Cartilage

- Specialized dense connective tissue
- Semi rigid, designed to give support, bear weight & withstand tension, torsion & bending
- Devoid of blood vessels and not innervated by nerve
- Most of them are calcified in old age.
- Cartilage can grow by interstitial & appositional growth
Composition of cartilage

- Perichondrium
- Ground substance-
  Highly hydrated Contains hyaluronic acid glucoseaminoglycans
- Cells- chondroblasts, chondrocytes
- Fibers- collagen, elastic fibers
Types of cartilage

- Hyaline cartilage
- Elastic cartilage
- Fibrous cartilage
Hyaline cartilage

• Most common type
• Makes the skeletal model of most bones in embryo
• Gradually replaced by bone in grown ups except at the articular surface of bones, ends of the ribs, nose, larynx, trachea and bronchi
• In living conditions looks translucent & bluish white in colour
• Covered with perichondrium. Articular cartilage is not covered by perichondrium
• Matrix is homogenous which consists of chondroitin sulphate & collagen fibers
• Cells are chondrocytes arranged in groups in lacunae
• Collagen fibers are not visible in matrix because of the same refractive index as that of matrix
Elastic cartilage

- Present in external ear, epiglottis, auditory tube & few cartilage of larynx
- Covered with perichondrium
- Number of cells are more
- Matrix consist of bundles of branching & anastomosing elastic fibers which give elasticity to the tissue
Fibrous cartilage

- Found in intervertebral disc, pubic symphysis, intrarticular disc of certain joints, menisci of knee joint & articular cartilage of temporomandibular cartilage
- Consists of bundles of collagen fibers embedded in minimal amount of matrix
- Cells are usually placed single in between the bundles of collagen fibers
- Not covered with perichondrium
BONE

- Specializes form of dense connective tissue
- Makes supportive frame work
- Support & transmit weight of the body
- Provide the levers for locomotion by forming articulations
- Give attachment to muscles & ligaments
- Provide mechanical protection to the vital organ
- Store calcium
- Form blood in their marrow
Classification of bones
According to position
Axial
Appendicular
Number of bones

- Total 206 bones
- Upper limbs - 64
- Lower limbs – 62
- Vertebrae – 26(33)
- Skull – 29(26Skull bones + hyoid +6 ossicle)
- Ribs – 24
- Sternum
• Appendicular-
  Upper limb
  64

- Acromioclavicular joint
- Acromion of scapula
- Greater tubercle
- Lesser tubercle
- Intertubercular groove
- Head
- Lateral epicondyle
- Capitulum
- Proximal radio-ulnar joint
- Head
- Tuberosity
- Radius
- Lower end
- Styloid process
- Wrist joint
- Phalanges

- Sternal end of clavicle
- Coracoid process
- Medial border
- Body of scapula
- Margin of glenoid cavity
- Shoulder joint
- Humerus
- Medial epicondyle
- Trochlea
- Elbow joint
- Coronoid process
- Ulna
- Head
- Distal radio-ulnar joint
- Styloid process
- Carpal bones
- Metacarpal bones

- Greater sciatic notch
- Ischial spine
- Lesser sciatic notch
- Ischial tuberosity

• Lower limb
  62

- Ilium
- Greater trochanter
- Head of femur
- Less tapering end
- Lateral condyle
- Lateral condyle of tibia
- Head of fibula
- Lateral malleolus
- Calcaneus
According to size & shape

- Long bones
- Short bones
- Short bones
- Flat bones
- Irregular bones
- Pneumatic bones
- Sesamoid bones
- Accessory bone
According to gross structure

- **Compact** (Lamellar) bone
- **Spongy** (cancellous) bone
- **Diploic bones**
According to development

- Membranous bones-
  Bone is laid down directly in the fibrous membrane e.g. bones of vault of skull, mandible

- Cartilaginous bones-
  Formation of bone is proceeded by the formation of a cartilage, which is later replaced by a bone e.g. femur, tibia
Membranous ossification

- Bone is formed in mesenchyme
- The cells in mesenchyme secrete ground substance & collagen fiber around themselves
- Thus ground substance, fiber & cells form a membrane
- Vascularization of membrane & differentiation of osteoblast cells
- Formation of osteoid matrix
- Formation of calcified matrix
- Formation of trabeculae, bone cells (osteocytes) & lacunae
- Subperiosteal ossification
Development

Endochondral ossification

- Condensation of mesenchymal cells occur at the site of bone formation
- Mesenchymal Cells are transformed into chondroblast which now form hyaline cartilage
- Formation of perichondrium which is highly vascular
- Hypertrophy of cartilage cells & formation of calcified matrix
- Subperiosteal ossification
- Vascular invasion & osteogenesis
Composition of bone -

• organic matter- forms 1/3 weight of bone. Consists of fibrous material & cells. Responsible for toughness & resilience

• Inorganic matter- forms 2/3 weight of bone. Consists of mineral salts like calcium carbonate, cal. Fluoride, and magnesium phosphate

Responsible for rigidity & hardness. Cal. In bone makes it opaque to x-ray
Macroscopic structure of living adult bone

- Compact bone
- Cancellous bone
Microscopic structure of bone

Microscopic structure of bone

1. Internal circumferential lamellae
2. Canalicular
3. Osteon (Haversian system)
   a. Central (Haversian) canal
   b. Lamellae
   c. Lacunae
4. Cement line
5. Interstitial lamellae
6. Perforating (Volkman's canal)
7. External circumferential lamellae
8. Lamellae
9. Lacunae
10. Osteons (Haversian systems)
11. Cement line
12. Interstitial lamellae
Parts of a developing long bone

- **Diaphysis** - intermediate region or shaft
- **Metaphysis** - developing extraepiphyseal regions of shaft
- **Epiphysis** - ends of bone which ossify with a separate centre of ossifi. (secondary)
Epiphyseal cartilage

- Zone of resting cartilage
- Zone of proliferating cartilage
- Zone of hypertrophied cartilage
- Zone of calcified cartilage
Centers of ossification

- Primary center
- Secondary center
- Epiphyseal line
Types of epiphysis

Pressure epiphysis - articular & take part in transmission of weight e.g. head of femur, lower end of radius

Traction epiphysis - Nonarticular & does not take part in the transmission of the weight.

- Tendons are attached here which exert a traction on the epiphysis
- Ossify later then the pressure epiphysis e.g. trochanters of tubercles of humerus
**Atavistic epiphysis**- femur, Phylogenetically an independent bone which in man become fused to another bone e.g. coracoid process of scapula & os trigonum

**Aberrant epiphysis**- Not always present e.g. epiphysis at the head of first metacarpal & at the base of other metacarpal bones
Blood supply of bone

- Nutrient artery
- Periosteal vessels
- Metaphyseal vessels
- Epiphyseal vessels
• Lymphatic supply- lymphatics present only in periosteum & Haversian system
• Accompany blood vessels
• No lymphatic in the bone marrow
• Lymphatic of the haversian system drain in to periosteal vessels
• Nerve supply- Most numerous at the articular ends of the long bones vertebrae & flat bones
• Distributed freely to the periosteum & with the branches of nutrient artery.
• Consist of both sensory & autonomic fibers (blood vessels)
Some important points about ossification

- Ossification begins constantly at a prefixed spot & at a fairly constant time
- Centre may be primary or secondary
- Primary center may be single or multiple but appear & as a rule appear before birth
- Between 6 to 8th wk of fetal life. Exception cuneiform & navicular bones
- Secondary center usually multiple & appear after birth. Exception are lower end of femur
Most long bones have epiphysis at both ends. The epiphysis which ossifies first unites with the diaphysis last & the epiphysis which ossifies last fuses first. **Exceptions.** Lower end of fibula where epiphysis ossifies first, also fuses last with shaft.

The end of the long bone where epiphysis appear first & fuses last is called the growing end of the bone.

The direction of the nutrient artery is always away from the growing end of the bone given away by rhyme, 

*To the elbow I go, from the knee I flee*”
• The different centers of ossification first unite together & then they unite with the shaft.
• In long bones growing ends of the bone fuses with the shaft at about 20 years & the opposite end at about 18 years i.e. 2 years earlier.
• Fusion of epiphysis with diaphysis occurs 2 years earlier in women than in men. Epiphysis also appear earlier in women.
• Epiphysis in bones other than long bones fuses with main part of the bone between 20-25 years.
Estimation of age, sex & height from the bones

• Timing of eruption of milk teeth & permanent teeth can estimate age up to 18 years
• Age at which epiphysis of the bone appears and fuses with the diaphysis is fairly constant. This can provides the age till 25 years
• After 25 years age is estimated by the closing of cranial sutures & changes occurring at the medial surface of pubic bones. This age can be estimated till 60 years
• **Sex** can be determined by studying morphological feature of the bone & the measurement of skull & pelvis

• **Race** can be determined with 85-90% accuracy by metrical & nonmetrical data developed from cranial & other parts of skeleton.