by a thin layer of compact bone; the articular ends participate in the joints.

The metaphysis is situated on the border of the diaphysis and the epiphysis at the neck of the bone and is the place of growth during development. This group of bones includes the:

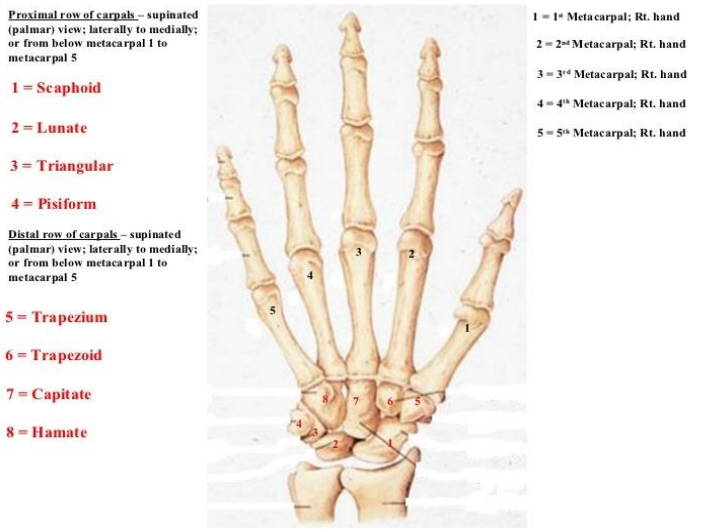
- humerus
- ulna
- radius
- fibula
- tibia
- femur



Short bones

A thin external layer of compact bone covers vast spongy bone and marrow, making a shape that is more or less cuboid. The carpal bones and tarsal bones fall into this category.

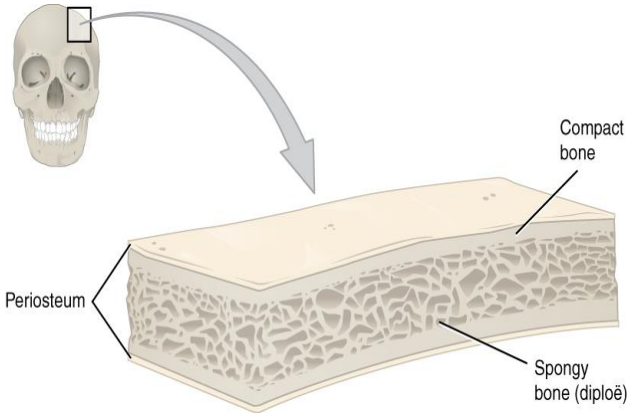
- metacarpal bones
- phalanges



Flat bones

Two layers of compact bone cover both spongy bone and bone marrow space. They grow by replacing connective tissue. Fibrocartilage covers their articular surfaces. This group is compiled of the:

- skull bones
- ribs
- sternum
- scapulae



Irregular bones

A thin layer of compact bone covers a mass of mostly spongy bone. This group is not categorized by shape, but by bone content and includes the

- bones of the skull
- vertebrae
- coxa
-

Sesamoid bones

Sesamoid bones are embedded within tendons. They are found at the end of long bones in the limbs, where the tendons cross, for example the patella bone in the knee. Sesamoid bones protect the tendons from excess wear by reducing friction.

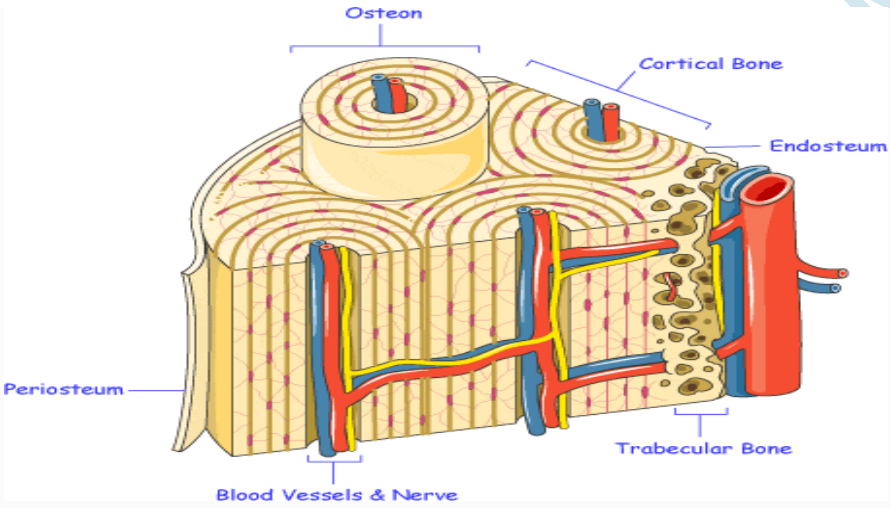
The major functions of bones are to:

- Provide structural support for the body
- Provide protection of vital organs
- Provide an environment for marrow (where blood cells are produced)

- Act as a storage area for minerals (such as calcium)

Bone is also composed of:

- Bone forming cells (osteoblasts and osteocytes)
- Bone resorbing cells (osteoclasts)
- Nonmineral matrix of collagen and noncollagenous proteins (osteoid)
- Inorganic mineral salts deposited within the matrix



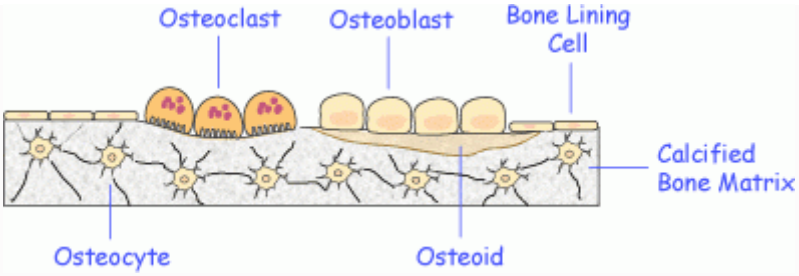
Bone cells

Cells in our bones are responsible for bone production, maintenance and modeling:

- **Osteoblasts**: These cells are derived from mesenchymal stem cells and are responsible for bone matrix synthesis and its subsequent mineralization. In the adult skeleton, the majority of bone surfaces that are not undergoing formation or resorption (i.e. not being remodeled) are lined by bone lining cells.

- **Osteocytes**: These cells are osteoblasts that become incorporated within the newly formed osteoid, which eventually becomes calcified bone. Osteocytes situated deep in bone matrix maintain contact with newly incorporated osteocytes in osteoid, and with osteoblasts and bone lining cells on the bone surfaces, through an extensive network of cell processes (canaliculi). They are thought to be ideally situated to respond to changes in physical forces upon bone and to transduce messages to cells on the bone surface, directing them to initiate resorption or formation responses.

- **Osteoclasts**: These cells are large multinucleated cells, like macrophages, derived from the hematopoietic lineage. Osteoclasts function in the resorption of mineralized tissue and are found attached to the bone surface at sites of active bone resorption. Their characteristic feature is a ruffled edge where active resorption takes place with the secretion of bone-resorbing enzymes, which digest bone matrix.



Bone matrix

Osteoid is comprised of type I collagen (~94%) and noncollagenous proteins. The hardness and rigidity of bone is due to the presence of mineral salt in the osteoid matrix, which is a crystalline complex of calcium and phosphate (hydroxyapatite). Calcified bone contains about 25% organic matrix (2-5% of which are cells), 5% water and 70% inorganic mineral (hydroxyapatite).

Bone development and growth

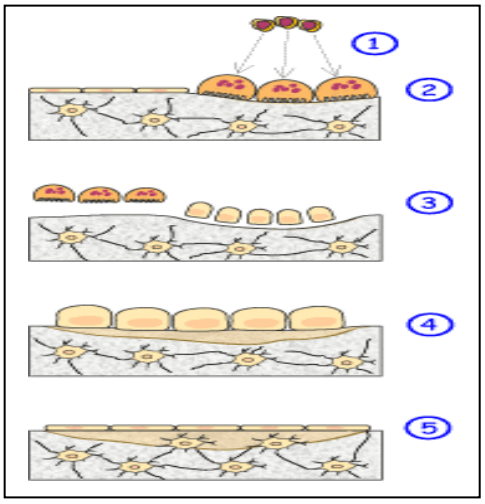
Osteogenesis (bone tissue formation) occurs by two processes:

- Intramembranous ossification involves the replacement of connective tissue membrane sheets with bone tissue and results in the formation of flat bones (e.g. skull, clavicle, mandible).
- Endochondral ossification involves the replacement of a hyaline cartilage model with bone tissue (e.g. femur, tibia, humerus, radius).

Long bones continue to grow in length and width throughout childhood and adolescence. Increase in length is due to continued endochondral bone formation at each end of the long bones. Increase in circumference of the bone shaft is achieved by formation of new bone on the outer surface of the cortical bone.

Bone modelling

Modeling is when bone resorption and bone formation occur on separate surfaces (i.e. formation and resorption are not coupled). An example of this process is during long bone increases in length and diameter. Bone modeling occurs during birth to adulthood and is responsible for gain in skeletal mass and changes in skeletal form.



Bone remodelling

Remodeling is the replacement of old tissue by new bone tissue. This mainly occurs in the adult skeleton to maintain bone mass. This process involves the coupling of bone formation and bone resorption and consists of five phases:

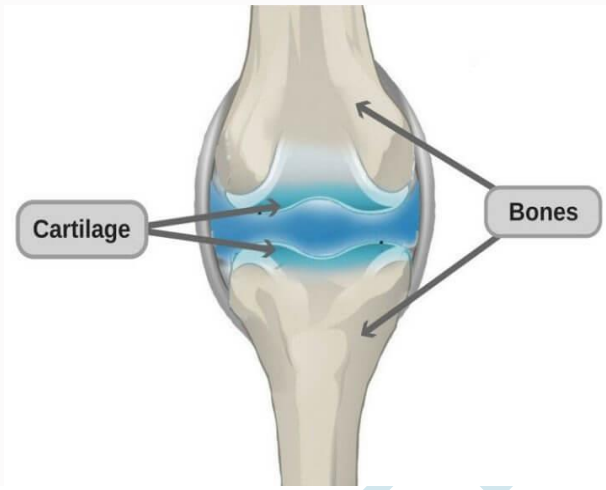
1. Activation: preosteoclasts are stimulated and differentiate under the influence of cytokines and growth factors into mature active osteoclasts

2. Resorption: osteoclasts digest mineral matrix (old bone)
3. Reversal: end of resorption
4. Formation: osteoblasts synthesize new bone matrix
5. Quiescence: osteoblasts become resting bone lining cells on the newly formed bone surface

CARTILAGE

- **Definition:**

Cartilage is a tough, semitransparent, elastic, flexible connective tissue consisting of cartilage cells scattered through a glycoprotein material that is strengthened by collagen fibers. There are no nerves or blood vessels in cartilage, which is found in the joints, the rib cage, the ear, the nose, the throat, and between vertebral disks.



- **Function:**

1. The main purpose of cartilage is to provide a framework on which bone deposition may begin.
2. Another important purpose of cartilage is to cover the surfaces of joints, allowing bones to slide over one another, thus reducing friction and preventing damage.
3. It also acts as a shock absorber.

- **Clasification:**

- **Hyaline Cartilage:** Hyaline cartilage is the most abundant type of cartilage. Hyaline cartilage is found lining bones in joints (articular cartilage). It is also present inside bones, serving as a center of ossification or bone growth. In addition, hyaline cartilage forms the embryonic skeleton.
- **Elastic Cartilage:** Elastic cartilage (also called *yellow cartilage*) is found in the pinna of the ear and several tubes, such as the walls of the auditory and eustachian canals and larynx. Elastic cartilage is similar to hyaline cartilage but contains elastic bundles (elastin) scattered throughout the matrix. This provides a tissue that is stiff yet elastic.
- **Fibrocartilage:** Fibrocartilage (also called *white cartilage*) is a specialized type of cartilage found in areas requiring tough support or great tensile strength, such as between intervertebral disks, at the pubic and other symphyses, and at sites connecting tendons or ligaments to bones.

- **Composition:**
- **Cells:** Chondrocytes and the precusor forms of chondrocytes known as *chondroblasts* are the only cells found in cartilage. Chondrocytes make up "cell nests," groups of chondrocytes within lacunae. Chondroblasts are responsible for the secretion and maintenance of the matrix.
- **Fibers:** Cartilage is composed of collagen and elastic fibers. In hyaline cartilage, type II collagen makes up 40% of its dry weight. Elastic cartilage also contains elastic fibers, and fibrocartilage contains more collagen than hyaline cartilage.
- **Matrix:** The matrix is mainly composed of proteoglycans, which are large molecules with a protein backbone and glycosaminoglycan (GAG) side chains.
- **Diseases:**
- Chondrodystrophies are a group of diseases characterized by disturbance of growth and subsequent ossification of cartilage. Some common diseases affecting/involving the cartilage are arthritis, achondroplasia, costochondritis, and herniated disk.