

LOCOMOTION

Locomotion is the movement of the whole organism from one place to another.

Movement is the displacement of part of the body of an organism.

Forms or types of locomotion

- ✓ By crawling
- ✓ By walking
- ✓ By flying
- ✓ By creeping

Structures used in locomotion are referred to as limbs and they include;

- | | |
|-----------|------------------|
| i) Wings | v) Cilia |
| ii) Fins | vi) Flagella |
| iii) Legs | vii) Pseudopodia |
| iv) Arms | |

An animal locomote in order to;

- ✓ Look for food
- ✓ Search for mates
- ✓ Avoid danger and catastrophes.
- ✓ Avoid competition with other animals
- ✓ Colonize new areas.

Requirements for locomotion

Locomotion requires the following.

1. Energy. This is obtained from respiration.
2. Skeleton. This is a rigid framework for support and attachment of muscles.
3. Muscles. These contract and relax in order to move the skeleton during locomotion.
4. Medium. This is the environment in which the organism moves. The medium can be water, land or air.

SKELETON

A skeleton is a frame work that provides rigid support.

Types of skeleton

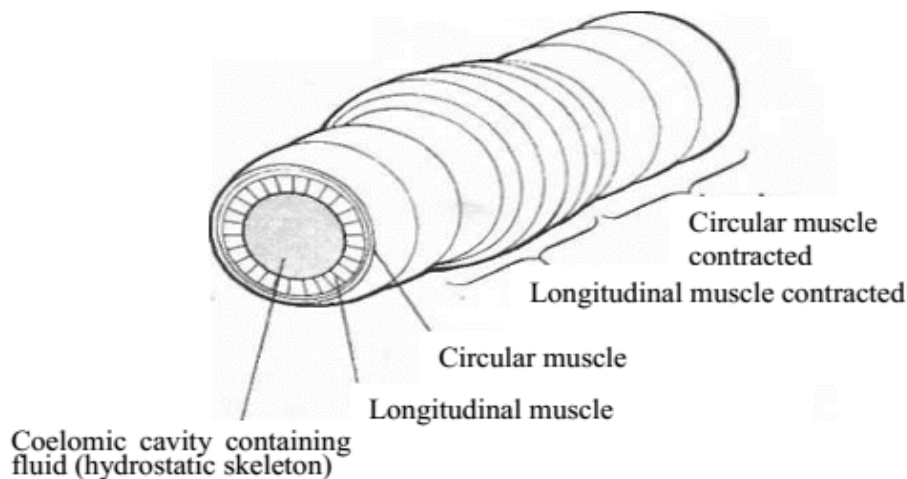
There are three types of skeleton.

- i) endoskeleton
- ii) exoskeleton
- iii) hydrostatic skeleton

HYDROSTATIC SKELETON

This is a type of skeleton made up of a water filled cavity. The cavity is surrounded by a set of antagonistic muscles. Locomotion is caused by compression of the fluid under high pressure by action of muscles on the fluid to form a rigid surface that offers support e.g. in earthworms.

Section through the earthworm



EXOSKELETON

This is a skeleton found outside the body of an organism. It is made up of a substance called chitin in insects and shells in molluscs. The exoskeleton is rigid and made up of nonliving material. It does not allow increase in size of an insect except for periods when it is shed during moulting.

ENDOSKELETON

This is a skeleton found inside the body of an organism. This is found in all vertebrates. It's made up materials called bone and cartilages.

Cartilage is softer and elastic and it's the first part to form the skeleton in the embryos of all vertebrates and it's gradually replaced by bone as growth takes place

Bone is harder and inelastic and is made up of living cells and nonliving material of calcium phosphate and calcium carbonate.

Ossification is the process through which cartilage changes to bones.

Merits of endoskeleton over exoskeleton

- i) The endoskeleton is more flexible hence it facilitates easier movement since it has movable joints.
- ii) The endoskeleton is harder so it offers better protection and support to the internal organs compared to exoskeleton.

- iii) It enables greater and continuous growth.
- iv) An endoskeleton can manufacture red and white blood cells required for oxygen carriage and body defense against diseases respectively.

Merits of exoskeleton over endoskeleton

- i) It can protect all the inner parts unlike the endoskeleton which can't protect the muscles and blood vessels.
- ii) It's lighter so it offers fewer burdens to the organism.

LOCOMOTION IN INSECTS

There are two types of locomotion in insects.

1. Walking and running with the help of legs.
2. Flight by use of wings.

Uses of legs in insects:

- i) Walking and running
- ii) Capturing prey.
- iii) Collecting nectar like in bees
- iv) Swimming
- v) Digging holes.

WALKING IN INSECTS

Insects have jointed legs. The leg is joined to the body by a ball and socket joint. The other joints are hinge joints called peg and socket because they allow movement in only one plane. The insect's leg has two sets of antagonistic muscles the **flexor** and **extensor** muscles.

When the flexor muscle contracts, the leg bends and when the extensor muscle contracts, the leg straightens thereby resulting into forward movement of the insect. Three legs move at once that is the fore and hind leg of one side plus one middle leg of the other side. The other three remain on the ground. During walking the claws and the pad (arolium) help in gripping onto the surface.

Therefore, that is why insects' move in some-how zig-zag fashion due to unequal number of legs moved at each side.

Adaptations of insects to move by legs

- i) Possession of claws at the end of the legs which enable them to move on rough surfaces e.g. in grass hoppers and cock roaches.
- ii) Possessions of glandular pad which enable them to move on smooth and wet surfaces and also to move upside down e.g. house flies.
- iii) Some insects e.g. locusts and grass hoppers have long hind and short fore legs. This helps them to jump over long distances.
- iv) Some insects e.g. cock roaches have got spines on their legs which prevent them from

slipping backwards.

MOVEMENT BY WINGS IN INSECTS

Flight is brought about by the action of flight muscles attached to the exoskeleton and wing. There are two types of flight muscles in insects

- 1) **Direct flight muscles**; these are attached to the base of the wing such as in dragonfly and butterfly.
- 2) **Indirect flight muscles**; these are attached to the exoskeleton that is on the roof of thorax (tergum) and floor of the thorax such as in bees, wasps, houseflies and other small insects.

When the depressor muscle contracts it lowers the wing. Contraction of the elevator muscle raises the wing. These two muscles work antagonistically whereby when one contracts the other relaxes. All flying insects have direct flight muscles, which adjust the angle of the wing to provide forward movement.

FLIGHT USING DIRECT FLIGHT MUSCLES

During the upward stroke:

The elevator muscles contract while the depressor muscles relax. This leads to upward movement of the wing.

During the down ward stroke:

The depressor muscles contract while the elevator muscles relax. This leads to down ward movement of the wing.

Diagram showing attachment of direct flight muscles on wings

FLIGHT USING INDIRECT FLIGHT MUSCLES

During the upstroke:

- ✓ The elevator muscles (dorsal-ventral muscles) contract
- ✓ The depressor muscles (longitudinal muscles) relax.
- ✓ The wing is pulled against the tergum of the thorax there by moving the thorax downwards.
- ✓ The wing moves up or it is elevated

During the down ward stroke:

- ✓ The depressor muscles contract.
- ✓ The elevator muscles relax,
- ✓ This pulls the wing down wards.

Indirect flight muscles

LOCOMOTION IN BIRDS

Some birds like ostriches, kiwi, move on their legs and cannot fly. However, majority of birds can fly.

Adaptations of birds to fly

1. They have hollow bones, which make them light in air.
2. They have feathers used for flight.
3. They have streamlined bodies due to lack of external ears and feathers face backward enabling them to minimize air resistance
4. They have an efficient respiratory system to provide the necessary oxygen for respiration by possessing air sacs.
5. They have large flight muscles, which move wings during flight.
6. Their fore limbs are modified into wings to provide a large surface area for flight.
7. They have good eyesight to dodge obstacles and correctly judge distance on landing.
8. They have an efficient circulatory system for quick transport of oxygen and nutrients.
9. They are warm blooded with a high metabolic rate to provide the required energy for flight.
10. They have a high red blood cell count for efficient transportation of oxygen.
11. They have the ability to fold legs away during flight to reduce air friction.

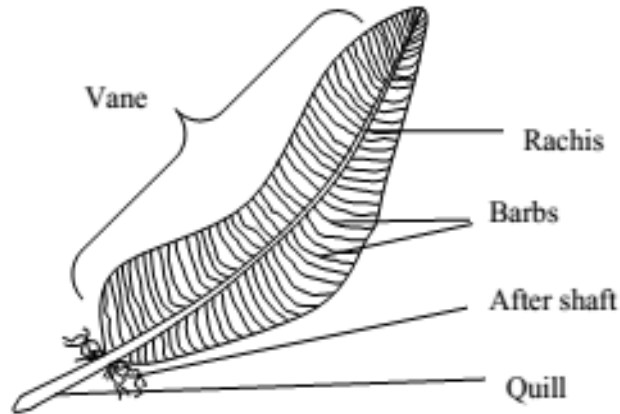
FEATHERS

These are structures that cover the entire body structure of the birds.

Function of feathers to birds.

1. They protect the skin from abrasion, rain and direct sunrays.
2. They assist in maintenance of body temperature or regulating body temperature by insulating against heat loss.
3. They are used in flight
4. They are for camouflage to avoid predators.
5. They are for courtship. Feathers are used to attract the opposite sex in birds.
6. They are for sensation, i.e. they collect sound waves

Structure of a typical feather



Parts of the feather

1. **The shaft.** This is the framework or axis of the feather. The shaft is divided into the quill and rachis.
2. **The quill.** This is a cylindrical structure pointed at the end. It has two openings at its ends called inferior umbilicus and superior umbilicus.
3. **The rachis.** This extends from the superior umbilicus of the quill. It provides attachment of the vanes.
4. **The vane.** This is a feathery flat blade attached to the rachis. It consists of structures called barbs. The barbs have smaller parallel projections called barbules. The barbules strengthen the feather by making interlocking connections with each other.

TYPES OF FEATHERS

1. Quill feather/contour feather.

Location: These are found on the tail and wing.

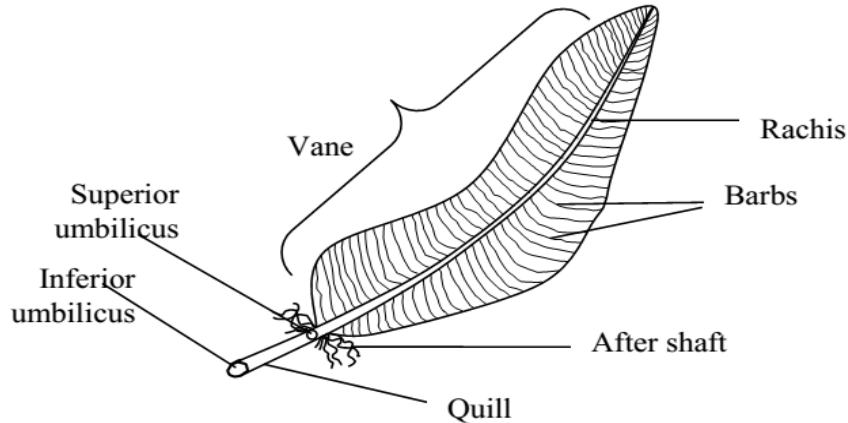
Characteristics:

- ✓ They have a hard strong hollow quill.
- ✓ They have a large vane.
- ✓ They have a small after shaft.
- ✓ Their vanes consist of barbs and interlocking barbules.
- ✓ They have two holes, i.e. the inferior umbilicus and superior umbilicus.
- ✓ They have a large and long shaft.

Functions of the quill feathers

1. They are used in flight.
2. They protect the skin of the bird.
3. They insulate the bird's body against heat loss.
4. They provide an air proof surface effective at breaking against air during flight.

Structure of the quill feather



Adaptations to flight

- ✓ Has a hollow quill, making it light, thus reducing weight.
- ✓ Has a broad vane thus offering a large surface area for beating air
- ✓ Has a strong rachis to provide firm attachment for vanes.
- ✓ It has a smooth vane to provide a stream lined body which reduces friction during flight.

2. The covert feather

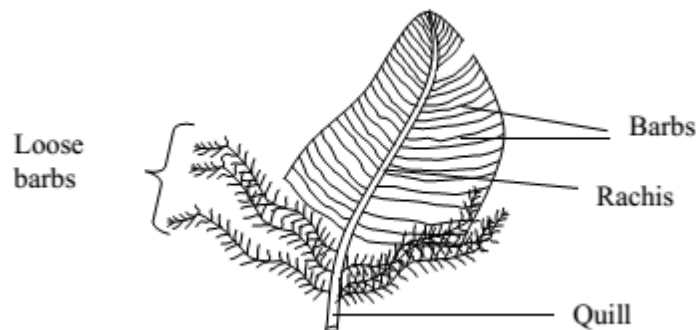
Location: These are found around the neck and the upper side of the body

Characteristics:

- ✓ It is smaller than the quill feather.
- ✓ It has a large after-shaft.
- ✓ It has a short vane.
- ✓ It has a soft quill.

Function: They help in temperature regulation by covering the body to prevent heat loss. They also give the body shape and colour.

Structure of the covert feather



Adaptations to its functions

- ✓ Has a curved surface which gives the bird its shape.
- ✓ Has a fluffy after shaft to insulate the body.

- ✓ Have interlocking barbs and a smooth vane that make the bird water proof.

Similarities between quill and contour feathers

- ✓ Both have a quill
- ✓ Both have barbs at the base of the rachis
- ✓ Both have vanes inter locked by barbs

Differences

Quill feathers	Contour feathers
Has a stiff rachis	Has a flexible rachis
Has a long vane	Has a short vane
Has a long quill	Has a short quill
Barbs closely interlocked	Less interlocked barbs

3. Down feathers

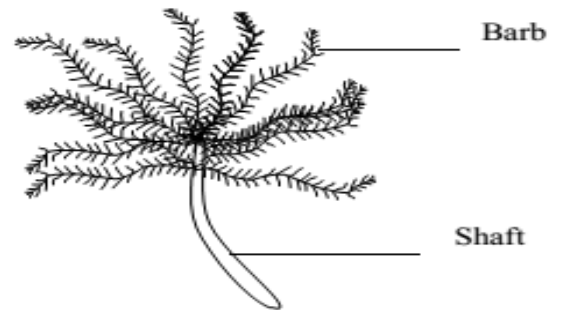
Location: These are found all over the body especially on the abdomen and between covert and flight feathers.

Characteristics:

- ✓ It is smaller than the quill and covert feathers.
- ✓ It is soft and fluffy.
- ✓ It has a short and small quill.
- ✓ It has no vane but instead it has free barbs.

Function: It insulates the body against heat loss.

Structure of the down feather



4. Filoplumes

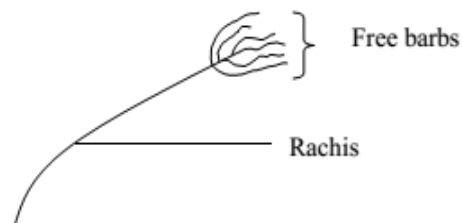
Location: These are found sparsely distributed all over the body amongst other feathers.

Characteristics:

- ✓ They are long and hair-like feathers.
- ✓ They have a long rachis.
- ✓ They have a thread-like shape.
- ✓ They have few free barbs at one end

Function. These feathers are for sensation.

Structure of the filoplume



FLIGHT IN BIRDS

TYPES OF FLIGHT

1. Flapping /active flight

This is a type of flight, which involves the up, and down movement of the wing against air. It is aided by the pectoralis muscles attached to the deep keel of the sternum.

2. Gliding.

This is a type of flight where the bird moves under the gravitational force by spreading its

wings and tail. This results into slow movement as the bird loses height. It is usually used when the bird is going to land.

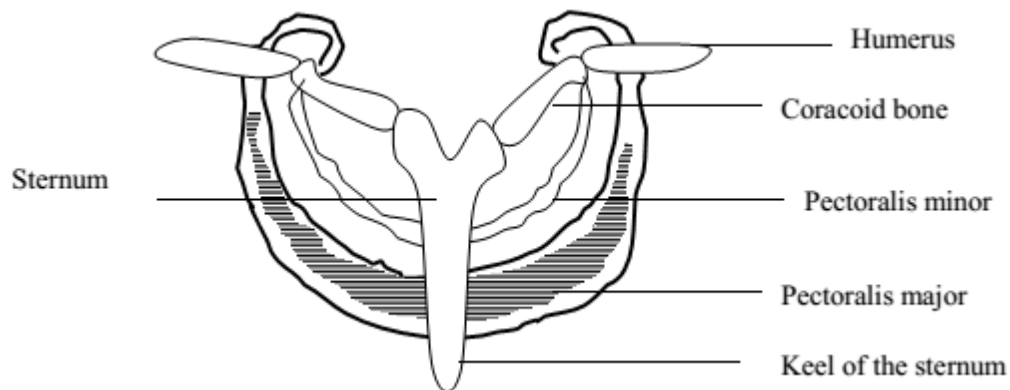
3. Soaring.

This is the upward movement of the bird by the help of upward air currents. It allows the bird to gain height without flapping of wings.

MECHANISM OF ACTIVE FLIGHT/FLAPPING IN BIRDS.

Active flight occurs with the help of flight muscles. These muscles are pectoralis minor and pectoralis major. The muscles are antagonistic that is when they contract, they produce opposite effects. Active flight involves two strokes, the downward stroke and upward stroke.

Structure showing attachment of flight muscles in a bird



During the down stroke:

The pectoralis major contracts and the pectoralis minor relax.

The flight feathers overlap and become air-tight in order to prevent air moving through them.

The wing moves down and backwards. The air offers resistance to the wing, which gives the bird an upward and forward thrust. The bird is then able to move upwards and forward.

Note: Forward movement is provided by the stream of air directed backwards because the wing is flapped with the leading edge below the trailing edge. In this way the wing acts as an aerofoil.

Upstroke:

This is also called the recovery stroke. It is brought about by the contraction of the pectoralis minor and relaxation of the pectoralis major.

The pectoralis minor contracts and the flight feathers open to allow air through them such that less resistance is felt.

The reduction in air resistance causes the wing to be raised. The wing reaches maximum point, the pectoralis major resumes its contractions, starting the downward stroke again.

Similarities between flight in birds and in insects

1. Both use wings for flight.
2. Both have streamlined bodies.
3. In both, flight occurs with the help of antagonistic muscles.
4. Both can glide and show active flight.

Differences between flight in insects and flight in birds

Flight in insects	Flight in birds
They lack the keel; muscles are attached on the exoskeleton.	They have a keel for attachment of flight muscles.
Wings are moved by direct and indirect muscles	Direct flight muscles move wings.
Skeleton is made of chitin	Skeleton is made up of bones, feathers and cartilage.
Wings are thin and membranous. They are supported by veins of chitin	Wings are thick.

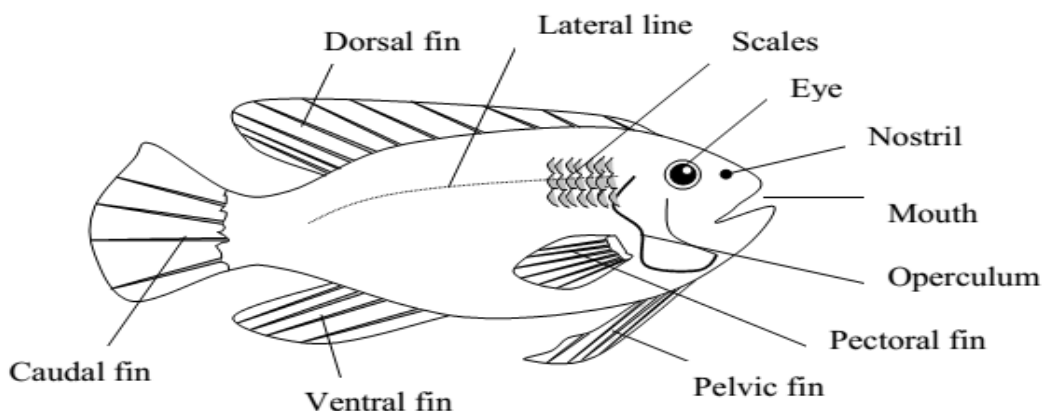
LOCOMOTION IN FISH

Fish move by swimming in water

Adaptations of the fish to swim in water

- 1) Fish have large eyes, which give them a wide field of view to detect and avoid obstacles and danger in water.
- 2) They have a lateral line, which enable the fish to detect vibrations and pressure changes in water.
- 3) They have fins for propulsion and stability while in water.
- 4) They have a swim bladder, which makes them buoyant. They can float in water and sink to the bottom by inflating and deflating their swim bladders.
- 5) They have streamlined bodies to reduce on water resistance.
- 6) They have gills, which help them to exchange gases while in water. The gills are adapted to obtain oxygen dissolved in water and to release Carbondioxide into the water.
- 7) They produce a thin layer of mucus over their body, which reduces water resistance.
- 8) They have a flexible skeleton with blocks of myotome muscles, which promote quick movement and caudal fin that propels the fish in water.
- 9) They have a slivery appearance on the ventral side and a dark colour on sides, which help it to camouflage in water to escape from predators.
- 10) Scales are arranged in a backward overlapping way that offers little resistance to water.
- 11) The vertebral column is considerably flexible to allow sideways movement.

Structure of the bony fish



Action of the myotome muscles

- As the caudal fin moves from side to side in water, it generates a thrust, which propels the fish forward.
- The side-to-side movement of the caudal fin is caused by the antagonistic contractions of myotome muscles arranged on both sides of the vertebral column.
- The myotomes of one side of the vertebral column contract, those on the opposite side relax causing the tail to bend.
- The muscles contract from head to tail alternately causing a wave movement to pass down the body.
- This movement of the caudal fin causes a force on the tail and body against water, which results in resistance of water pushing the fish sideways and forward to oppose the thrust.
- When the myotomes on the left contract from head to tail, those of right side relax to allow the front part of the body and caudal fin to bend against water exerting a backward pressure on the water.
- This results into a forward motion that drives the fish forward and sideways.
- Series of contraction then repeat on the right side of the body causing the caudal to be slashed against water to the left and this drives the fish forward and sideways.
- However to maintain direction, and stability the fish uses fins.

Action of fins

Fins control direction and stability in water.

There are two categories of fins.

1. **The paired fins**; these include pectoral and pelvic fins which are used for steering and balancing to control pitching
2. **The median fins**; these are unpaired fins. They include dorsal and ventral fins. These control rolling and yawing by increasing vertical surface.

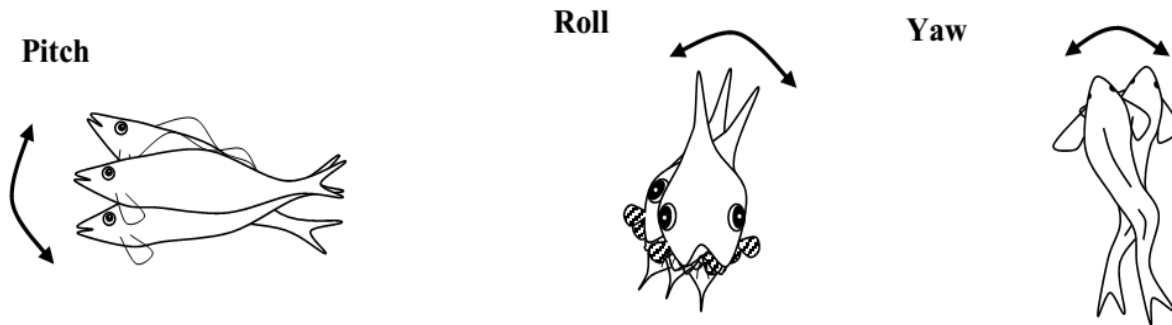
Type of fin	Function
Median fins (dorsal and ventral fins)	Control rolling and yawing by increasing vertical surface area.

Paired fins (pectoral and pelvic fins)	Control pitching and also act as breaks.
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Instabilities during fish locomotion

1. **Yawing**; this is the deflection of the head resulting from the propulsive action of the tail. It is prevented by dorsal and ventral fins
2. **Pitching**; this is the tendency of the head to plunge vertically downwards as the fish moves. This is prevented by pectoral and pelvic fins.
3. **Rolling**. This is the rotation of the fish about its longitudinal axis. It is controlled by median fins.

Illustrations of instabilities



LOCOMOTION IN MAMMALS

Mammals possess endoskeleton on which muscles are attached. The muscles pull on the skeleton to effect movement. The skeleton is made up bone and cartilage.

Differences between bone and cartilage

Bone	Cartilage
It is hard and compact due to hard ground tissue called collagen.	This is soft and flexible with chondrin ground tissue.
This consists of calcium and phosphorous salts	This has no salts
Long bones have marrows	No marrows.
Contain nerves	No nerves.
Contain blood vessels	No blood vessels
Occurs in adults	Occurs in fetus and some remain in adults
Bone cells are arranged in concentric layers around nerves and blood vessels	Cartilage cells are usually single or rows scattered in the ground tissue.
Rate of growth is slow	Growth rates are high.

Functions of mammalian skeleton

1) Support

The skeleton forms a rigid framework over which body organs are suspended e.g. the lungs, heart, intestines, kidney, bladder or else these organs would crush into one another and hence make the body shapeless.

2) Locomotion.

It provides surfaces for attachment of muscles to allow movement.

3) Protects delicate organs of the body.

Delicate parts of the body are protected by the skeleton. The skull protects the brain, inner ear and eyes. The vertebral column protects the spinal cord. The rib cage protects the heart, lungs and all organs in the thoracic cavity.

4) Stores calcium for usage in the body.

Calcium is an element that is added to cartilage to form bone. All bones contain calcium, which makes them strong. When calcium is needed in other areas, it can be obtained from the bones.

5) It is a site for manufacture of red blood cells and white blood cells. These cells are made in bone marrows.

6) It is used in breathing.

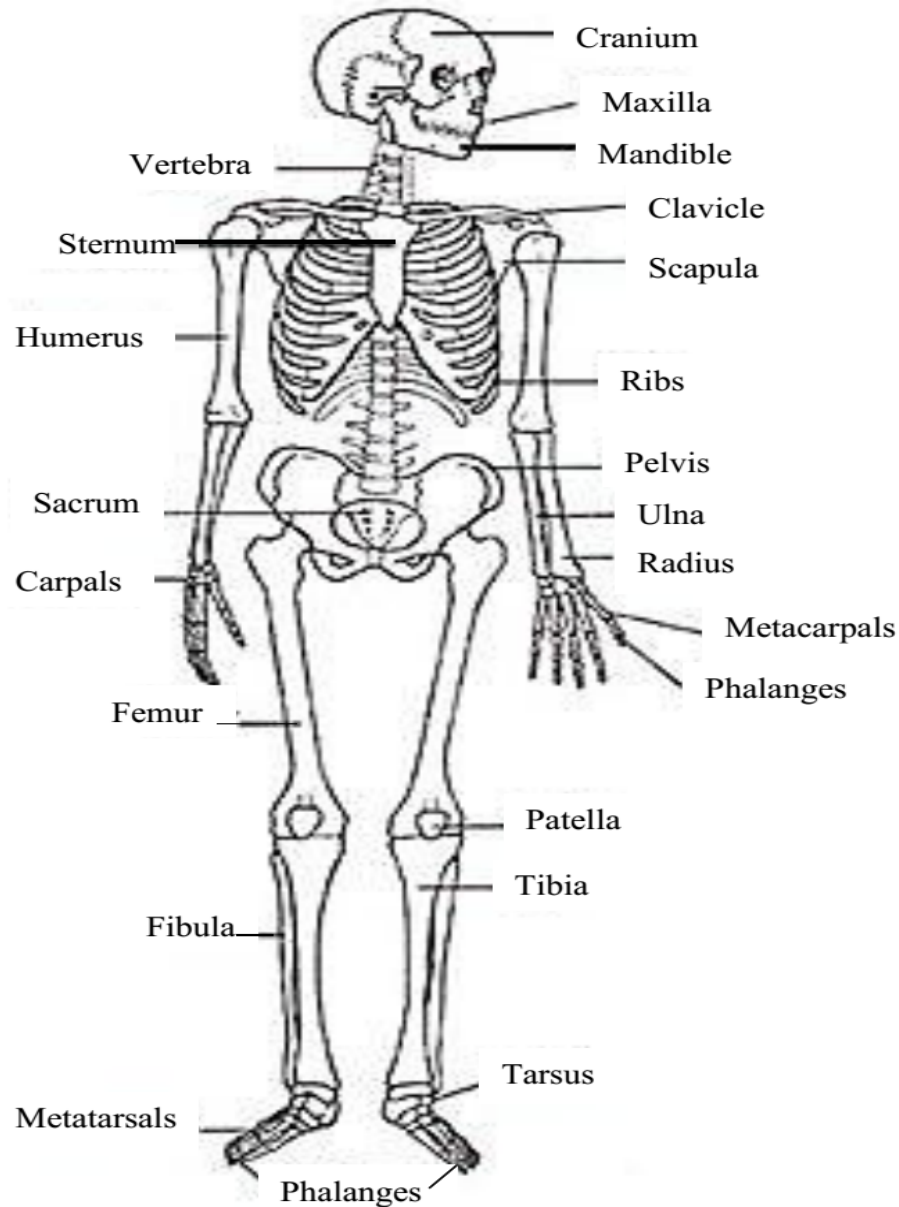
The rib cage adjusts the volume of the thoracic cavity during breathing.

7) It is used in transmission of sound by ear ossicles in the ear.

8) It is used in nutrition.

The teeth are bony structures, which help in tearing, grinding and cutting food.

Structure of the human skeleton



PARTS OF THE SKELETON

The skeleton consists of two major parts

1. The appendicular skeleton
2. Axial skeleton

AXIAL SKELETON

1. Skull

It is made of the brain box (cranium) and the upper jaw which together form the upper part. A cranium is made up of several flattened bones joined together by immovable joints called the suture joints. A cranium protects the brain eyes and inner ear.

2. Vertebral column

The vertebral column is made up of small bones called the vertebrae. Their number varies from one organism to the other. They are joined to one another by cartilage called inter vertebral disks which allow slight movement of the back.

Functions of the vertebral column

- i) It protects the spinal cord and allows for emergence of the spinal nerves.
- ii) It provides support to the head.
- iii) The joint between atlas and the skull allows slight movement of the head in a vertical plane.
- iv) Transverse processes provide points of attachment of tendon muscles, which straighten the back.
- v) The caudal vertebrae form the tail.

Types of the vertebrae

The vertebrae include:

Type of vertebra	Region of the vertebral column	Number in the human skeleton
Cervical vertebrae	Neck	7
Thoracic vertebrae	Thoracic region	12
Lumber vertebrae	Abdomen	5
Sacral vertebrae	Lower abdomen	5
Caudal vertebrae	Tail	4

Functions of parts of the vertebrae

- 1) **Centrum.** This is the lower part of the vertebra with a thick protective mass. It provides the main support of the backbone and allows articulation with other vertebra.
- 2) **Transverse processes.** These are projections on the sides of the neural arch. It provides surface for attachment of muscles. It also helps to articulate with ribs in the thoracic vertebra.
- 3) **Neural arch.** It is the ring of bone above the vertebra. It forms a bony tube that protects the spinal cord.
- 4) **Neural spine.** This is a pointed part or extension of the neural arch at the dorsal part.
- 5) **Neural canal.** It is the central hole that provides passage for the spinal cord.
- 6) **facets:** for articulation with other vertebra and ribs for the thoracic vertebrae
- 7) **Vertebral canal:** allows passage of the blood vessels.

THE CERVICAL VERTEBRA

These are found in the neck region. They are seven in number.

Characteristics of the cervical vertebrae

1. They have a pair of canals (openings) in the neural arch called vertebral canals through

which the neck vessels pass.

2. Their transverse processes are flattened and divide into two to form cervical ribs.
3. They have a short neural spine.
4. They have a large neural canal.
5. They have a small Centrum.

General functions of the cervical vertebrae

1. Supports the head region
2. Protects the blood vessels and the nerves that pass through them.
3. Support and protect the spinal cord.
4. Provides attachments to muscles of the head.

Drawing of the cervical vertebra (anterior)

The first cervical vertebra is the atlas and the second is the axis.

1. Atlas vertebrae (characteristics)

- ✓ Has no centrum
- ✓ Has very large neural canal
- ✓ Has a flat broad transverse process for muscle attachment
- ✓ Has two large facets for articulation with the skull base to permit the nodding movements of the head.
- ✓ Has a small rigid neural spine.

Structure of the Atlas

Front view

Side view

2. Axis (characteristics)

- ✓ Has a relatively small neural canal than the atlas.
- ✓ Has a large flat centrum that projects forward to form odontoids process that fixes in the neural canal of the atlas.
- ✓ Has a small transverse process
- ✓ Has two facets at the posterior part of the vertebrae called post zygapophysis for articulation with the atlas.

Lateral view of the axis

THORACIC VERTEBRAE

These are found in the chest region (thorax)

Characteristics

1. It has a large Centrum for articulation with ribs.
2. It has a large neural canal.
3. It has a long neural spine which projects upwards and backwards.
4. It has a pair of short transverse processes.
5. It has a pair of facets for articulation with other vertebra.
6. It has a large neural arch.
7. Has a pair of pre and post-zygapophysis for articulation with other vertebrae.

Structure of the thoracic vertebra (anterior view)

Adaptations to its functions

- ✓ Has a thick centrum to support upper body weight
- ✓ Has a long neural spine for attachment of thoracic muscles
- ✓ Have extra facets to articulate with the ribs
- ✓ Has a wide neural canal for accommodation of spinal cord.

Similarities between cervical and thoracic

- ✓ Both have a neural spine
- ✓ Both have a centrum
- ✓ Both have a neural canal
- ✓ Both have articulating facets

Differences

Cervical	thoracic
Short neural spine	Long neural spine
Has vertebrarterial canal	Lacks vertebrarterial canal
Has no notch	Has a notch
Transverse process divided	Transverse process not divided
Has no extra facet	Has extra facet

LUMBAR VERTEBRA

These are found in the abdominal region. They provide the only support for the trunk in the abdominal region. They are five in man.

Characteristics

1. They have long transverse processes facing forward for muscle attachment.
2. They have a broad neural spine.
3. Has a short flattened neural spine projecting forward
4. They have a large and thick Centrum than cervical and thoracic.
5. They have extra processes called metapophyses for muscle attachment of abdominal organs.
6. Has a prominent anterior facet.

Structure of the lumbar vertebra (anterior view)**Adaptations to its functions**

- ✓ Has a long and broad transverse process to increase surface area for attachment for the abdominal muscles.
- ✓ Has a short and broad neural spine for the attachment of muscles.
- ✓ Has a wide and thick centrum to support weight of abdominal organs.
- ✓ Has a thick neural arch for protection of the spinal cord.

Similarities between lumbar and cervical vertebrae

- ✓ Both have neural spine

- ✓ Both have a transverse process
- ✓ Both have a centrum

Differences:

Lumbar	Cervical
Long neural spine	Short neural spine
Transverse process not divided	Transverse process divided
Has no vertebrarterial canals	Has vertebrarterial canals
Has metapophysis and prezygapophysis	Lacks metapophysis and prezygapophysis.

SACRAL VERTEBRAE

This consists of 5 vertebrae in man and 4 in rabbits. In adult man they fuse together to form the sacrum that forms the base of the pelvis

Characteristics of the sacral vertebra

1. It has a narrow neural canal.
2. It has a small neural spine which is reduced to a small notch.
3. It has a large wing-like transverse process.
4. Each vertebra has a large Centrum.

CAUDAL VERTEBRAE

These decrease in size from the sacrum backwards and gradually lose their transverse processes, neural spine and facets. In man, the tail consists of four vertebrae called coccyx that do not protrude from the body.

Characteristics:

- i) Have no neural arch
- ii) Have no neural canal
- iii) Have no transverse process
- iv) Have no neural spine
- v) Their entire body consists of the centrum only.

APPENDICULAR SKELETON

This is the skeleton of limbs and limb girdles. There are four limbs and two girdles. i.e.

1. pectoral girdle(shoulder)
2. pelvic girdle (hip)

Functions of the limb girdles

1. It provides a connection between the Axil and the appendicular skeleton.
2. It provides stability of the body by separating limbs.
3. It provides a suitable surface for attachment of muscles that move the limb.

The pelvic girdle

It is made up of bone on either sides namely; Ilium, Ischium and Pubis.

The three bones are fused so tightly that their joints can't easily be observed thus they are collectively known as innominate bones.

Structure

Functions of the parts

1. Acetabulum: It provides a surface where the head of the femur articulates with the pelvic girdle.
2. Pubis symphysis: It joins the 2 pelvic girdles
3. Obturator foramen: It provides surface for attachment of muscles and passage for some nerves and blood vessels.

The pectoral girdle

It consists of mainly;

1. The scapular (shoulder blade)

This is a flat triangular shaped bone. It's anterior, with a hollow cavity called the glenoid cavity which articulates with the head of a humerus.

A scapular ridge spine runs across the outer surface of where powerful muscles are attached to.

Structure of the scapular

2. Clavicle (collar bone)

It consists of a lot of bones attached to a ligament joining the sternum to the end of the scapular ridge.

LIMB BONES

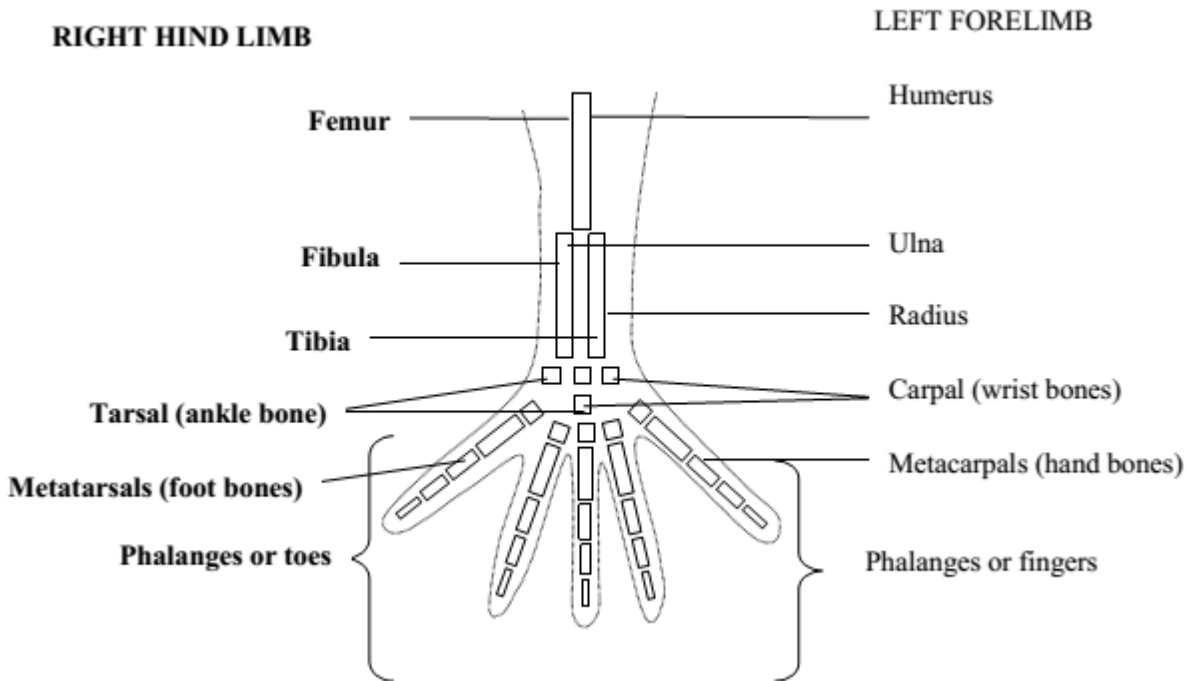
The mammalian skeleton has limb bones; the fore and hind limbs.

They are constructed with the same plan or arrangement known as the *pentadactyl plan*.

The limb consists of an upper long bone followed by a pair of long bones placed side by

side and a set of small bones. In 3 rows five thin long bones and finally 5 digits.

Structure of the pentadactyl limb



THE FORE LIMB

It consists of the upper arm, fore arm and the hand. The upper arm consists of a long bone called the humerus. The fore arm consists of the radius and ulna.

1. **Humerus:** it has a round head which articulates with a glenoid cavity of scapula. Its lower end is grooved to articulate with the radius and ulna.
2. **Radius:** it lies anterior to the ulna.
3. **Ulna:** it is longer than the radius at the elbow. It projects back ward to form olecranon. The tip of olecranon forms a joint with the humerus and so prevents the joint from being straightened.

HIND LIMB

It consists of the thigh, shank and the foot. The thigh is made up of the tibia and fibula.

1. Femur:

The proximal end is rounded to form the head which articulates with the acetabulum of the pelvic girdle to form a ball and socket joint. Near the head, there are three projections called trochanters which are points for attachment of some muscles.

At the distal (lower end) the femur has 2 rounded knobs called the condyles separated by a groove which articulates with the tibia.

Structure of the femur

2. **Tibia:** The proximal surface of the tibia is shaped into 2 shallow oval hollows which fit the condyles of the femur.
3. **Fibula:** This is a small bone which lies outside to the tibia and it's joined to it at the distal end.

JOINTS

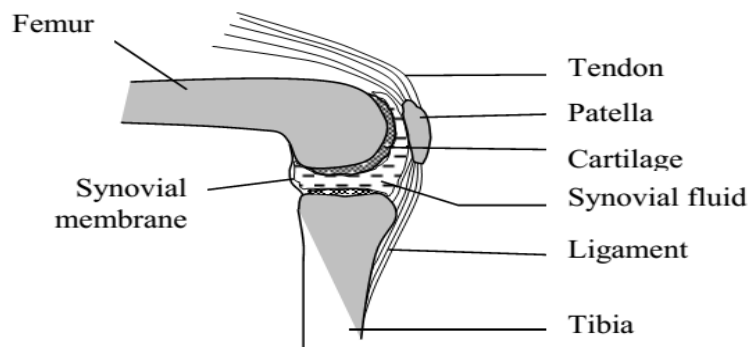
A joint is a place where two or more bones meet. The bones are connected together by ligaments to allow movement.

Types of joints

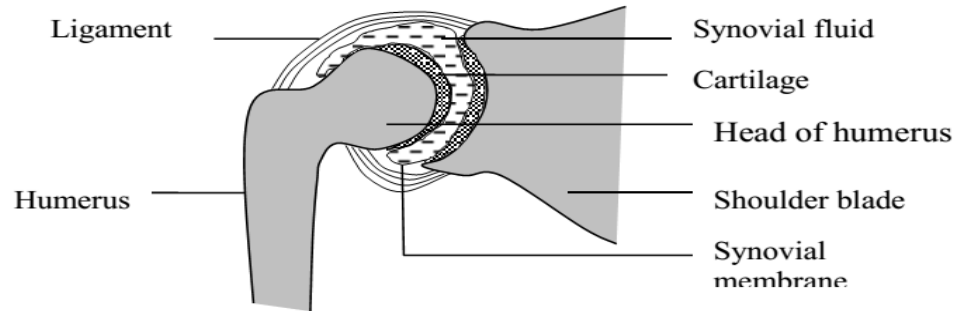
Joints are classified according to the degree of movement into the following categories.

1. **Immovable joints:** These are joints where no movement is possible for example the joints in the skull (sutures).
2. **Movable joints:** These are joints, which allow some degree of movement. They are also called synovial joints. The movable joints are further divided into the following types.
 - i) **Sliding joints.** These are joints, which allow bones to slide over one another for example in the wrist and ankle.
 - ii) **Pivot joints.** These allow rotation of one bone over the other for example between the axis and atlas of the vertebral column.
 - iii) **Hinge joint.** This allows movement in one plane for example in the elbow of the hand, in the knee, fingers and between the jaw and skull.
 - iv) **Saddle joints:** it allows twisting movements i.e. rotation of each bone between 2 axis e.g. the radius and ulna.
 - v) **Ball and socket joint:** this allows movement in all directions. The hip and shoulder joints are ball and socket joints.

Structure of a hinge joint at the knee



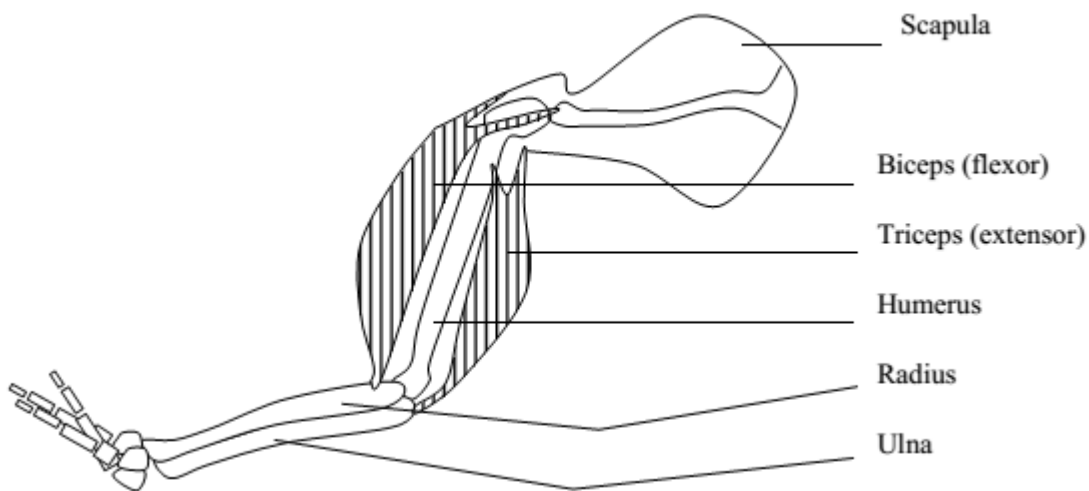
Structure of the ball and socket joint at the shoulder



Parts of the joint

1. **Ligament.** This is a tissue that connects a bone to another bone.
2. **Tendon.** This is a tissue that connects a muscle to a bone.
3. **Cartilage.** This is a tissue that encloses the ends of bones at the joints. It prevents articulating bones from wearing out due to friction. It also acts as a shock absorber.
4. **Synovial cavity.** This is located between two surfaces of articulating cartilage. It is surrounded by a synovial membrane that encloses the synovial fluid.
5. **Synovial fluid.** This acts as a lubricant during movement. Damage of a joint causes excess synovial fluid to be formed and the synovial cavity bulges causing a swelling in the joint.

Movement of the arm at the elbow



The contraction of the biceps (flexor) muscle pulls the radius, which causes the arm to be raised. This causes the elbow to bend (flex) hence the bending of the whole arm. When the triceps (extensor) muscle contracts, it pulls the ulna thus straightening the arm.

MUSCLES

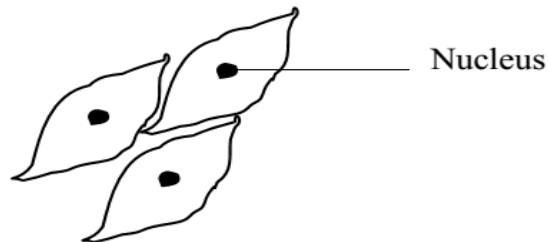
Muscles are bundles of elongated cells enclosed in a sheath of connective tissue. When stimulated, the muscles contract to shorten e.g. during locomotion or peristalsis.

Types of muscles

1. Smooth muscle/involuntary muscle.

This has spindle shaped cells held together by connective tissue. They are called involuntary muscles because the individual cannot have conscious control over them. The cells have one nucleus each. This muscle is located in the alimentally canal, reproductive organs, among other areas.

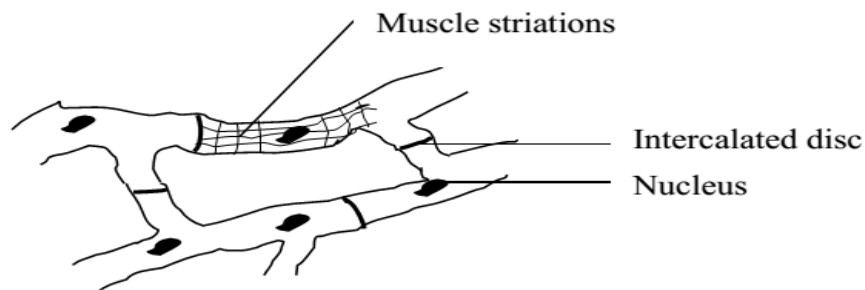
Structure of a smooth muscle



2. Cardiac muscle.

This is located in the walls of the heart. The cardiac muscle contracts without fatigue and its contractions are not initiated by the nervous system. Their contractions are described as myogenic that is the contractions arise from the heart muscle itself. The cardiac muscle has striations (strips). One cardiac muscle is connected to another via a strip of cartilage called **intercalated disc**.

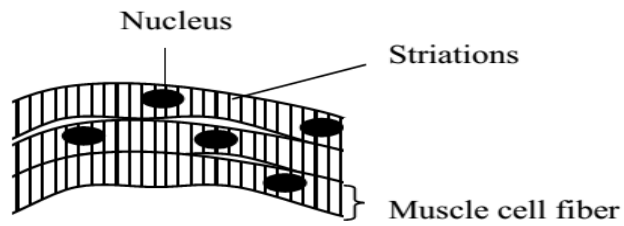
Structure of a cardiac muscle



3. The skeletal muscle.

This consists of elongated cylindrical and striated (striped) cells. It is attached to the skeleton by tendons and is responsible for voluntary movements. The cells occur in bundles surrounded by a connective tissue. Many bundles are enclosed by a tough connective tissue to form muscles such as biceps and triceps. The cells in the skeletal muscle are made up of more than one nucleus that is they are multinucleated.

Structure of the skeletal muscle



Most muscle cells are arranged in pairs where one moves in opposite direction to the other. When one contracts, the other relaxes. These muscles contract antagonistically.