
Locomotion and Movement - Part 3

Objectives

After going through this lesson, the learners will be able to understand the following:

- Skeletal system
- Types of skeletal system
- Bones, Cartilages, Ligaments, Tendons, Joints
- Axial skeleton and its components
- Appendicular skeleton and its components
- Functions of skeletal system
- Interesting facts

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- Skeletal system
- Types of Skeletal system
- Axial Skeleton and its components
- Appendicular Skeleton and its components
- Functions of Skeletal system
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Introduction

While standing erect for your school prayer, have you ever thought why you stand erect on two legs while the animals walk on 4 legs. Have you ever wondered how you do your daily activities like walking, running, sitting, talking, laughing, chewing, etc? What helps you in doing all this? Why do all human beings almost look alike? This all depends on your body structure or to be precise on your skeletal system.

In human beings, the Skeletal system consists of a framework of 206 bones and a network of tendons, ligaments and cartilage that connects them. This system has a significant role in movement shown by the body. The amount of bones a person is born with isn't the final tally later on. Human infants are born with about 300 bones, some of which fuse together as the body develops. By the time humans reach adulthood, they have 206 bones. Skeletal system is

grouped into two principal divisions – the axial and the appendicular skeleton. The axial skeleton comprises the vertebral column, the spine and much of the skull. The appendicular skeleton has the pelvic (hip) and pectoral (shoulder) girdles and the bones and cartilages of the limbs.

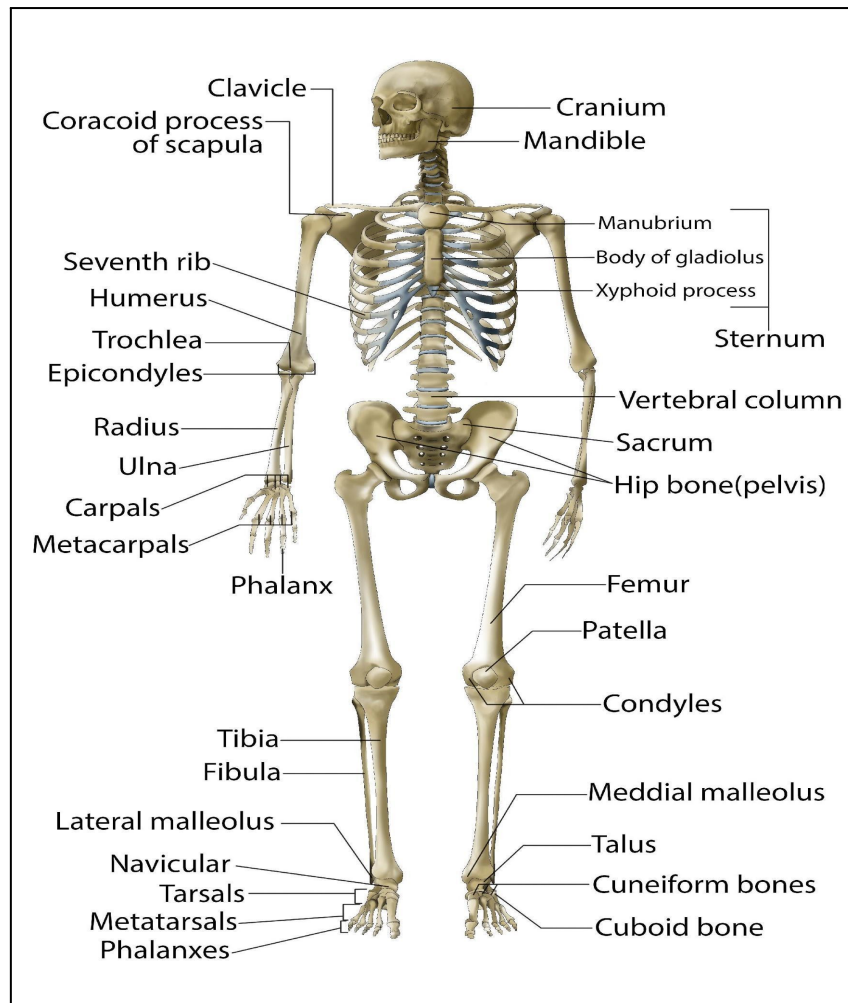
The skeletal system performs vital functions — support, movement, protection, blood cell production, calcium storage and endocrine regulation — that enable us to survive. The primary functions of the skeleton are to provide a rigid, internal structure that can support the weight of the body against the force of gravity, and to provide a structure upon which muscles can act to produce movements of the body. The lower portion of the skeleton is specialized for stability during walking or running. In contrast, the upper skeleton has greater mobility and ranges of motion, features that allow you to lift and carry objects or turn your head and trunk.

In addition to providing for support and movements of the body, the skeleton has protective and storage functions. It protects the internal organs, including the brain, spinal cord, heart, lungs, and pelvic organs. The bones of the skeleton serve as the primary storage site for important minerals such as calcium and phosphate. The bone marrow found within bones stores fat and houses the blood-cell producing tissue of the body.

Skeletal System

Altogether, the skeleton makes up about 20 percent of a person's body weight. There are also some differences in the male and female skeleton. The male skeleton is usually longer and has a high bone mass. The female skeleton, on the other hand, has a broader pelvis to accommodate for pregnancy and childbirth. Regardless of age or sex, the skeletal system can be broken down into two parts, known as the axial skeleton and the appendicular skeleton.

The adult human skeletal system consists of 206 bones, as well as a network of five main fibrous and mineralised connective tissues that connects them. A rigid form of connective tissue that is part of the skeletal system of vertebrates and is composed principally of calcium. The skeletal system is the body system composed of bones, cartilages, tendons, ligaments, joints and other tissues that perform essential functions for the human body.



Bone

Bones are a major component of the skeletal system. A typical bone has a dense and tough outer layer. Next is a layer of spongy bone, which is lighter and slightly flexible. In the middle of some bones is jelly-like bone marrow, where new cells are constantly being produced for blood.

Bones can be classified into four types based on their shape:

- **Long Bones:** They are long and slender bones found generally in the limbs. Ex. humerus, femur.
- **Short Bones:** They are short bones which are smaller in size and are found in the carpals and tarsals.
- **Flat Bones:** they are thin and flat in nature and not all of them are completely flat. They provide surface area for muscle attachment. Ex: scapula, sternum.

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- **Irregular Bones:** These bones do not have specific shapes and therefore cannot be put into any other group. Ex: vertebrae.

A type of mineralised connective tissue that contains collagen and calcium phosphate, a mineral crystal. Calcium phosphate gives bone its firmness. Bone tissue may be compact or spongy. Bones provide support and protection for the body's organs. Bone has a very hard matrix due to calcium salts in it. While they become brittle when outside of the body, bones are very much alive inside the body, being fed by a network of blood vessels from the circulatory system and nerves from the nervous system.

Teeth are considered part of the skeletal system but they are not counted as bones. Teeth are made of dentin and enamel, which is the strongest substance in your body. Teeth also play a key role in the digestive system.

Cartilage

Cartilage is the second component of the skeletal system. It is made up of fibers that are embedded in connective tissue or ground substance. A form of fibrous connective tissue that is composed of closely packed collagenous fibers in a rubbery gelatinous substance called chondrin. Cartilage provides flexible support for certain structures in adult humans, including the nose, trachea, and ears. Cartilage has a slightly pliable matrix due to chondroitin salts.

Cartilage consists of two types of fibers: Collagen and Elastin fibers. The cells that form cartilage are known as chondroblasts and the mature cells of the cartilage are known as chondrocytes. The chondrocytes lie in lacunae in the matrix. The outer layer of a cartilage is known as the perichondrium. Unlike the bone, cartilage is avascular which means that it contains no blood supply. However, the perichondrium contains blood supply.

There are 3 types of cartilages:

- **Hyaline Cartilage** – The most abundant of the three cartilages and functions to help surfaces slide over one another. Example: found in the respiratory system.
- **Fibrocartilage** – This cartilage is tough and its main function is to provide support and strength to structures. Example: found in healing tissue during bone repair (callus).
- **Elastic Cartilage** – This cartilage is abundant in elastic fibers and functions to maintain the shape of the area it is present in. Example: found in the middle ear.

Tendons

The structure that transmits the force of the muscle contraction to the bone is called a tendon. Tendons, located at each end of a muscle, attach muscle to bone. It is a flexible but inelastic cord of strong fibrous collagen tissue attaching a muscle to a bone and is capable of withstanding tension. Tendons are made of collagen. They connect muscle to bone for a proper functioning of the body. Tendons are very organised. The body creates very tightly packed fibres of collagen in parallel arrays that are flexible but very strong. The strength of tendons is important as these tight structures are required to resist the forces of very heavy loads. In the case of the eyeball, tendons attach muscles to that structure rather than a bone, allowing the muscles to move your eye. There are about 4,000 tendons in your body. Tendons are found throughout the body, from the head and neck all the way down to the feet. The Achilles tendon is the largest tendon in the body. It attaches the calf muscle to the heel bone. The rotator cuff tendons help your shoulder rotate forward and backward.

Ligaments

A fibrous band of connective tissue that joins bones and other connective tissues together at joints. Ligaments join one bone to another bone. They appear as criss cross bands that attach bone to bone and help stabilize joints. Ligaments also have some elastic fibres that allow the joint to move, but not so much that it moves beyond its capacity. Tendons are also tough cords. As a muscle contracts, the attached tendon pulls the bone into movement. Tendons also help absorb some of the impact muscles take as they spring into action. For example the knee joint has four major ligaments, one on each side of the knee and two that run diagonally across the front and back of the kneecap. These ligaments help stabilize the knee and keep it from moving too far to the left or right, forward or backward.

Joints

A site where two or more bones or other skeletal components are joined together are called **Joints**. Most **joints** are mobile, allowing the bones to move. They are constructed to allow for different degrees and types of movement. Some joints, such as the knee, elbow, and shoulder, are self-lubricating, almost frictionless, and are able to withstand compression and maintain heavy loads while still executing smooth and precise movements. Other joints such as sutures between the bones of the skull permit very little movement in order to protect the brain and the sense organs. There are three main types of joints; **Fibrous** (immovable), **Cartilaginous** (partially moveable) and the **Synovial** (freely moveable) joint.

Types of Skeletal System

There are two major types of skeletons: solid and fluid. Fluid skeletons are always internal and are called hydrostatic skeletons. Solid skeletons can be internal, called an endoskeleton, or external, called an exoskeleton.

Hydrostatic Skeleton

It is formed by a fluid-filled compartment held under hydrostatic pressure within the body called the coelom. The organs of the coelom are supported by the aqueous fluid, which also resists external compression. This compartment is under hydrostatic pressure because of the fluid and supports the other organs of the organism. This type of skeletal system is found in soft-bodied animals such as sea anemones, earthworms, Cnidaria, and other invertebrates. Movement in a hydrostatic skeleton is provided by muscles that surround the coelom. The muscles in a hydrostatic skeleton contract to change the shape of the coelom; the pressure of the fluid in the coelom produces movement. For example, earthworms move by waves of muscular contractions of the skeletal muscle of the body wall hydrostatic skeleton, called peristalsis, which alternately shorten and lengthen the body. Lengthening the body extends the anterior end of the organism. Most organisms have a mechanism to fix themselves in the substrate. Shortening the muscles then draws the posterior portion of the body forward. Although a hydrostatic skeleton is well-suited to invertebrate organisms such as earthworms and some aquatic organisms, it is not an efficient skeleton for terrestrial animals.

Exoskeleton

It is a hard external skeleton that protects the outer surface of an organism and enables movement through muscles attached on the inside. An exoskeleton is an external skeleton that consists of a hard encasement on the surface of an organism. For example, the shells of crabs and insects are exoskeletons. This skeleton type provides defence against predators, supports the body, and allows for movement through the contraction of attached muscles. As with vertebrates, muscles must cross a joint inside the exoskeleton. Shortening of the muscle changes the relationship of the two segments of the exoskeleton. Arthropods such as crabs and lobsters have exoskeletons that consist of 30–50 percent chitin, a polysaccharide

derivative of glucose that is a strong but flexible material. Chitin is secreted by the epidermal cells. The exoskeleton is further strengthened by the addition of calcium carbonate in organisms such as the lobster. Because the exoskeleton is acellular, arthropods must periodically shed their exoskeletons because the exoskeleton does not grow as the organism grows.

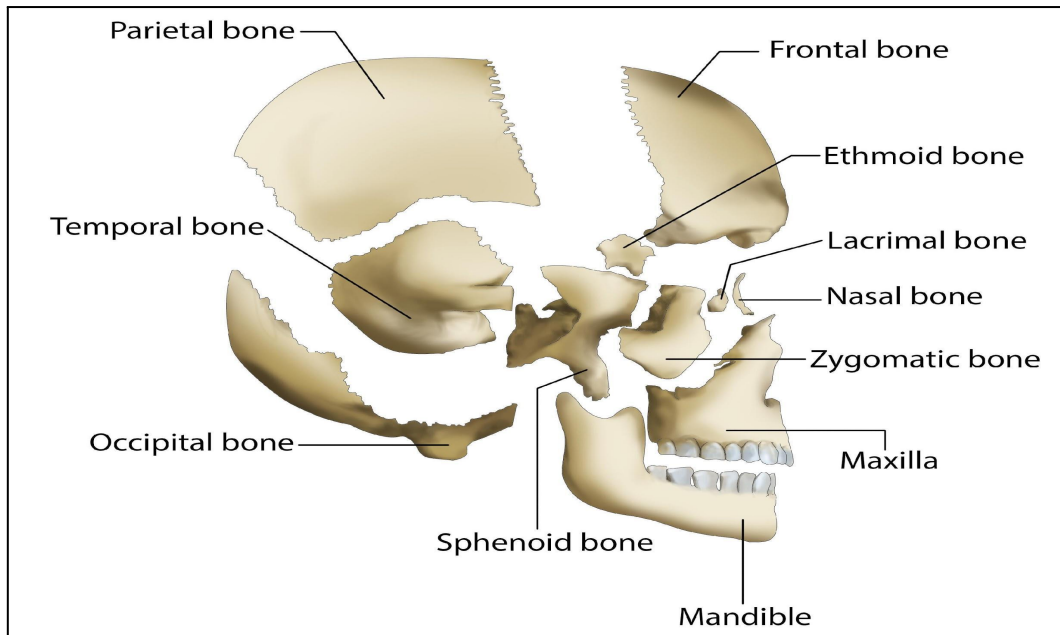
Endoskeleton

It is an internal skeleton composed of hard, mineralised tissue that also enables movement by attachment to muscles. An endoskeleton is a skeleton that consists of hard, mineralised structures located within the soft tissue of organisms. An example of a primitive endoskeletal structure is the spicules of sponges. The bones of vertebrates are composed of tissues, whereas sponges have no true tissues. Endoskeletons provide support for the body, protect internal organs, and allow for movement through contraction of muscles attached to the skeleton.

Animals with hydrostatic skeletons and exoskeletons are considered invertebrates, meaning they don't have a backbone. Animals with endoskeletons, like us, are considered vertebrates because they have a backbone. The human skeleton is an endoskeleton that consists of 206 bones in the adult. It has five main functions: providing support to the body, storing minerals and lipids, producing blood cells, protecting internal organs, and allowing for movement. The skeletal system in vertebrates is divided into the axial skeleton (which consists of the skull, vertebral column, and rib cage), and the appendicular skeleton (which consists of the shoulders, limb bones, the pectoral girdle, and the pelvic girdle).

Axial Skeleton and its Components

The axial skeleton, with a total of 80 bones, consists of the vertebral column, the thoracic / rib cage and the skull. The **axial skeleton** forms the vertical, central axis of the body and includes all bones of the head, neck, chest, and back. The axial skeleton includes bones that run along the medial sagittal plane of the body. Imagine a vertical plane that runs through your body from front to back and divides the body into equal right and left regions. This is the medial sagittal plane.



Skull

The adult **skull** comprises 22 bones. These bones can be further classified by location:

- **Cranial bones:** The eight cranial bones form the bulk of your skull. They help to protect your brain.
- **Facial bones:** There are 14 facial bones. They're found on the front of the skull and make up the face.

Auditory Ossicles

The auditory ossicles are six small bones found within the inner ear canal in the skull. There are three auditory ossicles on each side of the head, known as the:

- Malleus (hammer)
- Incus (anvil)
- Stapes (stirrup)

They work together to transmit sound waves from the surrounding environment to the structures of the inner ear.

Hyoid

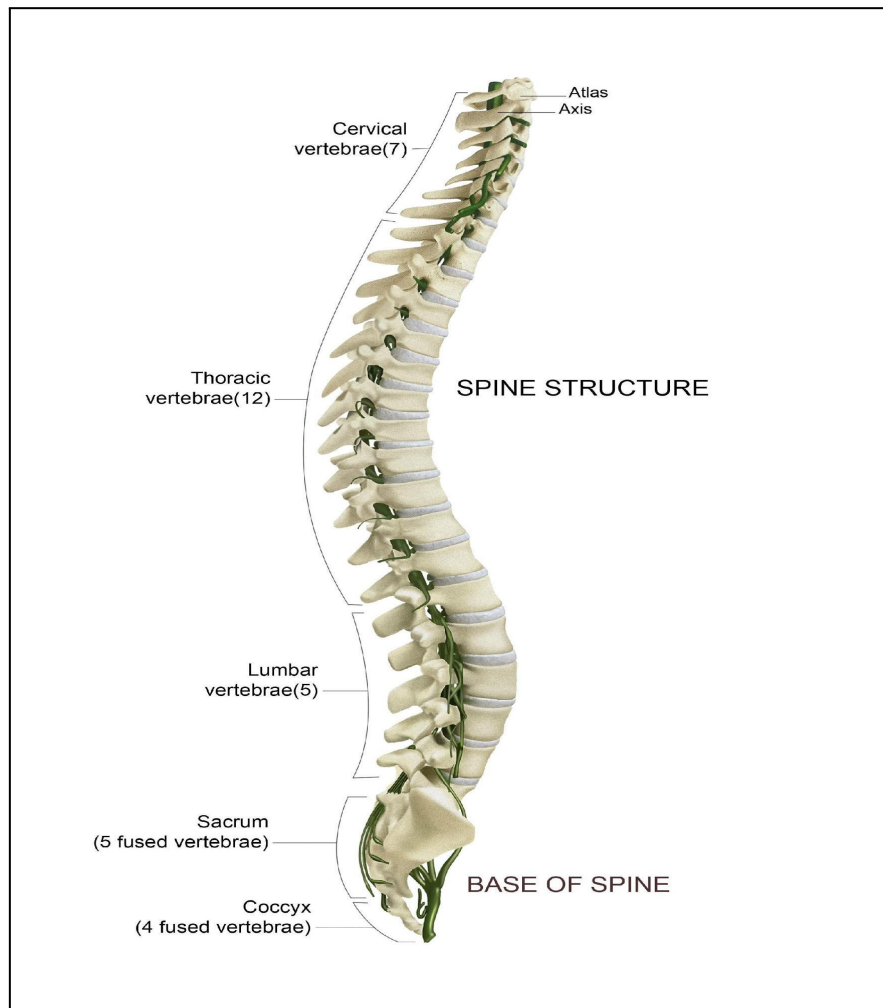
The hyoid is a U-shaped bone found at the base of the jaw. It serves as a point of attachment for muscles and ligaments in the neck.

Vertebral Column

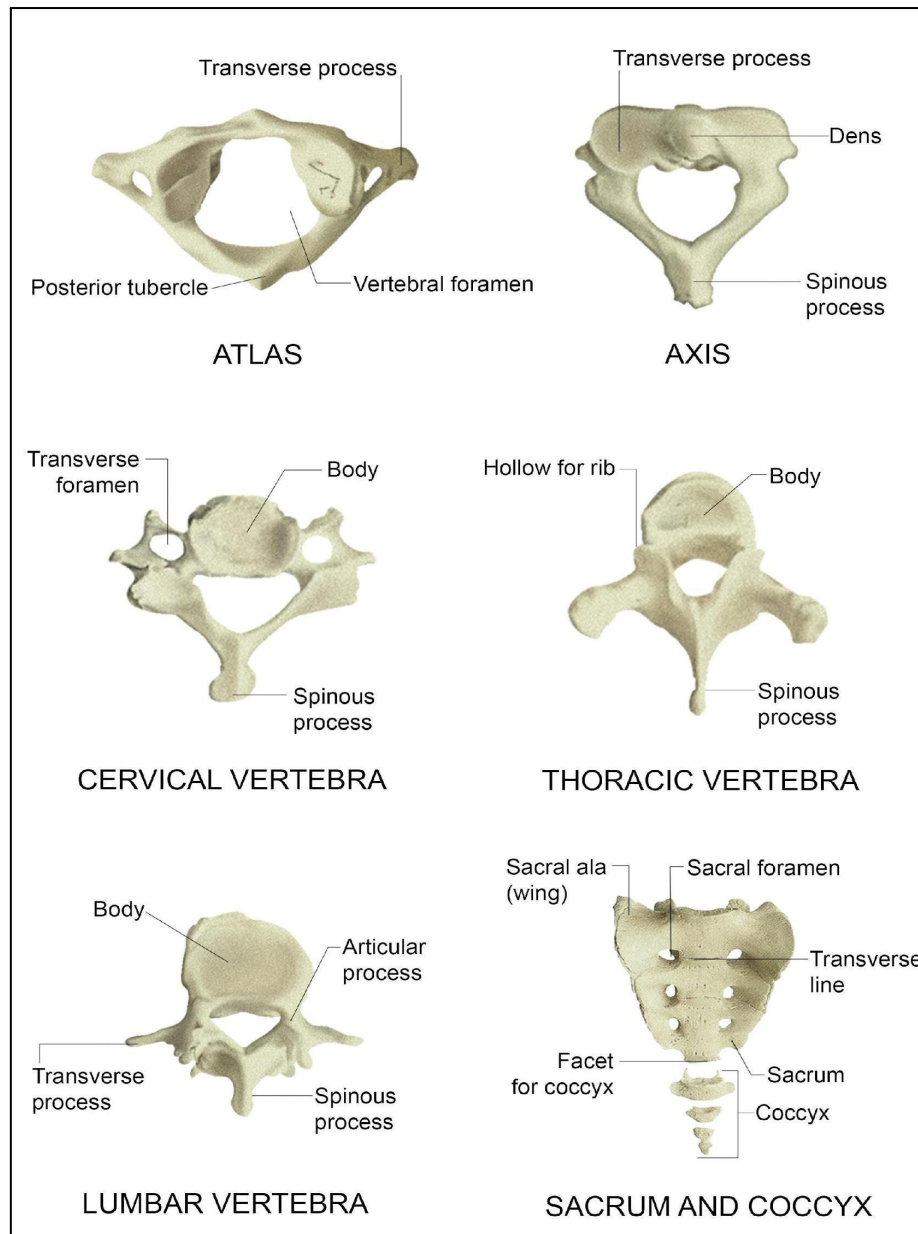
The vertebral column is made up of 26 bones. The first 24 are all vertebrae, followed by the sacrum and coccyx (tailbone).

The 24 vertebrae can be further divided into the:

- **Cervical Vertebrae:** These seven bones are found in the head and neck.
- **Thoracic Vertebrae:** These 12 bones are found in the upper back.
- **Lumbar Vertebrae:** These five bones are found in the lower back.



The sacrum and coccyx are both made up of several fused vertebrae. They help support the weight of the body while sitting. They also serve as attachment points for various ligaments.



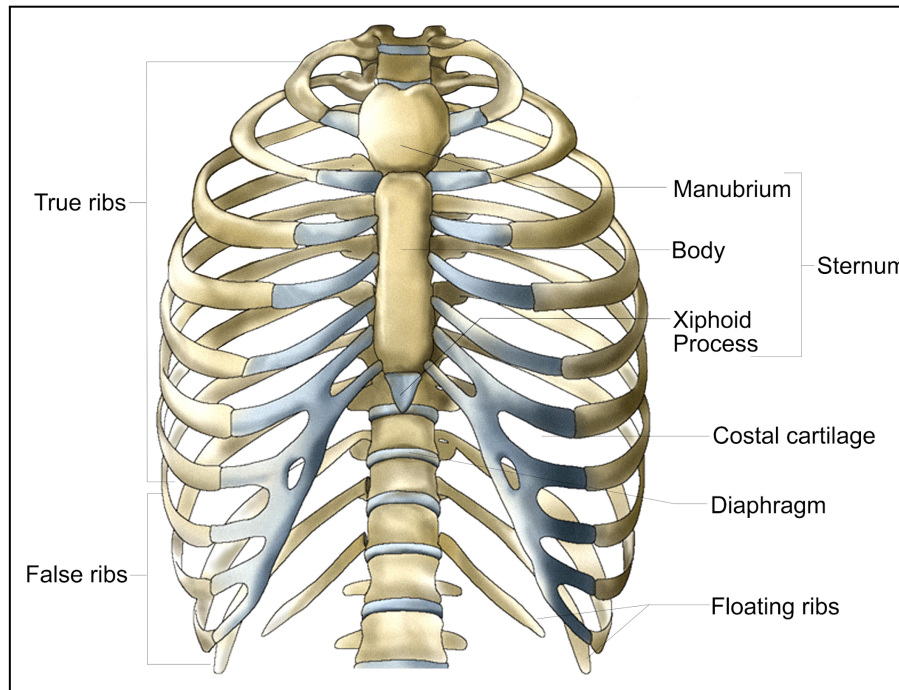
Thoracic Cage

The thoracic cage is made up of the sternum (breastbone) and 12 pairs of ribs. These bones form a protective cage around the organs of the upper torso, including the heart and lungs.

Some of the ribs attach directly to the sternum, while others are linked to the sternum via cartilage. Some have no attachment point and are referred to as “floating ribs”.

The axial skeleton transmits the weight from the head, the trunk and the upper extremities down to the lower extremities at the hip joints, which help humans maintain our upright posture. It serves to protect the brain, spinal cord, heart, and lungs. It also serves as the

attachment site for muscles that move the head, neck, and back, and for muscles that act across the shoulder and hip joints to move their corresponding limbs. The axial skeleton protects numerous vital organs and soft tissues of the body. The skull provides protection for



the brain, the vertebral column protects the spinal cord, and the thoracic cage protects the heart and lungs.

Appendicular Skeleton and its Components

Appendicular skeleton consists of a total of 126 bones, pectoral girdle, upper limbs, pelvic girdle, and lower limbs. The appendicular skeleton is composed of body limbs and structures that attach limbs to the axial skeleton. It consists of the bones that make up the arms and legs, as well as the bones that attach them to the axial skeleton. Bones of the upper and lower limbs, pectoral girdles, and the pelvic girdle are components of this skeleton.

Pectoral Girdle

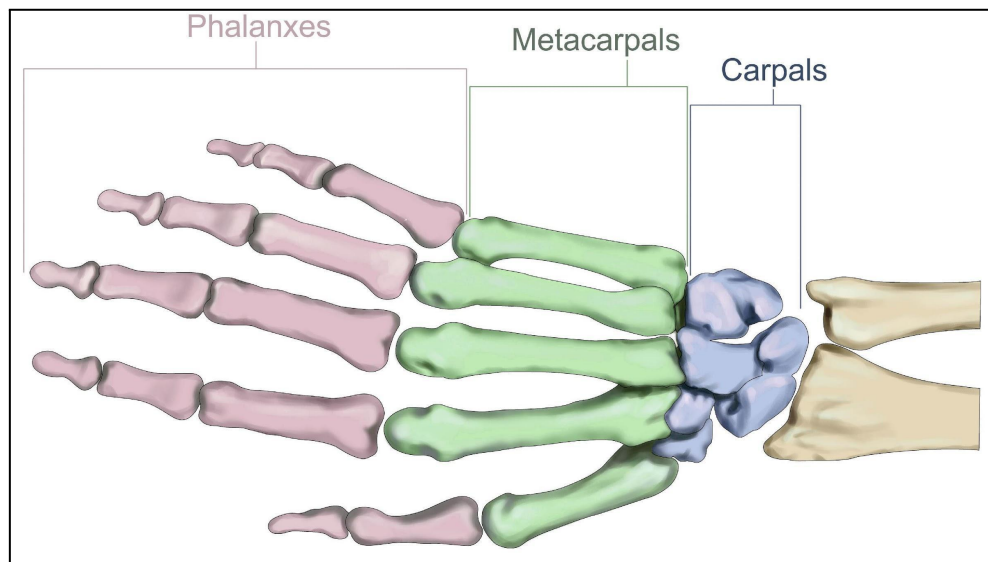
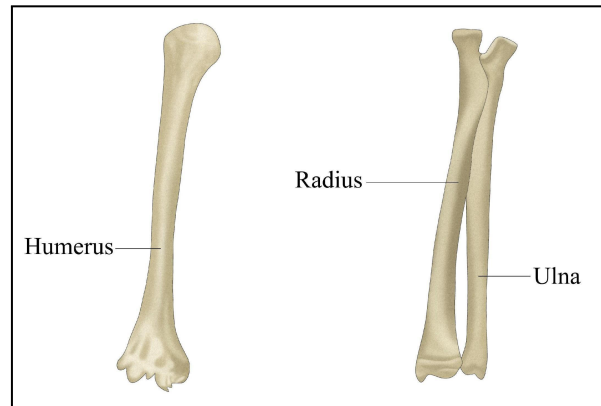
The pectoral girdle is where the arms attach to the axial skeleton. It's made up of the clavicle (collarbone) and scapula (shoulder blade). There are two of each of these — one for each arm.

Upper Limbs

Each arm contains 30 bones, known as the:

- **Humerus:** The humerus is the long bone of the upper arm.

- **Radius:** The radius is one of two long bones of the forearm, found on the thumb side.
- **Ulna:** The ulna is the second long bone of the forearm, found on the pinky finger side.
- **Carpals:** The carpals are a group of eight bones found in the wrist area.



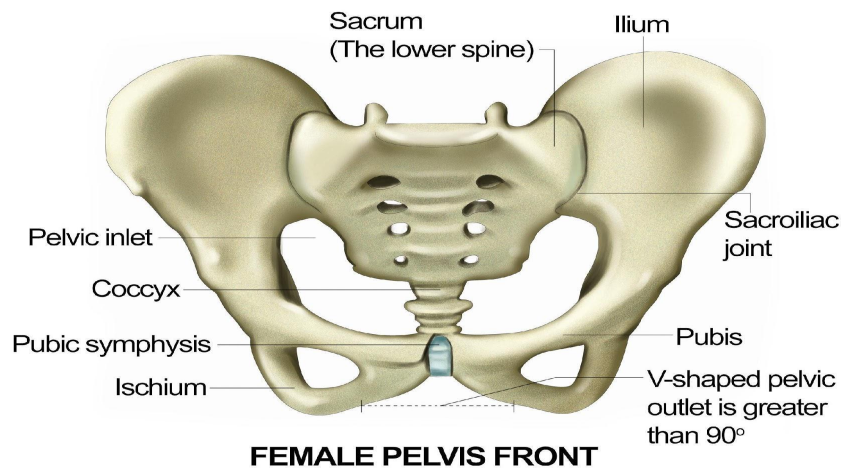
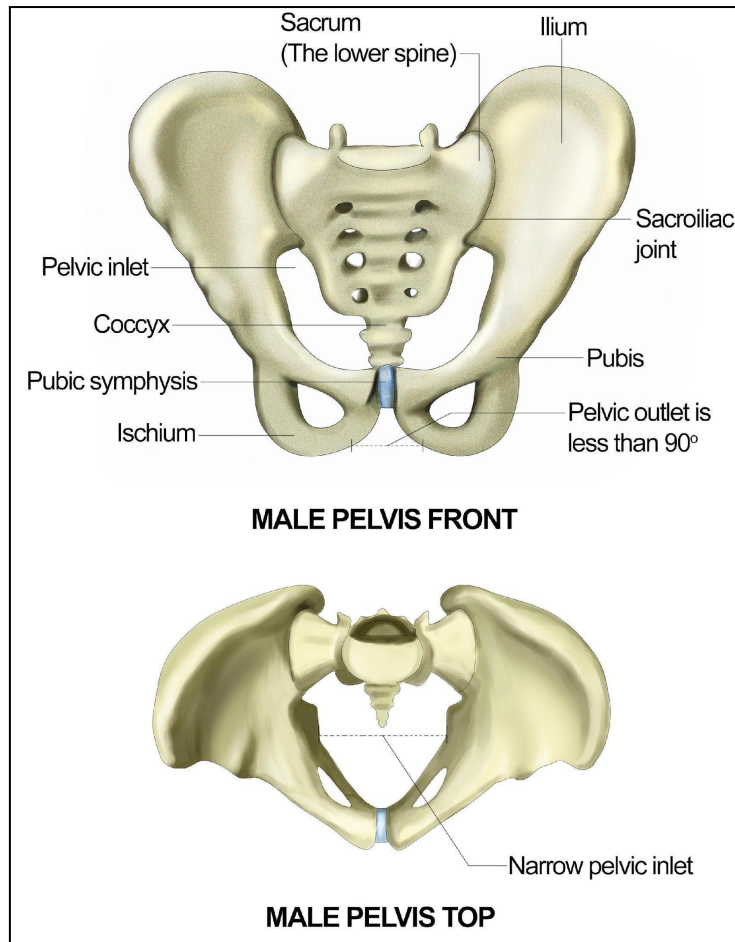
- **Metacarpals.** The metacarpals are five bones found in the middle area of the hand.
- **Phalanges.** The phalanges are 14 bones that make up the fingers.

Pelvic Girdle

The pelvic girdle, commonly known as the hips, is where the legs attach to the axial skeleton. It's made up of two hip bones — one for each leg.

Each hip bone consists of three parts, known as the:

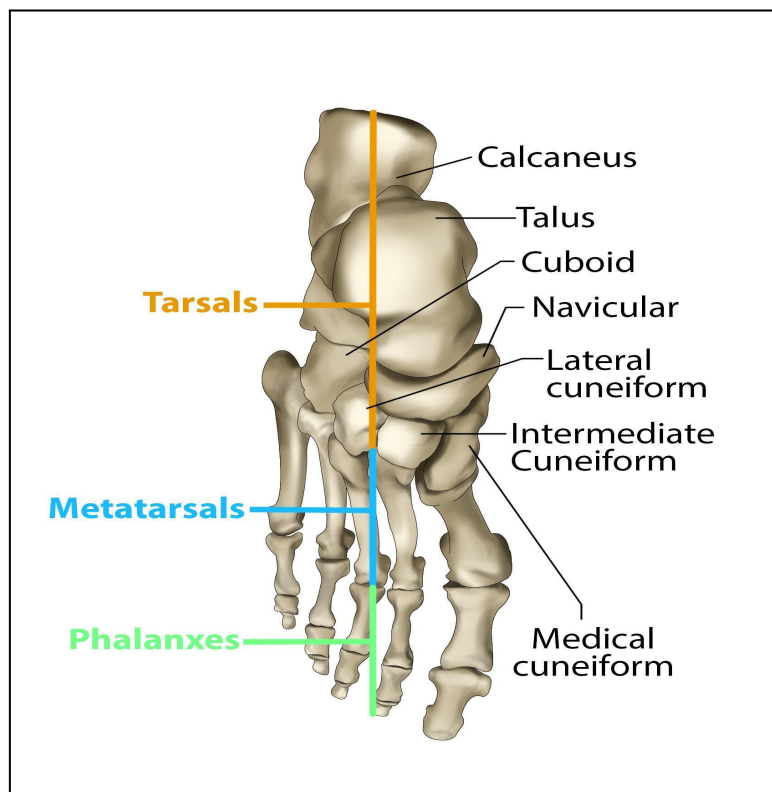
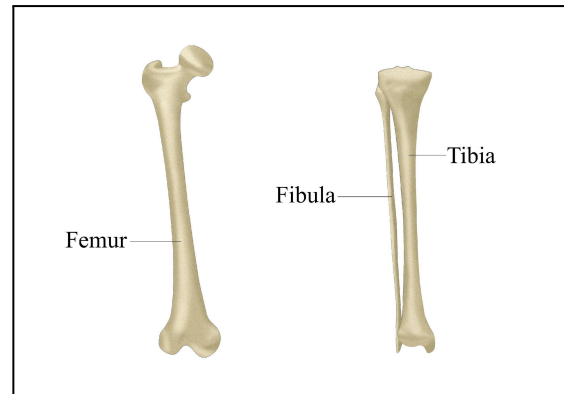
- **Ilium:** The ilium is the top portion of each hip bone.
- **Ischium:** The ischium is a curved bone that makes up the base of each hip bone.
- **Pubis:** The pubis is located in the front part of the hip bone.



Lower Limbs

Each leg is composed of 30 bones, known as the:

- **Femur:** The femur is the large bone of the upper leg.
- **Tibia:** The tibia is the main bone of the lower leg. It forms the shin.
- **Fibula:** The fibula is the second bone in the lower leg, found in the outer leg.
- **Patella:** The patella is also called the kneecap.
- **Tarsals:** The tarsals are the seven bones that make up the ankle.
- **Metatarsal:** The metatarsals are the five bones that make up the middle area of the foot.
- **Phalanges:** The phalanges are 14 bones that comprise the toes.



Although the primary function of the appendicular skeleton is for bodily movement, it also provides protection for organs of the digestive system, excretory system, and reproductive system. Their functions are to make walking, running and other movement possible and to protect the major organs responsible for digestion, excretion and reproduction.

Functions of Skeletal System

The skeletal system performs vital functions like:

1. It provides a kind of framework for the body.
2. It provides shape and posture to the body.
3. It provides protection to some of the inner delicate organs like the brain, spinal cord and lungs.
4. It gives a rigid surface for the attachment of muscles with the help of tendons.
5. It helps in locomotion.
6. The bone marrow serves as the center for the production of red blood cells and white blood cells.
7. The movements of ribs and sternum help in breathing.
8. In the ear, the sound vibrations are conveyed from the tympanum to the internal ear by a set of three bones as in man.
9. It helps the body to be an integrated unit.
10. It serves to store various ions like calcium and phosphate, which are then released into the body at the time of need. These minerals perform various functions of the body.

Summary

Skeletal system gives us the shape we have, and the power to move. It supports and protects the internal body organs and acts as a storehouse for minerals such as calcium. Skeletal system makes your body. It is supported by various components discussed in this module. It supports movement, protection, blood cell production, calcium storage and endocrine regulation — that enable us to survive. Skeleton supports the body, gives rigidity to body, provides surface for attachment of muscles, and protects soft internal organs like the brain, heart, lungs etc.

The male and female differ slightly in their skeletal systems. Males have thicker and longer legs and arms, whereas females have a wider pelvis and wider space within the pelvis for babies to travel. Whether male or female, young or old, everyone should take care of their skeletal system with exercise and good nutrition. Just remember, be kind to your bones and they will treat you right.

Interesting Facts:

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- Three bones in the inner ear, called malleus, incus and stapes, are the smallest bones in the human body. The thigh bone or femur, is the largest bone.
 - The hyoid bone situated behind the lower jaw is also called a ‘floating’ bone because it is not part of any joint, and is not directly attached to any other bone.
 - The position of the hyoid bone makes it extremely resistant to fractures. However, autopsies that reveal a broken hyoid bone indicate death from strangulation.
 - Plaster of Paris (POP) casts for immobilizing a fractured bone were invented in 1851.
 - Newborn babies have about 300 bones. Many of these bones fuse together to form the 206 bones of the adult.
 - Though teeth are considered a part of the skeletal system, they aren’t counted among the 206 bones.