

Unit 13

SUPPORT AND MOVEMENT



Students Learning Outcomes

The students will be able to:

- ❖ Define a skeleton and differentiate between cartilage and bone.
- ❖ Describe the role of the skeleton in support and movement.
- ❖ Explain that skeleton system is actually a dynamic, living tissue that is capable of growth, adapts to stress and repairs itself after injury.
- ❖ Describe the main components of the axial skeleton and the appendicular skeleton.
- ❖ Describe the contribution of Vesalius in describing the bones and muscles in human.
- ❖ Differentiate between moveable joints and immovable joints.
- ❖ State the role of ligaments and tendons.
- ❖ Describe the location and movement of hinge joints.
- ❖ Identify ball and socket joints in the human body.
- ❖ Define antagonism.
- ❖ Describe the action of flexors and extensors as a pair of opposing muscles selecting biceps and triceps as an example.
- ❖ Describe the effect of deficiency of calcium on bones and relate this deficiency with osteoporosis.
- ❖ Discuss the causes, symptoms, and treatment of arthritis.
- ❖ Relate the onset of arthritis with age and weight-bearing joints.

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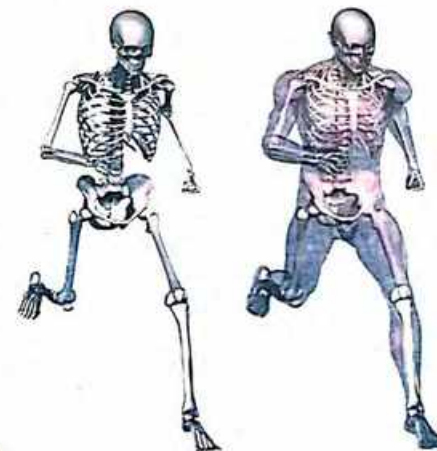
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Introduction

You might have seen a very common invertebrate the earthworm, which is generally found in the soil. Have you ever thought why it always crawls on the ground? Why it moves so slowly? Why it can not stand erect like human beings and other mammals? The answer to these questions is, "It does not have any skeleton which can support it to stand erect and move faster". In previous classes you have studied the human skeleton, which not only gives proper shape to the human body but also provides support for movement. All animals, which can move fast, possess some type of skeleton. Free movement, also known as locomotion is a life characteristic of all living animals. It enables them to utilize the environment in the best possible way and to save themselves from predators and a range of environmental factors. For all types of movements, the skeleton plays a basic role.

13.1 Human Skeleton

A skeleton is defined as the framework of hard structures that provide physical support and protection for the bodies of animals. The skeleton also provides helps in locomotion. Like other vertebrates, the human skeleton is inside the body i.e. it is an endoskeleton. The skeleton is made of living tissues. It contains living cells and also has nerves and blood vessels. It can also grow and repair itself.



Science, Technology and Society

The skeleton performs various functions in the living body. These functions include shape, support, movement, protection and blood cells production. In different animals, these functions are variously performed and the shape of the skeleton is in accordance with the requirement of the particular animal's types.

The human skeleton is composed of two parts i.e. the axial skeleton and the appendicular skeleton. The axial skeleton consists of 80 bones of the head, neck, and chest. The appendicular skeleton consists of 126 bones of the limbs, and the pectoral and pelvic girdles.

For Your Information

The skeletal system of some invertebrates e.g. arthropods, is outside the body, and is called an **exoskeleton**.

13.1 Axial Skeleton

The term axis means the central point around which other structures are distributed. The axial skeleton lies in the centre of the body around which the whole body is built. The axial skeleton includes the skull, the vertebral column, the ribs and the sternum.

1. Skull

The skull is made up of the cranium and facial bones. The cranium consists of 8 bones, which protect the brain. There are 14 facial bones, which make the skeletal part of our face.

2. Vertebral Column

The vertebral column extends from the skull to the pelvis. It consists of the backbone, which not only allows us to stand erect but also protects the spinal cord. The vertebral column consists of 33 vertebrae. The vertebrae are named according to their location in the body. Those 7 vertebrae present in neck are called cervical vertebrae. 12 vertebrae which lie in the chest region are called thoracic vertebrae. Those five vertebrae which lie in the back region are termed as the lumbar vertebrae and those nine found between the lower limbs area are called the pelvic vertebrae. The pelvic vertebrae make two sets i.e. the sacrum and the coccyx. The sacrum is formed by the fusion of anterior five vertebrae, whereas coccyx is formed by the fusion of four posterior vertebrae.

3. Chest bone and Ribs

There are 12 pairs of ribs in the human body, which are attached on dorsal (back) side with the vertebrae. Out of the 12, 10 pairs of ribs connect anteriorly with the chest bone (sternum) either directly or through an arch. The rib cage provides support to the thoracic cavity (chest cavity) in which vital organs like the heart, lungs etc. are present. The lower 2 pairs of ribs are called floating ribs because they do not attach with the sternum.

4. Middle Ear Bones

Each human ear has three bones called ossicles. These are the malleus, the incus and the stapes.

5. Neck bone

There is one bone in the neck called the hyoid bone.

13.1.2 Appendicular Skeleton

The appendicular skeleton consists of the following parts.

1. Pectoral Girdle

The pectoral girdle attaches the forelimbs to the vertebral column. It is comprised of 4 bones of the shoulder (2 bones on each side).

2. Forelimbs (Arms and Hands)

The arms contain 6 bones (3 in each arm). The hands contain 54 bones (27 in each hand).

Table

At the time of birth human infants have 350 bones in their body. As a baby grows up towards adult stages, many of these bones fuse together and their number reduces to 206. The largest bone is the femur whereas the smallest bone is found in the internal ear.

3. Pelvic Girdle

The pelvic girdle attaches the hind limbs to the vertebral column. It consists of 2 bones.

4. Hind limbs (Legs and Feet)

The legs contain 8 bones (4 in each leg) while both feet contain 52 bones (26 in each foot).

Activities

Identify and draw labelled diagrams of different bones of the human skeleton from real specimen models or charts.

3.1.3 Role of the Skeletal System

The skeleton performs the following functions in the body.

- The skeleton forms the hard structure of the body and gives it a definite shape.
- the skeletal muscles are attached to the bones. Hands, legs, pectoral girdle and the pelvic girdle help in movement. The muscular system has an important role in movement. Due to the attachment of muscles with the bones, these bones can move and thus we can move.
- The skull protects the brain and the vertebral column protects the spinal cord. Similarly, the lungs and heart are protected in the rib cage.
- Bone marrow produces the red blood cells, platelets and white blood cells.
- Bones store mineral salts (calcium, potassium, phosphorus). This is the reason why the bones remain hard and strong.

Appendicular Skeleton

Axial Skeleton

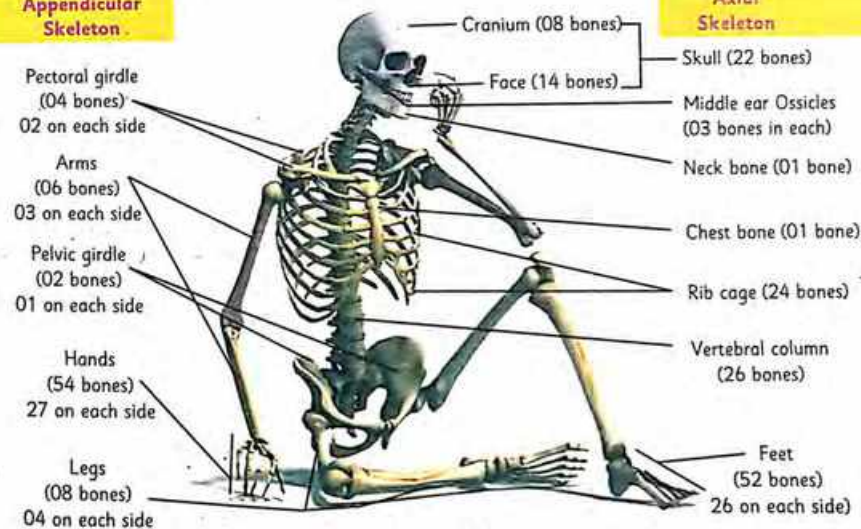


Fig.13.1 Human Skeleton

13.2 Composition of Skeleton

The human skeleton is made up of two types of connective tissue i.e. bones and cartilage.

1. Bones

Bones are the hardest and the most rigid form of connective tissue in the human body. Muscles pull our bones to enable movements. Bones give shape and structure to the body. It provides support and protect delicate internal organs. In addition, the internal portion of many bones produce red blood cells, platelets, and white blood cells.

The hard, white outer layer of the bone is called compact bone. The matrix (plural: matrices) is the material (or tissue) in animal cells in which more specialised structures are embedded. The bone matrix contains collagen fibres. The matrix is also saturated with calcium phosphate. It gives strength to the bone. Within the bone matrix, bone cells called osteocytes are present in spaces called lacunae. The bone matrix contains nerve fibres and blood vessels, which keep the osteocytes alive. Beneath the compact bone the spongy bone is present. The spaces within the spongy bone contain bone marrow, where most blood cells are formed.

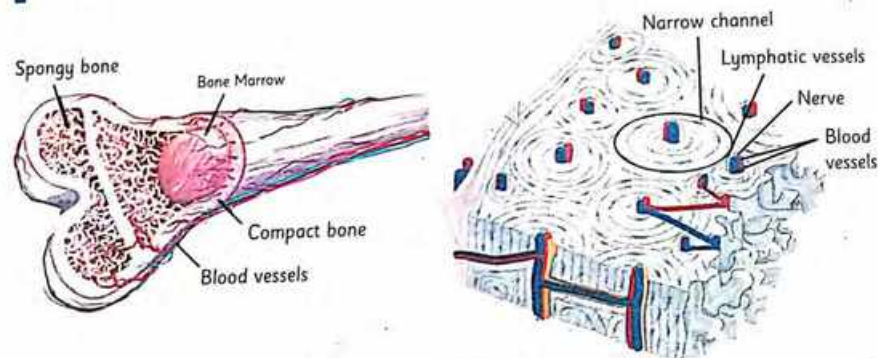


Fig.13.2 Structure of Bone

2. Cartilage

Cartilage is a specialised connective tissue, which is firm and flexible and does not stretch. It has great tensile strength and is much softer than bone. In adults the cartilage covers the ends of the bone at the joints like the knee joints. It also supports the flexible portion of nose the and the external ears called the pinna.

Tidbit

In common words, cartilage is referred to as "soft bone". In early embryonic life, the whole skeleton is made of cartilage which then gradually turns into bones.

Ground substance is the amorphous gel like substance present in extracellular spaces. The ground substance of cartilage contains **collagen fibers** in parallel arrangements. The cells of the cartilage are called **chondrocytes**. These are also present in this ground substance within spaces called **lacunae**. The number of chondrocytes found in cartilage determines how flexible or elastic the cartilage is. One of the main functions of some cartilage types is to keep bones from rubbing together, thus reducing friction. There are no blood vessels present in the ground substance of cartilage. There are three types of cartilage i.e. hyaline, elastic, and fibrous cartilage.

Activities

Investigate the nature of bones (by putting three pieces of lamb rib bone in water, sodium hydroxide and dilute Hydrochloric acid). Observe the changes in the nature of bone after 60 minutes.

What will students learn from this? Explain what is expected to happen...

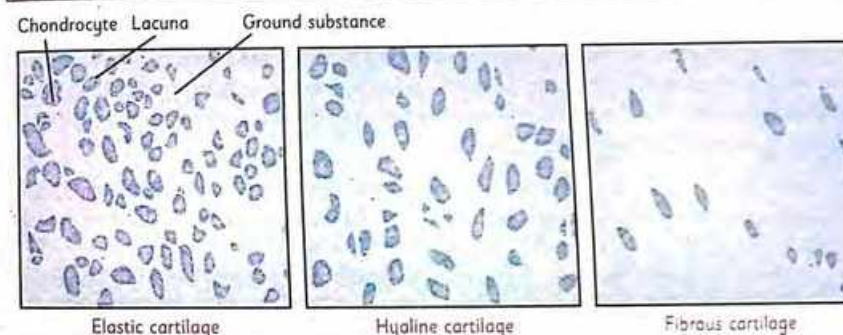


Fig.13.3 Structure of Cartilage and its Types

In **elastic cartilage** the cells are closer together and there is less ground substance. Elastic cartilage is found in the external ear flaps and in the epiglottis.

Hyaline cartilage has less number of cells and more ground substance. Hyaline cartilage is found at the ends of long bones, in the nose, ears, trachea, larynx, and bronchi.

Fibrous cartilage has the least number of cells so it has maximum ground substance. Fibrous cartilage is found in the inter-vertebral disc.

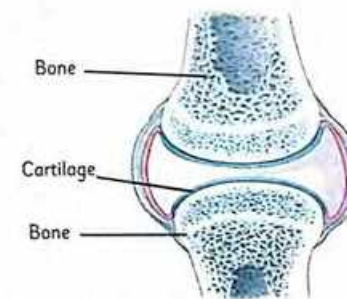


Fig.13.4 Location of Hyaline Cartilage

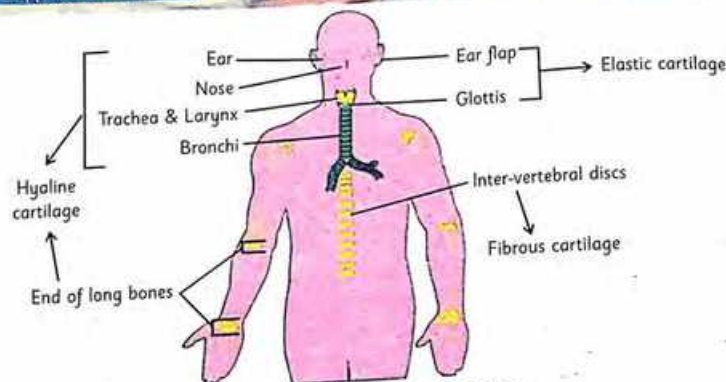


Fig.13.5 Locations of the Types of Cartilage

13.3 Joints

Joints are formed at the meeting point of two or more bones. They keep our bones together by holding them with each other. They also allow the bones to move to different extents and give mobility to our body. Joints are classified into three categories on the basis of the extent of movement they allow:

- Immovable joints:** In immovable joints the bones are fused together and do not allow any movement. For example, the joints present among the bones of the skull are immovable joints.
- Slightly movable joints:** These are the joints which allow little movement for example, joints of the vertebral column, ribs etc.
- Freely movable joints:** These joints allow free movements. There are two major types of freely moveable joints i.e. hinge joint and ball-and-socket joints.

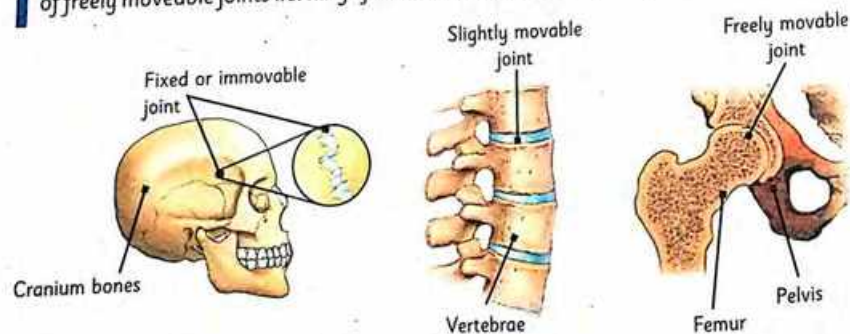


Fig.13.6 Immovable, slightly movable and freely movable joints

(i). **Hinge joints:** Hinge joints allow movements only in two directions. These are present at the elbow and the knee.

(ii). **Ball-and-socket joint:** Ball-and-socket joints allow movement in all directions (up, down, forward, and backward). Hip joint and shoulder joint are examples of ball-and-socket joints.

Activities

Observe models for the movements at joints and describe how joints allow various movements.



Hinge Joint



Ball-and-Socket Joint

Fig.13.7 Hinge and ball-and-socket joints in the human body

13.3.1 Roles of Tendons and Ligaments

Ligaments are tough bands of connective tissue, which hold the bones at the joints, in place.

Tendons are tough connective tissues, which attach muscles to bones. When a muscle contracts, the tendon exerts a pulling force on the attached bone. As a result the bone is pulled towards the muscle.

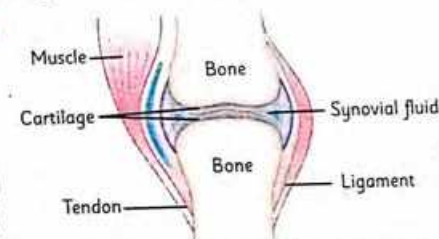


Fig.13.8 Structure of a joint (showing ligament and tendon)

13.5 Contributions of Vesalius (1514-1564)

Andreas Vesalius was born in Brussels. He was professor of Anatomy at Padua University in Italy. In 1543, he wrote the first major book on human anatomy. It was called '**de Humani Corporis Fabrica**' (The Fabric of the Human Body). Vesalius worked closely with the famous artist Titian who produced 277 anatomical illustrations for his book. He explained the different parts of the human skeleton, including the number of bones. He also described the source and position of each muscle and provided information on their respective functions.



Fig.13.9 Andreas Vesalius

13.6 Muscles and its Types

Locomotion and all other types of movements are due to the contraction of muscles of the body. We have three types of muscles in our body.

- (i). The **Cardiac muscle** (heart muscle) is an involuntary muscle – meaning we cannot control its function. Contractions of the cardiac muscle help the heart to pump blood throughout the body. Cardiac muscles keep on contracting throughout our life.
- (ii). **Smooth muscles** are found in the walls of organs e.g. the digestive tract, air passageways, blood vessels and the urinary bladder etc. Their contractions move the materials present in the organs.
- (iii). **Skeletal muscles** are attached to the bones of the skeleton. Their contractions help us in movement and locomotion.

13.6.1 Antagonistic Movement of Skeletal Muscle

We know that muscles are attached to bones by tough connective tissue called **tendons**. Skeletal muscles move the body. These muscles are under voluntary control, meaning you consciously control what they do. Almost all body movement, like walking and waving your hand is caused by skeletal muscle contraction.

Interesting facts

Muscles can only pull bones. They cannot push bones.
The human body has over 500 muscles responsible for all types of movement.

One end of a skeletal muscle is always attached with some fixed bone while the other end is attached to a moving bone. The point where the muscle attaches to the fixed bone is called the **origin**. The point where the muscle attaches to the moving bone is called the **insertion**.

For Your Information

It should be remembered that the arm does not have these two muscles only. Many other muscles are also present, which work at the same time e.g. muscles which work to give direction to these movements.

Most skeletal muscles are arranged in **pairs**. One muscle in a pair moves a bone in one direction, the other muscle moves it in the opposite direction. In other words when one muscle in the pair contracts to exert a pull, the other muscle will relax or elongate to allow the effect of the contraction of the prior muscle. The phenomenon in which a muscle opposes the action of the other is called **antagonism** and the muscles which show antagonism are called **antagonistic muscles**.

An example of this type of movement is the movement of arm muscles. Our upper arm has two major muscles called **biceps** and **triceps**. When the lower arm is bent it is called in **flexed state**. When the lower arm is in hanging condition, it is called in **extended state**. This extension and flexion is caused by the above mentioned pair of muscles i.e. biceps and triceps.

When the biceps muscle contracts, its insertion with the radius bone, pulls the bone upward. At the same time the triceps muscle relaxes and the lower arm moves upwards causing a flexion. The biceps muscle in this case is the flexor and the triceps muscle the extensor.

For Your Information

Similarly there are more complex movements of fingers and wrists about which you will study in detail in higher classes

On the other hand when triceps muscle contracts, its insertion with the ulna bone pulls the bone back. At the same time the biceps muscle relaxes and allows the ulna bone to move down easily. It results in the extension of the lower arm. This example explains the general principle of the working of skeletal muscles.

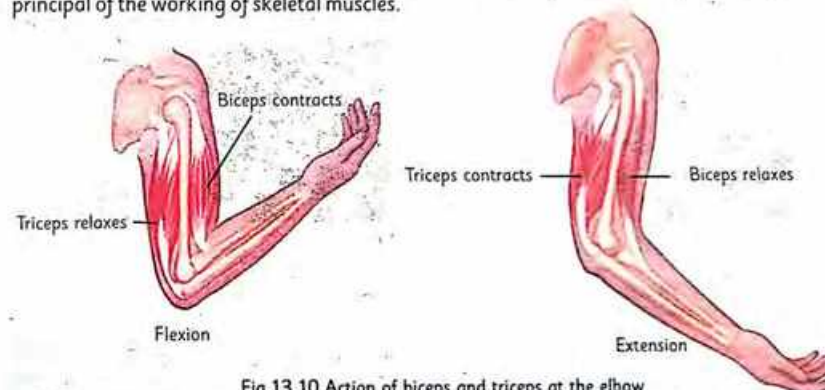


Fig.13.10 Action of biceps and triceps at the elbow

Activities

Describe the movement of biceps and triceps through presentation of the movement of your elbow.

13.7 Disorders of Skeletal Muscles

From your day-to-day experience you might have learnt about many problems associated with skeletal system. Sometimes during a cricket match the muscle of a fast bowler gets pulled, joint of a wrestler may get dislocated, the bones of a person may be fractured in an accident and so on. Some of the disorders of skeletal system are described here briefly.

13.7.1 Osteoporosis

You learned in this chapter that the process of mineralisation, forms bones. Calcium phosphate is deposited in collagen fibres to make the bones hard. This calcium is absorbed from the food we eat.

When a person is not taking sufficient calcium in their daily diet, their bones start becoming weak. Demineralisation is the process in which calcium moves from the bones to the blood in order to maintain its level. If this situation prolongs the bones become soft and fragile and start bending and can be broken easily. This disorder is known as osteoporosis. Osteoporosis occurs especially in old people and in women.

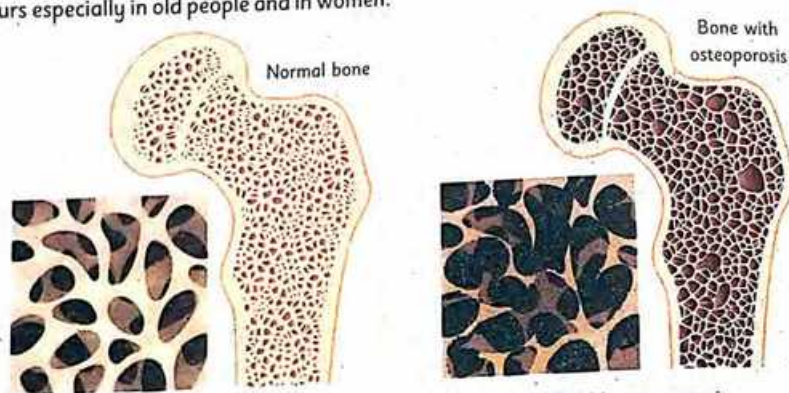


Fig.13.11 Comparison of normal bone with the bone affected by osteoporosis

13.7.2 Arthritis

Arthritis is the disorder of the joints where they get inflamed. This is a degenerative disease that damages the joints permanently. As a result, pain, stiffness and swelling of the joints takes place. The different types of arthritis are osteoarthritis, rheumatoid arthritis, and gouty arthritis. In this disorder, membranes lining the joints thicken and fluid production is decreased, which results in increased friction causing severe pain and in later stages complete immobility. With the passage of time the joints become permanently swollen and get de-shaped.

a. Osteoarthritis: Osteoarthritis is the most common type of arthritis. This disease affects the cartilage, which starts to wear away over time. In extreme cases, the cartilage can completely wear away, leaving nothing to protect the bones in a joint, causing direct bone-on-bone contact. It occurs most often in older people. Osteoarthritis usually affects the **weight-bearing joints** (the joints of the vertebrae, knee and hip). Osteoarthritis causes joint pain and can limit a person's normal range of mobility.

b. Rheumatoid arthritis: Rheumatoid arthritis is an autoimmune disease in which the body's immune system attacks healthy joints, which become inflamed and swollen. It can destroy cartilage and bone within the joint. It usually affects joints in the fingers, wrists, knees and elbows. It causes pain, stiffness, swelling, and loss of function in joints.

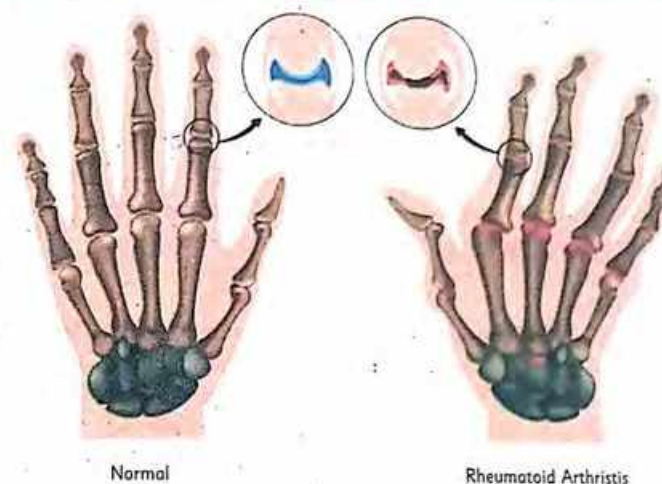


Fig.13.12 Rheumatoid arthritis in finger joints

c. Gouty arthritis: Gouty arthritis is caused by higher than normal levels of uric acid in the blood and the deposit of large amounts of uric acid in the lining of the joints in the form of crystals. It causes inflammation in the joints called gout or gouty arthritis. It usually affects the joint at the base of big toe. Other joints (knees, wrists and fingers) may also be affected.

Treatment of arthritis: The treatment of arthritis focuses on relieving symptoms and improving joint function. Analgesics (pain killers), non-steroidal anti-inflammatory drugs (NSAIDs) are used to treat arthritis. Surgery can also be performed in which the affected joint is replaced with an artificial joint.

Science, Technology and Society

Arthroplasty is a surgery that involves replacing a damaged, worn out or diseased joint with an artificial joint. Adults of any age can be considered for a knee replacement, although most are carried out on people between the ages of 60 and 80. The most common reason for knee replacement surgery is osteoarthritis.

Key Points

- ❖ A skeleton consists of a hard living substance, which provides a framework for maintaining the body shape or support.
- ❖ Human skeleton can be divided into two further types; the axial skeleton and the appendicular skeleton.
- ❖ The axial skeleton includes the skull, the vertebral column, and the ribs with sternum.
- ❖ The appendicular skeleton consists of the pectoral girdle and the appendages (fore limbs).
- ❖ Human skeleton is made up of two types of materials i.e. bones and cartilage.
- ❖ Cartilage is much softer than bone. It is also a form of connective tissue.
- ❖ Joints are formed at the meeting point of two or more bones. They keep our bones together by holding them with each other.
- ❖ On the basis of the extent of movement allowed by the joints, they are classified into three categories immovable joints, slightly movable joints and freely movable joints.
- ❖ There are three types of muscles in our body which are cardiac muscles which make up our heart, smooth muscles are found in digestive, respiratory, circulatory and urinary tract etc and skeletal muscles are found attached to the bones of the skeleton.
- ❖ The muscles in our body work in pairs. When one muscle of the pair contracts (shortens) the other relaxes (elongates) to perform a coordinated movement known as the antagonistic movement of muscles.
- ❖ Although bones are the hardest parts of our body, however, sometimes our skeletal system becomes weak and results in deformations.

Exercise

A. Select the correct answer.

- Which of these is a part of the appendicular skeleton?
a. Ribs b. Sternum c. Pectoral girdle d. Vertebral column
- The joints between the skull bones are an example of:
a. Ball and socket joints b. Hinge joints
c. Immoveable joints d. Slightly moveable joints
- Which type of joint is present between the vertebrae?
a. Fixed joint b. Slightly moveable joint
c. Ball-and-socket joint d. Hinge joint
- Which of the following is not part of the axial skeleton
a. Sternum b. Vertebrae c. Leg bones d. Skull
- Bones are stronger than cartilage due to the presence of:
a. Collagen fibres b. Osteocytes c. Calcium phosphate d. Lacunae
- The main protein in the matrix of cartilage is:
a. Collagen b. Osteo-nectin c. Keratin d. Actin
- Which connective tissue attaches two bones at a joint?
a. Ligament b. Tendon c. Cartilage d. Marrow
- In which disease do the bones become weak and brittle?
a. Osteoporosis b. Osteoarthritis
c. Rheumatoid arthritis d. Vertebral column
- The point where the muscle attaches to the fixed bone is called;
a. Tendon b. Ligament c. Insertion d. Origin
- Arthritis is defined as inflammation in:
a. Bones b. Joints c. Cartilage d. Muscles

B. Write short answers to the following questions.

- Why are bones considered as dynamic structures?
- What is the contribution of Vesalius in understanding the human skeleton?
- Describe the function of three major types of joints and give an example of each.
- How are different types of arthritis caused?
- Differentiate between a skeletal muscle's origin and insertion.
- State the functions of flexors and extensors.