CHAPTER

1

General Considerations of Bone

DEFINITION

Bone is the hard part of the body providing dynamic framework to it.

PROPERTIES

1. Bone is a living tissue.
2. Bone is supplied by arteries and nerves.
3. Bone is drained by veins.
4. Bone grows with age.
5. Bone is subject to disease.
6. Bone regenerates when damaged. It has greater regenerative power than any other tissue of the body, except blood.
7. Fractured bone heals leading to union.
8. Bone can undergo remodelling.
9. Bone can withstand strains and stresses.
10. Bone can atrophy or hypertrophy.

FUNCTIONS

1. Bones provide framework to the body.
2. Bones accord shape to the body.
3. Bones act as levers for muscles and, therefore, help in the movements of the body.
4. Bones provide protection to number of viscera, e.g. brain, lungs and heart.
5. Bone is site of blood formation.
6. Bone plays important role in the immune responses of body by producing cells of reticuloendothelial system.
7. Bones are store houses of calcium and phosphorus.

CHEMICAL COMPOSITION

Bone is one-third organic and two-thirds inorganic. Inorganic calcium salts [calcium phosphate, calcium carbonate and crystals of hydroxyapatite, i.e. $Ca_{10}\{PO_4\}_4(OH)_2$] make it hard and rigid. The organic connective tissue (collagen fibres) makes it tough and resilient. The collagen protein of collagen fibres is characterised by hydroxyproline amino acid.

STRUCTURE OF BONE

I. Macroscopically

There are two types of bones, *spongy* or *cancellous bone* and *compact* or *dense bone*. Outer part of all bones is made up of *compact bone* (Fig. 1.1). *Cancellous bone* fills up the interior of the bone except the following.

i. In the shaft of long bone, it is replaced by *medullary cavity*. This is filled with *red marrow* in new born but replaced by *yellow* or *fatty marrow* in adults.

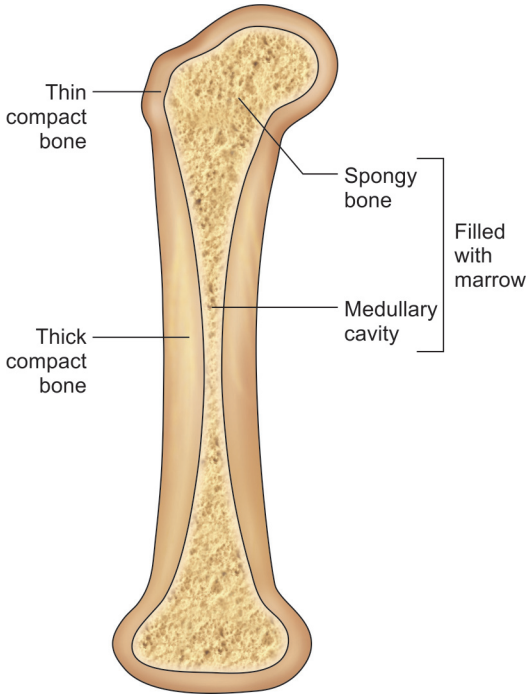

Fig. 1.1: Longitudinal section through a long bone

ii. In maxilla, sphenoid, ethmoid and frontal bones, it is replaced by large air spaces called *sinuses*.

iii. At many places the cancellous bone is replaced by marrow. The red marrow is active in hematopoiesis. Yellow marrow is mainly inert and fatty.

The flat bones of skull cap (calva) have spongy bone (*diploe*) sandwiched between two compact bones called *outer and inner tables* (Fig. 1.2). Red marrow persists in spongy bone throughout life.

The compact bone is more radio-opaque, while spongy bone is relatively more radiolucent. In radiograph, therefore, the compact bone looks more white than spongy bone which appears relatively darker.

II. Microscopically

Microscopically the bones can be classified into four types:

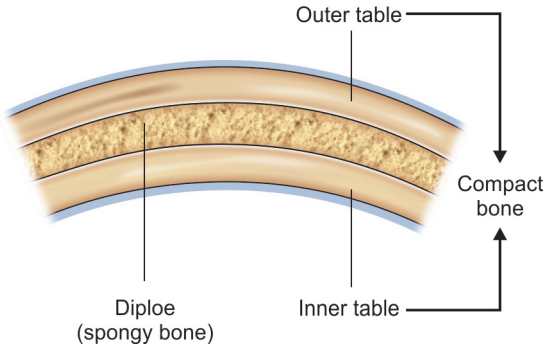

Fig. 1.2: Structure of the flat bone of calva

i. ***Lamellar bone:*** Most of the mature human bones, both compact and spongy, are of this type.

ii. ***Fibrous bone:*** It is found in early foetuses.

iii. ***Dentine:*** It is found in teeth.

iv. ***Enamel:*** It is found in teeth.

The compact bone shows typical *Haversian systems* each of which is comprised of a central canal along the long axis of bone surrounded by *concentric lamellae*. *Volkmann's canals* connect the adjacent Haversian canals. *Osteocytes* are located in the small spaces (*lacunae*) between adjacent lamellae (Fig. 1.3). The cytoplasmic processes of osteocytes extend into *canaliculi* diverging from lacunae. *Circumferential lamellae* adjoin the surface or medullary cavity of long bones. *Interstitial lamellae* fill the spaces between Haversian systems.

Spongy bone differs from compact bone in 'lacking Haversian systems' and 'having irregularly arranged bony lamellae'

Periosteum, the outer covering of bone, consists of an external collagen fibrous layer and inner osteogenic cellular layer. Collagen fibres from periosteum piercing the bone are called *Sharpey's fibres*. Periosteum has a rich nerve supply which makes it most sensitive part of bone.

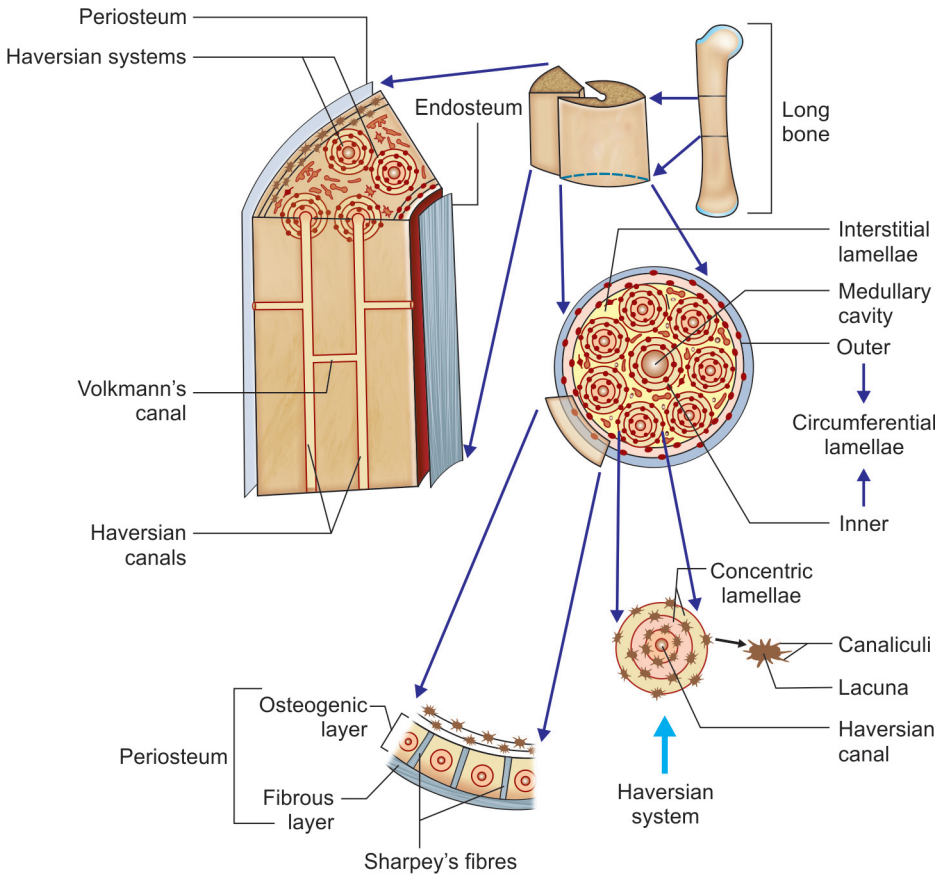

Fig. 1.3: Microscopic structure of compact bone

CLASSIFICATION OF BONES

Bones may be classified according to their development, shape or location.

I. Phylogenetic classification

From comparative anatomy point of view skeleton may be classified as:

a. Exoskeleton

Nails, hairs and enamel of teeth are the only remnants of exoskeleton observed in human being.

b. Endoskeleton

It includes most of the bones.

II. Developmental classification

Developmentally bones may be classified as:

a. ***Cartilaginous bones***
b. ***Membranous bones***

III. Morphological classification

According to shape, the bones may be classified as:

a. Long bones	– Femur, humerus
b. Short bones	– Carpal and tarsal bones
c. Miniature long bones	– Metacarpals and metatarsals
d. Flat bones	– Parietal bone
e. Irregular bones	– Hip bone
f. Pneumatic bones	– Maxilla, ethmoid, sphenoid and frontal bone.

IV. Regional classification

Bones may be classified regionally as:

a. Axial bones

It includes 80 bones as shown below.

i. Skull bones	–	22
ii. Vertebrae	–	26
iii. Ribs	–	24
iv. Sternum	–	1
v. Auditory ossicles	–	6
vi. Hyoid	–	1

b. Appendicular bones

It includes 126 bones which are further subgrouped as:

i. Upper limb bones – 64
ii. Lower limb bones – 62
Total number of bones is 206

V. Miscellaneous classification

a. Accessory bones

An accessory bone is a small piece of bone which develops from a separate centre of ossification but fails to unite with the main mass of bone, e.g. sutural (Wormian) bones and interparietal bones (Fig. 1.4).

b. Sesamoid bones

A sesamoid bone is a bone usually small, developing in the tendon of a muscle, ligament or joint capsule. They ossify after birth and are devoid of periosteum. Sesamoid bones possibly resist pressure, they alter the direction of pull of muscle and minimize the friction.

BLOOD SUPPLY OF BONES

I. Short bones: These are supplied by numerous periosteal vessels.

II. Vertebrae: The body of vertebra is supplied by the anterior and posterior vessels (Fig. 1.5). The vertebral arch is supplied by large vessels entering through the bases of transverse processes.

III. Ribs: These are supplied by nutrient and periosteal vessels.

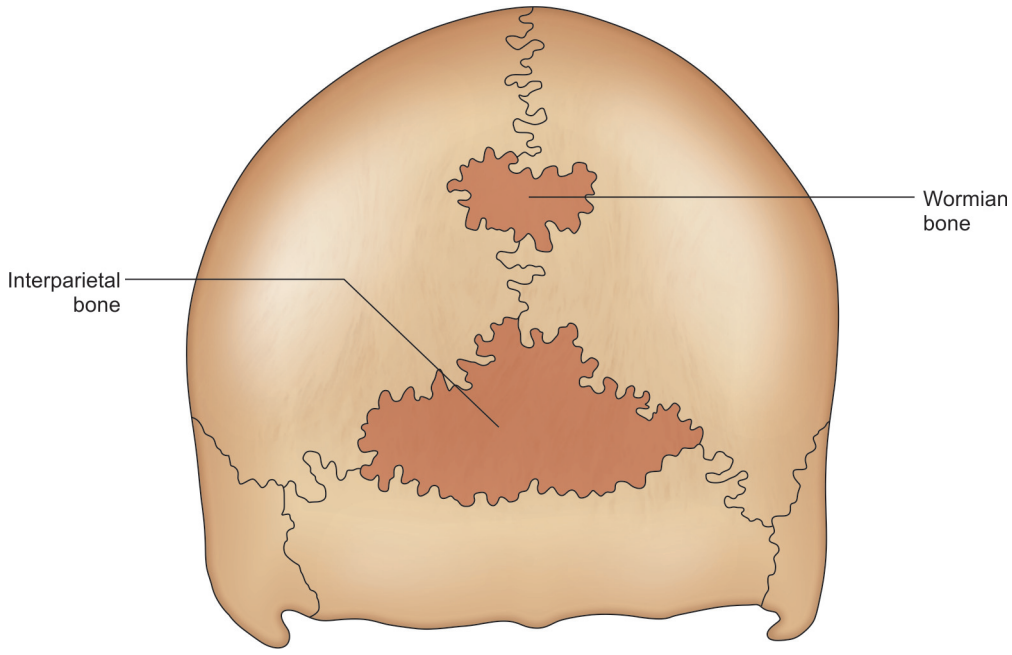

Fig. 1.4: Accessory bones

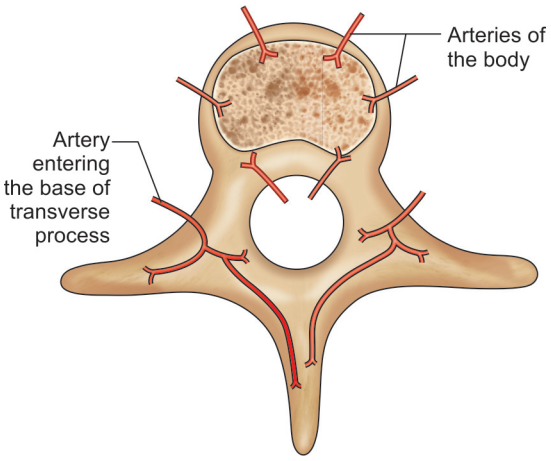

Fig. 1.5: Arterial supply of vertebra

IV. Flat bones: These are supplied by nutrient and periosteal vessels.

NERVE SUPPLY OF BONES

Nerves accompany the blood vessels of bone. Periosteal nerves are sensory (carry pain) while others are vasomotor in nature.

LYMPHATIC DRAINAGE OF BONES

Lymphatics have not been demonstrated within bone but these are very much present in periosteum which drain into regional lymph nodes.

OSSIFICATION OF BONES

1. Bones ossify from centres of ossification from where laying down of long lamellae starts by osteoblasts.
2. Centres of ossification may be primary or secondary. *Primary centre* appears before birth, usually during 8th week of intrauterine life and gives rise to diaphysis. *Secondary centre* appears at or after birth and gives rise to epiphysis.
3. Most of the long bones have *epiphysis* at each end but the growth in length occurs mainly at one end. This end is called *growing end*. Here, the epiphysis usually appears earlier and fuses with the body later than that at the non-growing end.

APPLIED ANATOMY OF BONES

1. Organic matter in the bone is greatest in childhood making it more flexible.
2. In *rickets* and *osteomalacia* there is inadequate calcium in bone leading to knock knees and bowlegs (Fig. 1.12).
3. Metaphysis is the commonest site of infection due to rich vascular anastomosis which has relatively less lymphocytes and has hairpin loop arrangement of blood vessels.
4. Capsular relations of metaphysis are clinically important. The inflammation of intra-articular metaphysis may result into septic arthritis, e.g. upper end of femur.
5. Injury of the growing ends of long bones is more dangerous in young children because it will directly affect the growth.
6. In certain conditions (e.g. *pernicious anaemia*) the yellow marrow is replaced by red marrow to enhance the formation of red blood cells.
7. Some interesting facts regarding fractures in young children are as follows:
   i. It is more common due to care-free activities.
   ii. *Green-stick fracture* (incomplete fracture with bending) is common in children due to excessive elasticity in bone.
8. In old age there is generalized skeletal atrophy called *osteoporosis* which makes the bone very weak. *Osteoporosis* is relatively more common in females, therefore, fracture of femoral neck is more common in elderly lady.
9. In *sternal puncture* the needle pierces the compact bone to reach central spongy bone from where red marrow is aspirated for haematological examination. The same procedure is used for bone marrow transplantation.

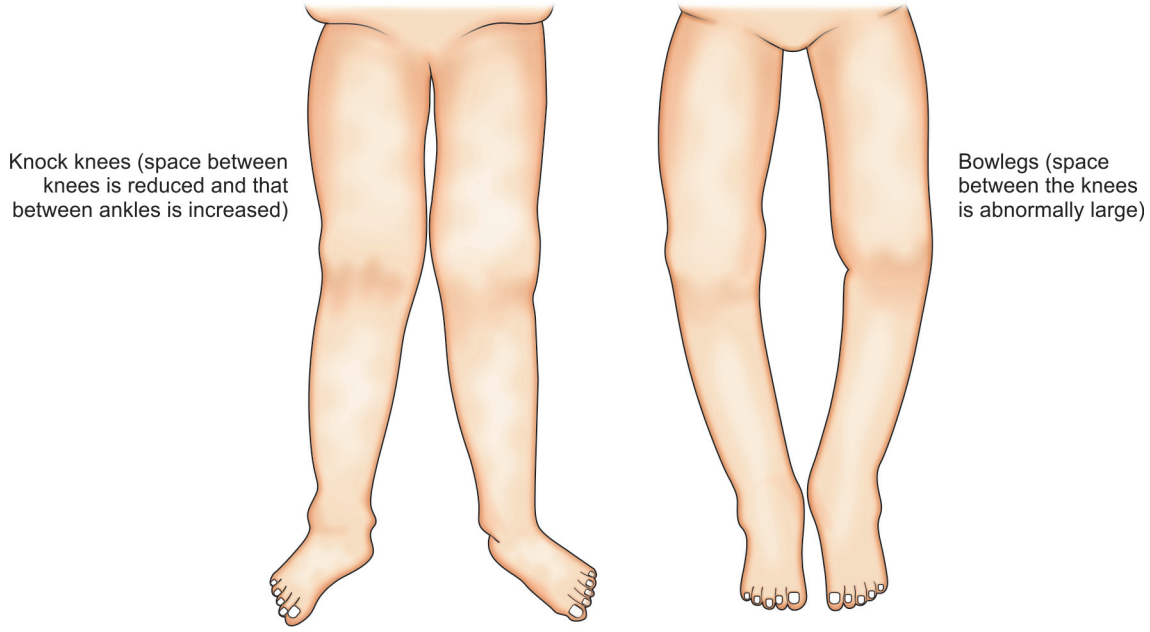

Fig. 1.6: Deformities of the lower *limb* in *rickets* and osteomalacia

10. For perfect healing, the fractured ends of a bone should be properly aligned. This is called *reduction*. Healing is difficult and defective if the bony ends are mobile. To make them immobile, a hard cast is made around the fractured site and adjacent joints. This is called *plaster immobilization*.
11. Age of a person can be determined by observing the ossification centres of the bones and their fusion in the radiographs. This is of *medicolegal importance*.
12. Part of a bone may be deprived of blood supply after fracture. This leads to *avascular necrosis*. The best example of avascular necrosis is head of femur after fracture of neck.
13. Fibrous capsule is the most sensitive structure in a joint.
14. *Bone cyst* is the most common cause of pathological fracture in child.
15. Increased density in metaphysis is seen in *hypervitaminosis*.
16. *Senile osteoporosis* is radiologically manifested only when 30% of skeleton has been lost.
17. Multiple bone fracture in a newborn is seen in *osteogenesis imperfecta.*
18. Two interesting facts regarding *Ewing's tumour* are:
    a. It arises from diaphysis.
    b. It is very sensitive to radiotherapy.