

UNIT 6**SKELETAL SYSTEM**

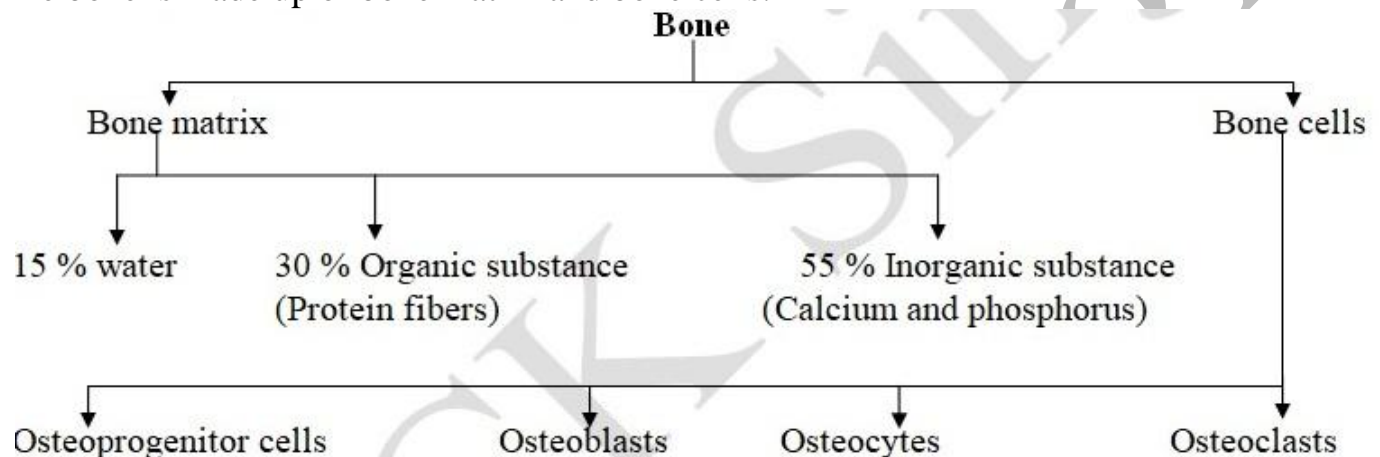
Skeletal system is the framework of the body, consisting of bones and other connective tissues (cartilages, ligaments, tendons etc), which protects and supports to the body and the internal organs. The skeletal system contains about 270 bones at birth, this total decreases to about 206 bones by adulthood after some bones get fused together.

BONE

Bone is highly vascularised, mineralized and constantly changing rigid connective tissue which form the skeleton or frame-work of the body.

COMPOSITION OF BONE

The bone is made up of bone matrix and bone cells.

**FUNCTIONS OF BONE**

1. Bones give shape and support to the body and resist all forms of stress.
2. Bones provide surface for the attachment of muscles, ligaments, tendons etc.
3. Bones serve as levers for muscular actions.
4. Bones store 97% of the body calcium and phosphorus.
5. Bones protect internal organs of the body like skull protect brain, vertebral column protect spinal cord and thoracic cage protect thoracic viscera.
6. Bone marrow produces blood cells.
7. The larger paranasal air sinuses (ethmoidal sinuses) affect the timbre (quality) of the voice.
8. Bone marrow contains reticulo-endothelial cells which are phagocytic in nature and take part in immune responses of the body.
9. Bone cells release a hormone known as osteocalcin, which contributes to the regulation of blood sugar (glucose) and fat deposition.

TYPES OF BONE

On the basis of shape and size, the bones are classified into six different types:

No	Type	Examples
a.	Long bones	Humerus, radius, ulna, femur, tibia, fibula etc.
b.	Short bones	Carpals and tarsals bone.
c.	Flat bones	Scapula, sternum, ribs etc.
d.	Irregular bone	Hip bone, vertebral column etc.
e.	Pneumatic bones	Maxilla, sphenoid, ethmoid and frontal.
f.	Sesamoid bones	Patella and pisiform.

DIVISIONS OF THE SKELETAL SYSTEM

The adult skeleton usually consists of 206 bones. These bones can be grouped in two divisions.

1. **Axial skeleton:** The 80 bones of the axial skeleton form the vertical axis of the body. They include the bones of the skull (head), vertebral column and thoracic cage (ribs and breastbone or sternum.).
2. **Appendicular skeleton:** The appendicular skeleton consists of 126 bones and includes the free appendages and their attachments to the axial skeleton. The free appendages are the upper and lower extremities, or limbs, and their attachments which are called girdles.

Bones	Number	Bones	Number
Axial Skeleton			
1. Skull		5. Thoracic cage	
(a) Cranium		Ribs	24
Parietal	2	Sternum	1
Temporal	2		25
Frontal	1	Total Axial Skeleton	
Occipital	1	80	
Sphenoid	1	Appendicular skeleton	
Ethmoid	1	Pectoral Girdle	
		Scapula	2
		Clavicle	2
		Upper limbs	
		Humerus	2
		Ulna	2
		Radius	2
		Carpals	16
		Metacarpals	10
		Phalanges	28
		Total Girdle and Upper Limbs	
		64	
		Pelvic Girdle	
		Hip bone (Coxa)	2
		Lower limb	
		Femur	2
		Tibia	2
		Fibula	2
		Patella	2
		Tarsals	14
		Metatarsals	10
		Phalanges	28
		Total Girdle and Lower Limbs	
		62	
		Total axial skeleton	
		80	
		Total Appendicular Skeleton	
		126	
		Total Bones	
		206	
Total skull			
22			
2. Auditory Ossicles			
Malleus	2		
Incus	2		
Stapes	2		
Total			
6			
3. Hyoid bone			
4. Vertebral column			
Cervical vertebrae	7		
Thoracic vertebrae	12		
Lumbar vertebrae	5		
Sacrum (5 fused)	1		
Coccyx (4 fused)	1		
Total vertebral column			
26			

BONE MARROW

Bone marrow is soft, spongy, gelatinous tissue present in the hollow spaces in the interior of bone. The average weight of bone marrow is about 4% of the total body weight. Bone marrow is also an important part of the lymphatic system.

Types of Bone Marrow

Bone marrow is of two types:

- Red bone marrow
- Yellow bone marrow

At birth, all bone marrow is red. With age, more and more of it is converted to the yellow type. In an adult, roughly half of the bone marrow is still red.

1. **Red bone marrow:** Red marrow is found mainly in the irregular and flat bones, such as the hip bone, sternum (breast bone), skull, ribs, vertebrae, and shoulder blades, as well as in the metaphyseal and epiphyseal ends of the long bones, such as the femur, tibia, and humerus, where the bone is spongy. The red bone marrow contains hematopoietic stem cells that produce blood cells.
2. **Yellow bone marrow:** The yellow bone marrow found in the shaft of long bones and is often surrounded by a layer of red bone marrow. Yellow bone marrow contains mesenchymal stem cells (marrow stromal cells), which produce cartilage, fat and bone.

BONE GROWTH AND DEVELOPMENT

The process of development of bone is known as ossification or osteogenesis. This process of bone formation begins before birth and does not complete until the 21 year of life. Bones are formed from condensation of mesodermal tissue. There are two types of process of bone formation.

1. **Intra membranous ossification:** Bones develop in membranes is known as intra membranous ossification. Example: Bones of the skull.
2. **Intra cartilaginous ossification:** Bones develop in cartilage is known as intra cartilaginous ossification. Examples: Bones of the limbs.

Growth in Length

- During growth, the epiphysis at the end of each long bone is separated from diaphysis by a plate of proliferative cartilage termed as epiphyseal plate.
- Increase in the length of the bone occurs due to the formation of new bone from epiphyseal plate.
- The thickness of the epiphyseal plate reduces as the length of bone increases. Increase in length of the bone occurs as long as the epiphyseal plates remain separated from diaphysis (shaft).
- The growth of the bone stops when the epiphysis fuses with the shaft. Epiphysis fuses with shaft by a process called epiphyseal fusion or closure. It occurs usually at the time of puberty.

Factors Helping Bone Growth

1. **Hormonal regulation of bone growth:** The hormones that regulate the growth, size and shape of bones include:
 - **Growth hormone** and the **thyroid hormones** (thyroxine and tri-iodothyronine) are especially important during infancy and childhood, (Excessive secretion of these hormone results in abnormal development of the skeleton).
 - **Testosterone** and **oestrogen** influence the physical changes that occur at puberty and help to maintain bone structures throughout life.
 - **Calcitonin** and **parathyroid hormone** control blood levels of calcium by regulating its uptake into and release from bone. **Calcitonin** increases calcium uptake into bone, and parathormone decreases it.
2. **Diet and bone:** The healthy bone tissue requires adequate dietary calcium and vitamins A, C and D. Calcium and smaller amounts of other minerals such as phosphate, iron, and manganese, is essential for adequate mineralization of bone.
 - Vitamin A is needed for osteoblasts activity.
 - Vitamin C is used in collagen synthesis.
 - Vitamin D is required for calcium and phosphate absorption from the intestinal tract.
3. **Exercise and bone:** Weight bearing and strengthening exercise stimulates thickening and strength of bone. (Lack of exercise then weaker bone).

SUTURE OF THE SKULL

- A suture is an immovable joint located in the bones of the skull.
- Sutures in the skull of infant and children, however, often are movable and function as important growth centers in the developing skull.
- Many sutures found in the skull we will identify only four prominent ones:
 1. **Coronal suture:** The coronal suture unites the frontal bone and both parietal bones.
 2. **Sagittal suture:** The sagittal suture unites the two parietal bones on the superior midline of the skull.
 3. **Lamboid suture:** The lamboid suture unites the two parietal bones to the occipital bone.
 4. **Squamous sutures:** The two squamous sutures unite the parietal and temporal bones on the lateral aspects of the skull.

FONTANELS

In a neonatal skull, the bones of the vault are not closely knit at sutures, but are separated by unossified membranous intervals called fontanelles.

Types of Fontanelles

1. **Anterior fontanelle:** The anterior fontanelle is the largest fontanelle located at the midline among the two parietal bones and the frontal bone. It is roughly diamond-shaped. It usually closes 12 to 18 months after birth.
2. **Posterior fontanelle:** The posterior fontanelle is located at the midline among the two parietal bones and the occipital bone. Because it is much smaller than the anterior fontanelle. It is generally closes about 2 months after birth.
3. **Sphenoidal fontanelle:** The sphenoidal fontanelles are the paired structure located laterally among the frontal, parietal, temporal, and sphenoid bones. It is small and irregular in shape. Normally, they close about 3 months after birth.
4. **Mastoid Fontanelle:** The mastoid fontanelles are paired structure located laterally among the parietal, occipital, and temporal bones. It is irregularly shaped. They begin to close 1 to 2 months after birth, but closure is generally not complete until 12 months.

Functions of Fontanelles

During birth, fontanelles enable the bony plates of the skull to flex, allowing the child's head to pass through the birth canal. After birth, they have no further function.

SINUSES

- Sinuses or paranasal air sinuses are air filled cavities of the certain cranial and facial bones near the nasal cavity.
- There are four paired of paranasal air sinuses name according to the bone in which they are located such as maxillary, frontal, sphenoid and ethmoid.
- Each sinus is lined by a mucus membrane, interspersed with mucus-secreting goblet cells.
- Paranasal sinuses are quite small or absent at birth, but increase in size during two periods of facial enlargement during the eruption of the teeth and at the onset of puberty.

Functions of Paranasal air Sinuses

1. The paranasal sinuses allow the skull to increase in size without a change in the mass (weight) of the bone.
2. The paranasal sinuses increase the surface area of the nasal mucosa, thus increasing the production of mucus to help moisten and cleanse inhaled air.
3. The paranasal sinuses serve as resonating (echo) chambers within the skull that intensify and prolong sounds, thereby enhancing the quality of the voice.

JOINTS

Joint is a junction between two or more bones or cartilages. It is a device to permit movements in a hard and rigid skeleton.

Types of Joints

1. **Fibrous joints:** The bones are joined by the fibrous tissue are known as fibrous joints. It is also known as fix joints or immovable joints. Examples: Suture, inferior tibiofibular joints, root of the tooth in its bony socket.
2. **Cartilaginous joints:** The bones are joined by the cartilage are known as cartilaginous joints. It is also known as slightly movable joints. Examples: Joint between epiphysis and diaphysis of a growing long bone, sphenoid-occipital joint, symphysis pubis, manubriosternal joint, intervertebral joints etc.
3. **Synovial joints:** The joint where cavity is present within the capsule separates the bones so that the joint can move freely is known as synovial joint. It is also known as freely movable joint. Examples: Shoulder joints, elbow joints, wrist joints, hip joints, knee joints ankle joints etc.

Types of Synovial Joint

According to the shape, size and their movements, the synovial joints are classified in seven subtypes:

No.	Joint types	Examples
1.	Ball and socket joints	Shoulder joints, hip joints.
2.	Hinge joints	Elbow joint, ankle joint, interphalangeal joints.
3.	Pivot (trochoid) joints	Superior and inferior radioulnar joint, atlantoaxial joint.
4.	Condylar (bicondylar) joints	Knee joint, right and left jaw joint or temporomandibular joint.
5.	Ellipsoid joints	Wrist joint, atlantooccipital joint, metacarpophalangeal joints.
6.	Saddle (sellar) joints	Sternoclavicular joint, calcaneocuboid joint.
7.	Plane synovial joints	Intercarpal joint, intertarsal joint, sacroiliac joint.

Movements of Synovial Joints

- See the unit: 1 (Body movements).

LEVER SYSTEM: BONE MUSCLE RELATIONSHIP

In the human body, the joints are fulcrums, and the bones act as levers. Muscle provides the effort. The load is the bone itself, along with overlying tissues and anything else you are trying to move with that lever.

Classes of Levers

Depending on the relative position, the levers are of three elements such as effort, fulcrum, and load. A lever belongs to one of three classes.

1. **First class lever:** In a first class lever system, effort arm may be greater than resistance arm. Examples:
 - Muscle of neck acts as effort
 - Weight of skull and face resistance
 - Atlanto-occipital joint as fulcrum in between effort and resistance.
2. **Second class lever:** The effort arm is always larger than resistance are. It is best use for power. Examples:

- Tendocalcaneus muscle is effort
 - Weight of lower limb is resistance in middle
 - Metacarpophalangeal joint is fulcrum at one end.
3. **Third class lever:** The effort is always smaller than the resistance arm. It is ideally designed for range of motion. Third class lever is the most common type of lever in the body. Examples:
- Biceps is effort arm is middle
 - Forearm weight is resistance elbow joint is fulcrum at one end.

DISORDERS OF BONE AND JOINT

1. **Fracture:** Fracture is the break in the continuity of the cortex of bone.
- Causes of fracture**
- Direct trauma where the bones break at the point of impact
 - Injury
 - Indirect trauma
 - Stress fracture due to stress and strain on the bone
 - Pathological fracture causes: osteomyelitis, tumors, osteoporosis, etc
2. **Osteoporosis:** Osteoporosis is the metabolic bone disease, characterized by a diffuse reduction in the bone density due to decrease in the bone mass. It occurs when the rate of bone resorption exceeds the rate of bone formation.
3. **Rickets:** It is a metabolic disease of childhood in which, the osteoid, the organic matrix of bone, fails mineralize due to interference with calcification mechanism. It is usually common between six months and two years.
4. **Osteomalacia:** It is the adult counterpart of rickets and is characterized by failure of mineralization and an excess of osteoid due to an interference with calcification mechanism.
5. **Osteomyelitis:** Osteomyelitis is defined as inflammation of the bone and bone marrow caused by infective organisms. Osteo indicates inflammation of bone.
6. **Paget's disease (Osteitis deformans) :** Paget's disease is seen after 40 years of age and is more common in males. There is impairment in the bone resorption and bone formation due to defective osteoclastic functions. As a result of this, bone gets thickened and bent more, so the tibia. Bone is soft in the initial stages and dense later.
7. **Tumors of bone:** Bone tumors develop when cells within a bone divide uncontrollably, forming a lump or mass of abnormal tissue.
- Most bone tumors are benign (not cancerous). Benign tumors are usually not life-threatening and, in most cases, will not spread to other parts of the body.
- Some bone tumors are malignant (cancerous). Malignant bone tumors can *metastasize* or cause cancer cells to spread throughout the body. In almost all cases, treatment for malignant tumors involves a combination of chemotherapy, radiation, and surgery.
7. **Arthritis:** Arthritis is an inflammation of the joint, characterized by pain, swelling and limitation of the movements. Clinically arthritis falls into the following groups:
- Osteoarthritis
 - Rheumatoid arthritis
 - Infective arthritis
 - Metabolic arthritis : Gout, pseudo gout
- a. **Osteoarthritis:** It is defined as a degenerative, non inflammatory joint disease characterized by destruction of articular surfaces and margins. (OA = can also called O = old age, a = arthritis).

- b. Rheumatoid arthritis:** Rheumatoid arthritis is a chronic non-suppurative inflammation of the synovial joints. It is more common in females than males and can affect all ages, including children (Still's disease), although it usually develops between the ages of 35 and 55 years.
- c. Infective arthritis:** Infective arthritis is defined as a bacterial infection of the joint which causes an intense inflammatory reaction with migration of polymorphonuclear leucocytes and subsequent release of proteolytic enzymes. This could lead to destruction of the articular cartilage and later the joint.
- d. Metabolic arthritis / Crystal deposition arthritis**
- **Gout:** Gout is heterogenous disorder characterized by the defective metabolism of purine leads to deposition of sodium biurate crystal on joint.
 - **Pseudo gout:** It is defective metabolism of pyro-phosphate leads to deposition of sodium pyrophosphate crystal on joint.
9. **Carpal Tunnel Syndrome:** This is a syndrome characterised by the compression of the median nerve as it passes beneath the flexor retinaculum.

SKELETAL SYSTEM

Prepared By: Dr. C K Singh

