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 crowling
- ✓ By walking
- ✓ By flying
- ✓ By creeping

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

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

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 of bones.

Types of skeleton

There are three types of skeleton.

i) endoskeleton

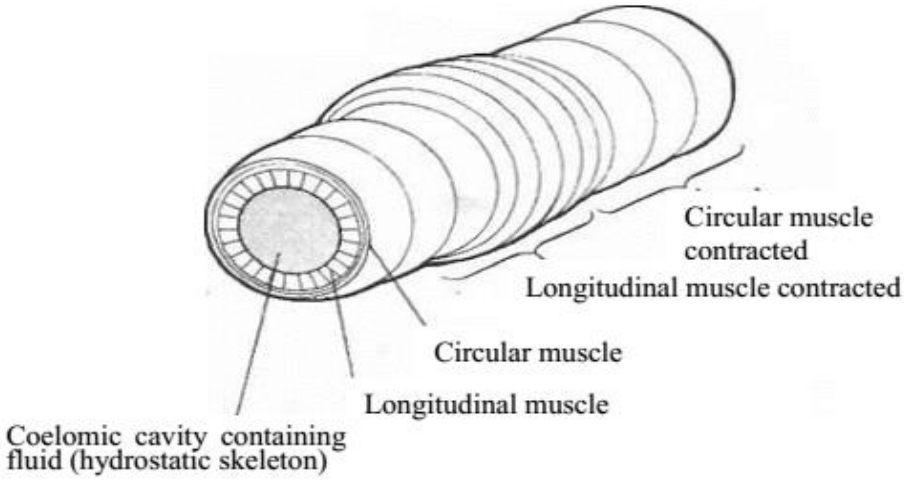
ii) exoskeleton

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 shade 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.

Ossification is the process through which cartilage changes to bones. Bone is harder and inelastic and is made up of living cells and nonliving material of calcium phosphate and calcium carbonate.

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

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 like in ducks
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 **flexo**r 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 move 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

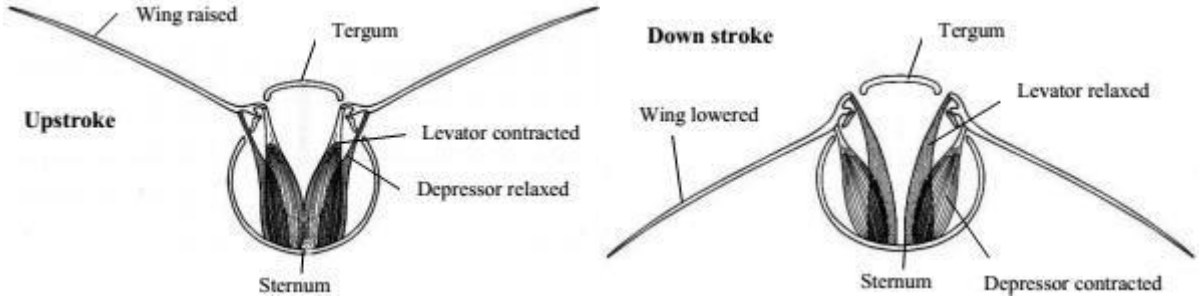
During the upward stroke:

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



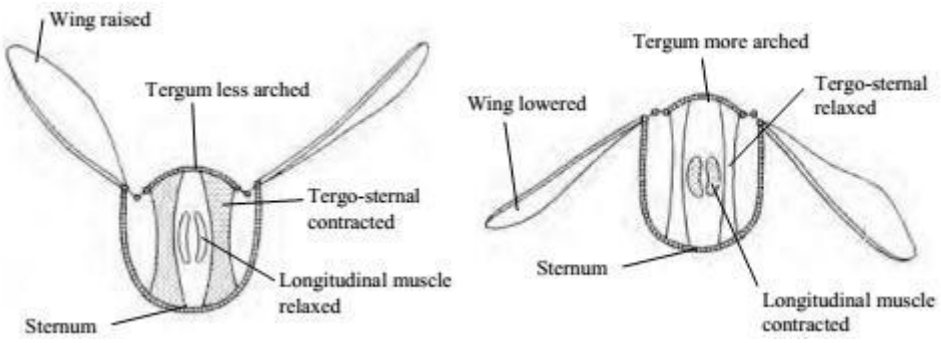
FLIGHT USING INDIRECT FLIGHT MUSCLES

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 down wards.
- ✓ 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.



LOCOMOTION IN BIRDS

Some birds like ostriches, kiwi, and emu 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.

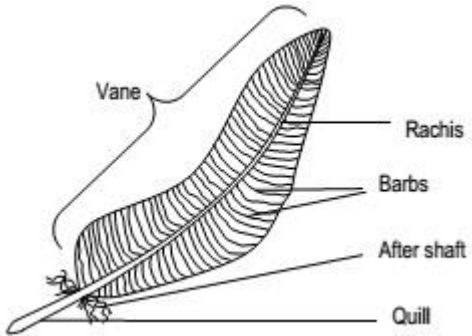
FEATHERS

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.

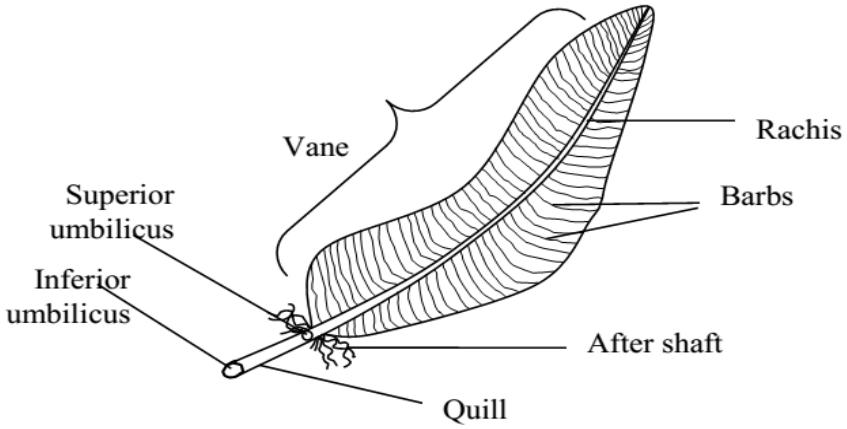
Characteristics

- ✓ 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.
- ✓ Has a smooth vane to provide a stream lined body which reduces friction during flight.

2. The covert feather

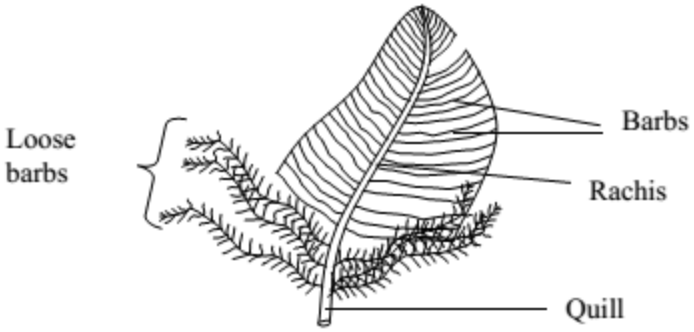
Location: These are found around the neck and the upper side of the body

Characteristics:

- ✓ It is smaller than the quill feather.
- ✓ It has a large aftershaft.
- ✓ 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

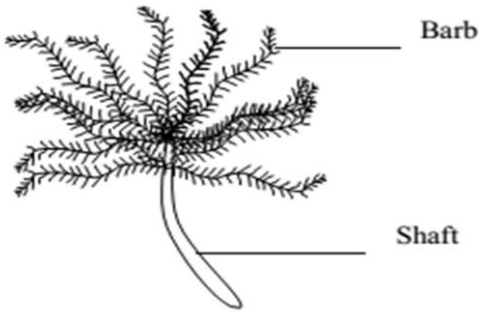
Location: These are found allover the body especially on the abdomen and between covert and flight feathers.

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

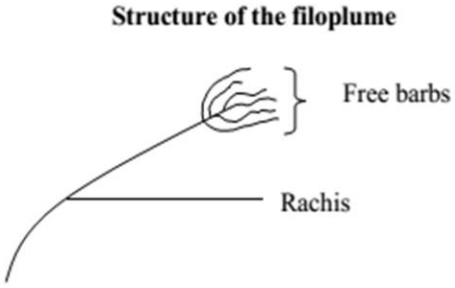


4. Filo plumes

Location: These are found sparsely distributed allover 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.

FLIGHT IN BIRD

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 losses height. It is usually used when the bird is going to land.

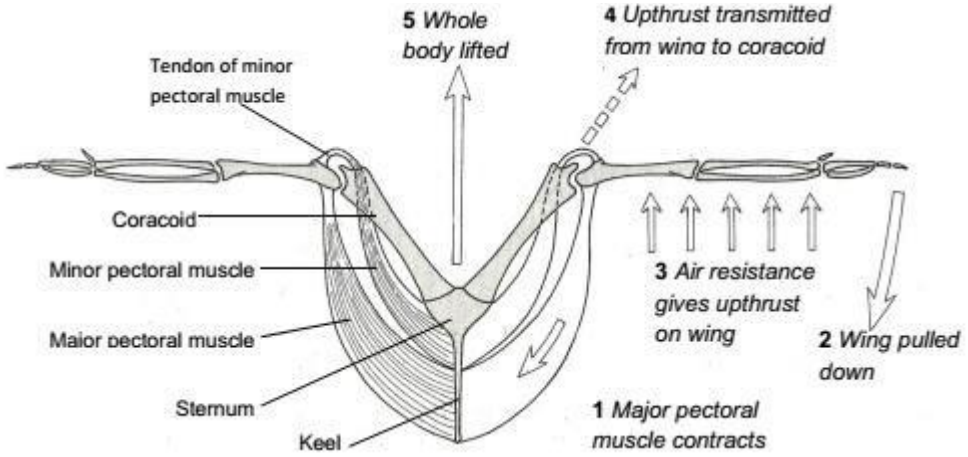
3. Soaring.

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 aero foil.

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

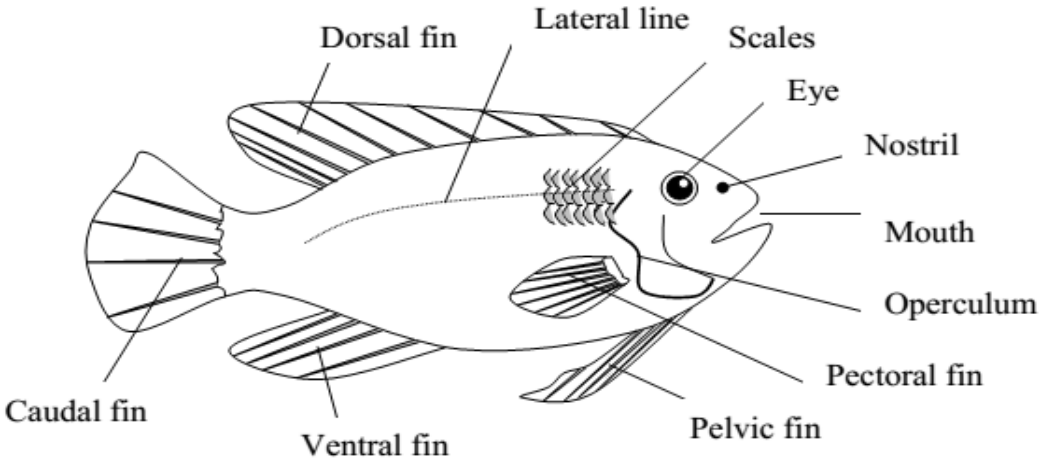
Fish move by swimming in water

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 Carbon dioxide 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.

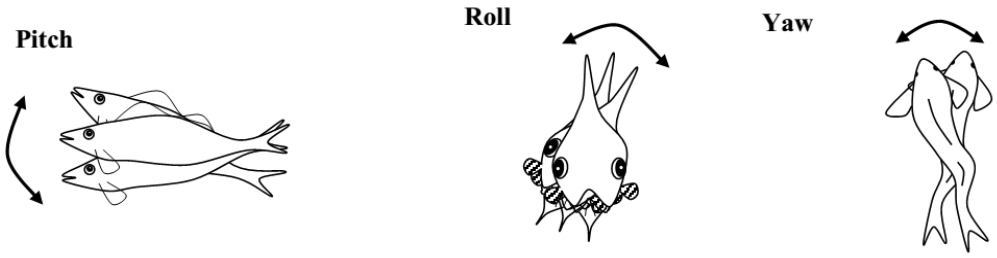
1. **The paired fins**; these include pectoral and pelvic fins which are used for steering and balancing to control pitching
2. **The median fins**; these are unpaired fins. They include dorsal and ventral fins. These control rolling and yawing by increasing vertical surface.

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.

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

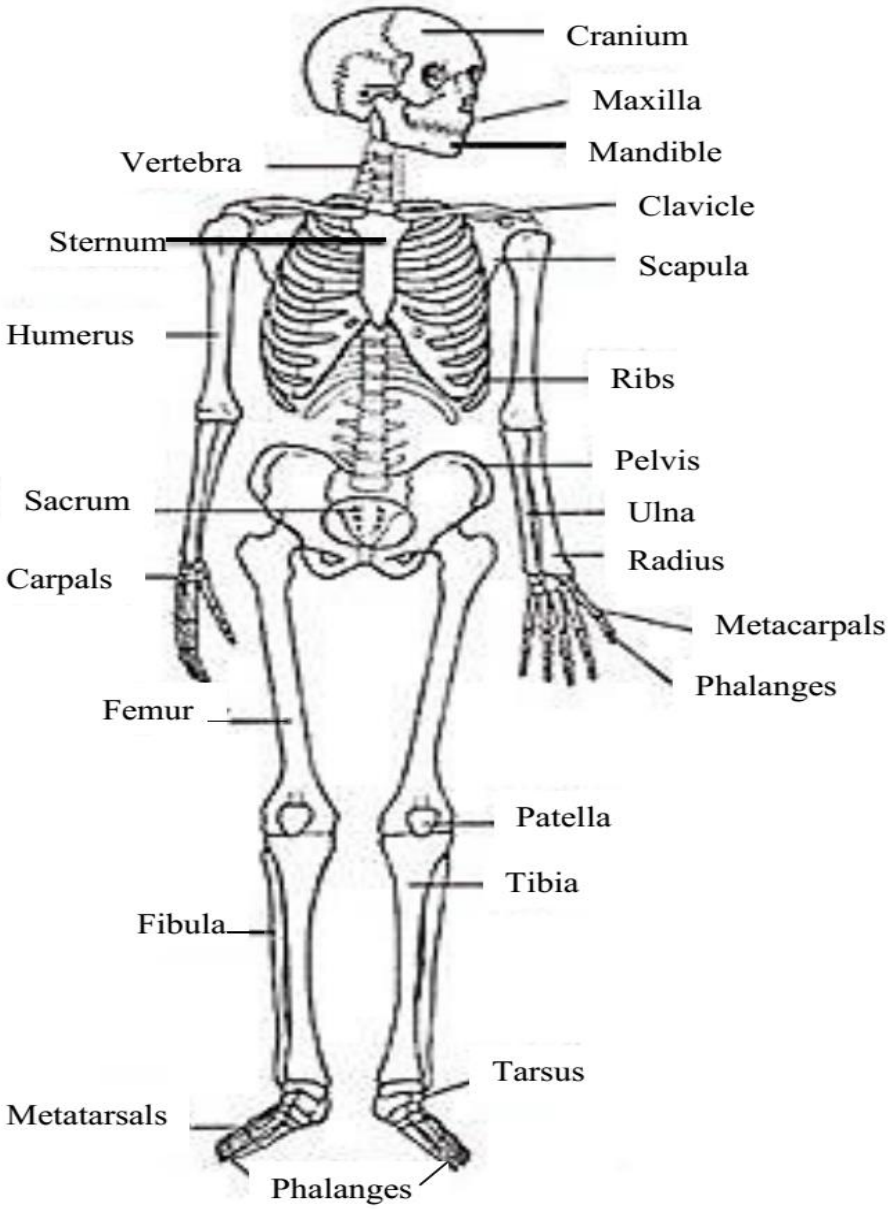
Bone	Cartilage
It is hard and compact due to hard ground tissue called collagen.	This is soft and flexible with chondrin ground tissue.

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.

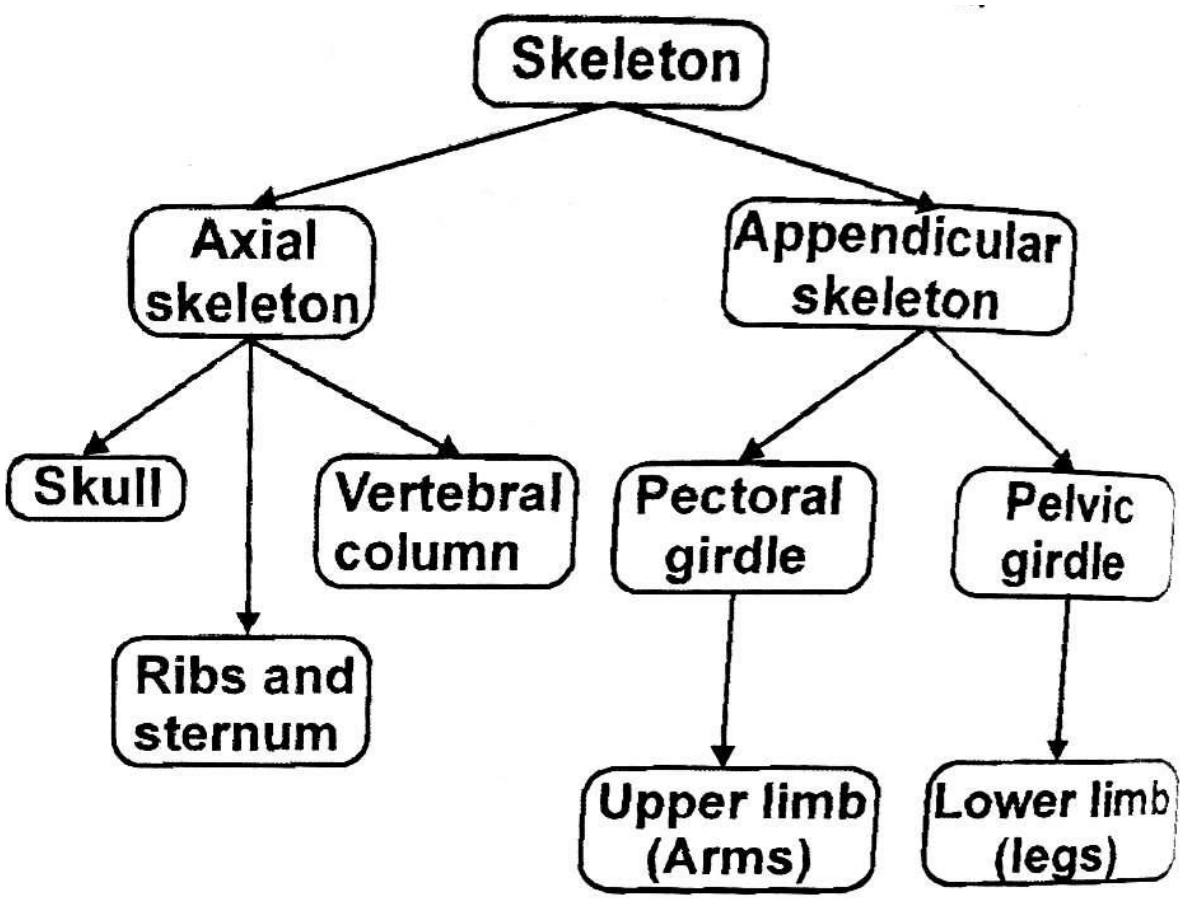
Functions of mammalian skeleton

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.

The lower part is made up the lower jaw. The upper and the lower parts are joined by strong muscles which allow movement of the joints.

The lower and the lower jaws are made up of flattened bones called palate.

Vertebral column

The vertebral column is made up of smalls bone 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 bark.

Functions of the vertebral column

1) It protects the spinal cord and allows for emergence of the spinal nerves.
2) It provides support to the head.
3) The joint between atlas and the skull allows slight movement of the head in a vertical plane.
4) Transverse processes provide points of attachment of tendon muscles, which straighten the back.
5) 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 bonny 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) Vertebraterial canal: allows passage of the blood vessels.

THE CERVICAL VERTEBRA

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

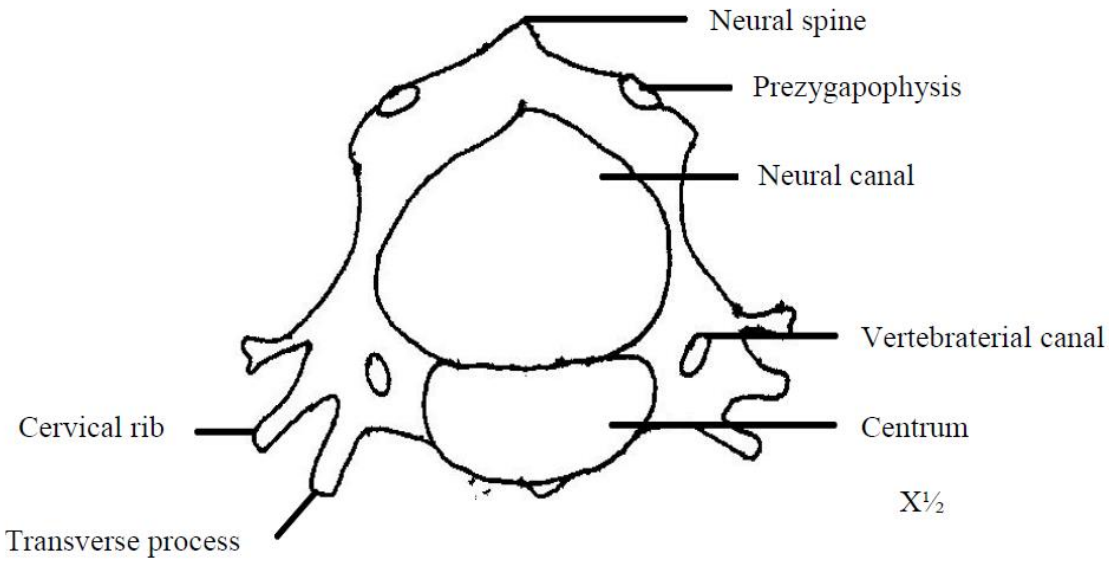
Characteristics of the cervical vertebrae

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 anterior view of cervical vertebra



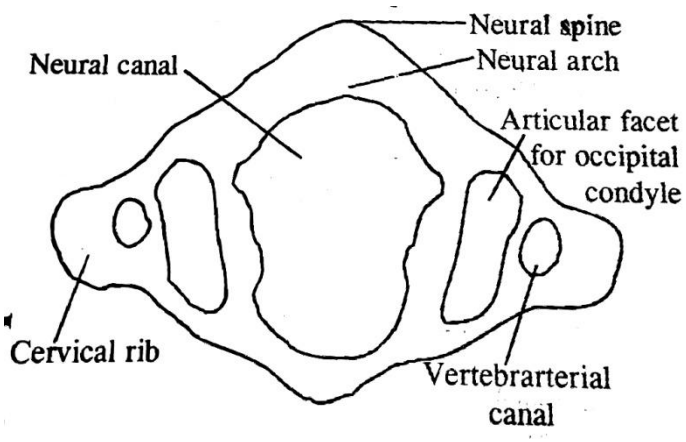
The first cervical vertebra is the atlas and the second is the axis.

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

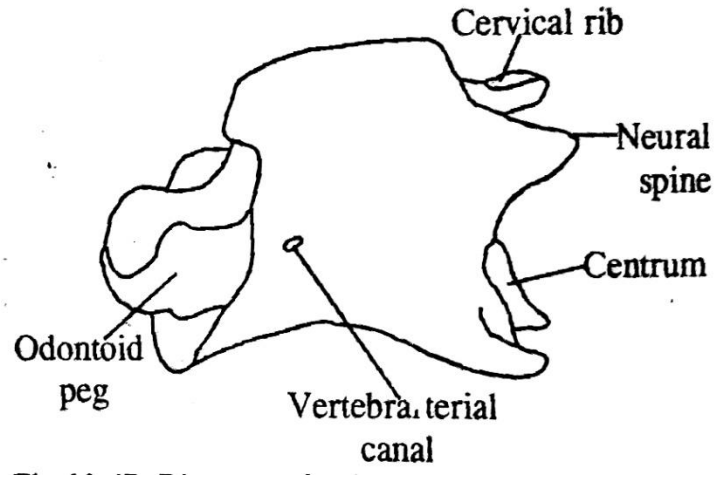
Front view



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



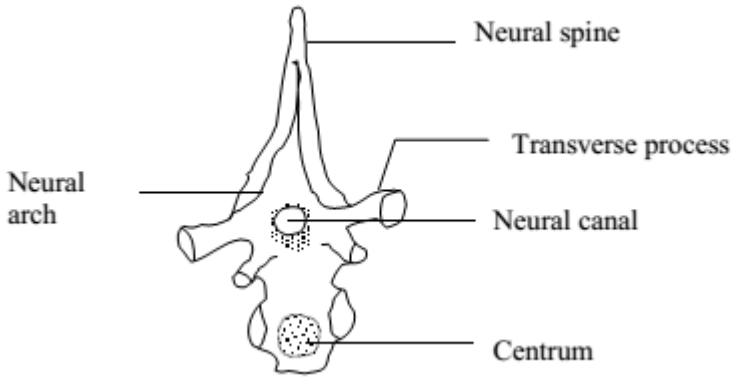
THORACIC VERTEBRAE

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-zygophysis 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 vertebraterial canal	Lacks vertebraterial canal
Has no notch	Has a notch
Transverse process divided	Transverse process not divided
Has no extra facet	Has extra facet

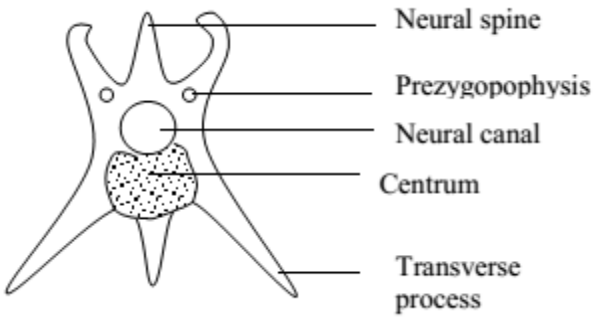
LUMBAR VERTEBRA

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 vertebraterial canals	Has vertebraterial canals
Has metapophysis and prezygapophysis	Lacks metapophysis and prezygapophysis.

ASSIGNMENT: *compare and contrast the lumbar and the thoracic.*

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.

Structure of the sacral vertebrae

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) There 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;

i) Illium
ii) Ischium
iii) Pubis

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

Functions of the parts

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

The pectoral girdle

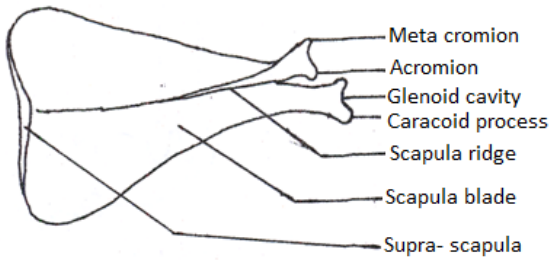
It consists of mainly;

1. The scapular (shoulder blade)

This is a flat triangular shaped bone. It's anterior, with a hollow cavity called the glonoid cavity which atticulates with the head of a humerous.

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

Structure of the scapular



2. Clavicle (colar bone)

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

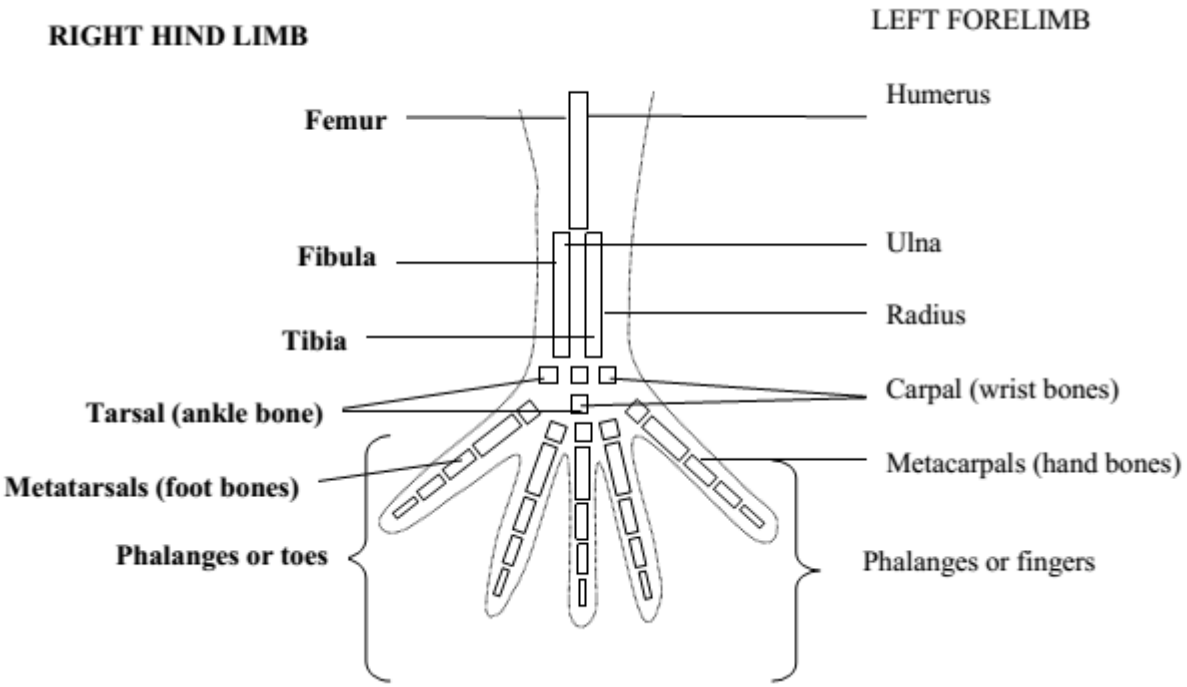
LIMB BONES

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



2. Axil skeleton.

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 glonoid cavity of scapular. It's 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

If 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 trachantes which appoints 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.

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.

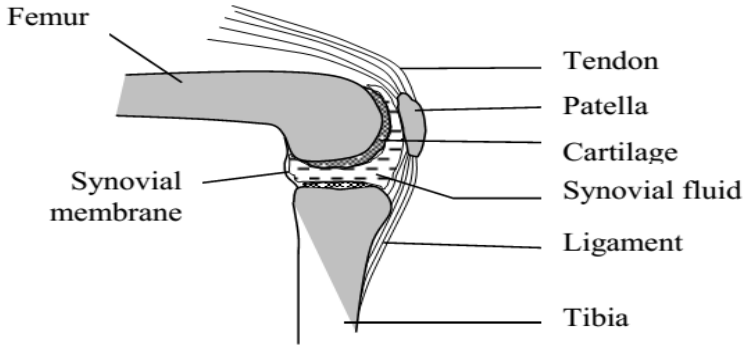
ii) **Pivot joints.** These allow rotation of one bone over the other for example between the axis and atlas of the vertebral column.

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.

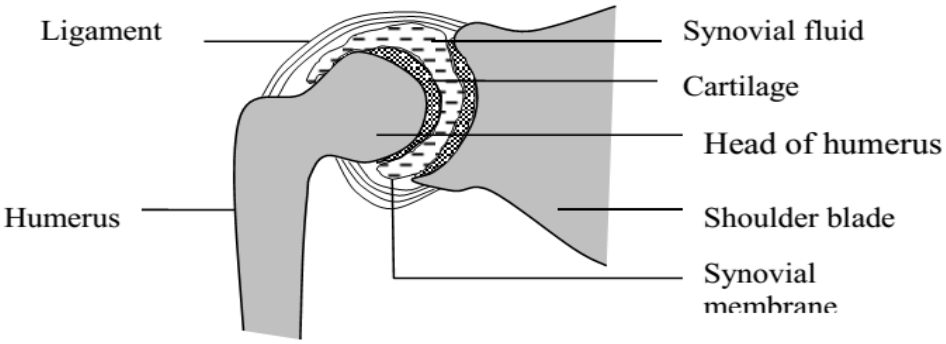
iv) **Saddle joints:** it allows twisting movements i.e. rotation of each bone between 2 axis e.g. the radius and ulna.

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



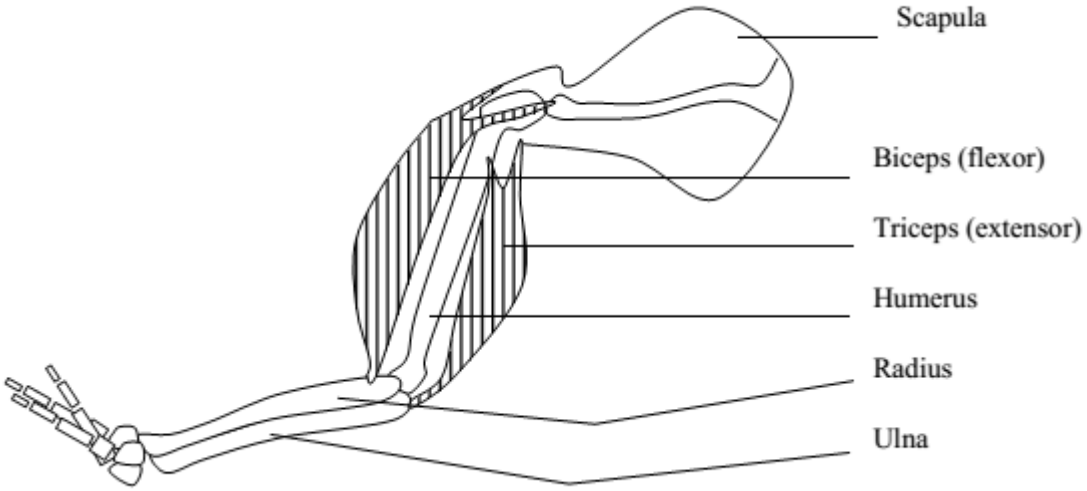
Structure of the ball and socket joint at the shoulder



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

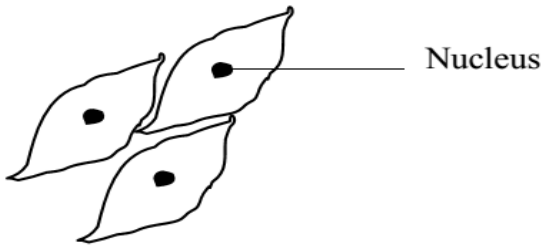
Muscles are bundles of elongated cells enclosed in a sheath of connective tissue. When stimulated, the muscles contract to shorten e.g. during locomotion or peristalsis.

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.

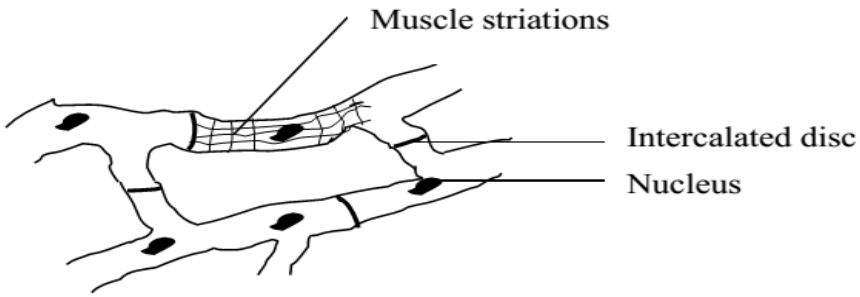
Structure of a smooth muscle



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**.

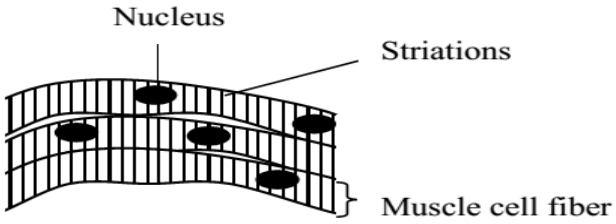
Structure of a cardiac muscle



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.

GROWTH AND DEVELOPMENT

Growth is defined as an irreversible or permanent increase in the size and dry weight of an organism. Growth in multicellular organisms is divided into 3 phases.

1. **Cell division**

This involves increase in the number of cells mainly as a result of mitosis.

2. **Cell expansion**

This is the permanent increase in the cell size as a result of uptake of water or synthesis of living materials.

3. **Cell differentiation**

This involves specialization of cells to suit particular functions. Growth is usually accompanied by an increase in the complexity of an organism which is also called **development.**

Development is the increase in complexity and change of form of an organism.

FACTORS AFFECTING GROWTH

A. External factors

i) Nutrients

Growth of an organism increases in the availability of nutrients and decreases when nutrients are in short supply. This is because nutrients are used in the building up of new protoplasm and organic matter. Also nutrients can be oxidized to provide energy required for growth. Therefore lack of nutrients can lead to decrease in growth or even death.

ii) Accumulation of the by products of metabolism (excretory substances):
Growth may be inhibited by metabolic waste products which are toxic to the body cells. Fortunately most plants and animals are not affected much because they can convert these substances to less toxic excretions.

iii) Temperature:
Growth depends on bio-chemical reactions which are catalyzed by enzymes. Temperature affects growth by affecting enzymes which catalyzes the chemical reactions in the body. Increase in temperature to the optimum increases the rate of growth, beyond which retardation of growth occurs.

iv) Light:
In plants, light affects growth by affecting the rate of photosynthesis which adds more organic matter to the plant. Therefore increase in light intensity in green plants increases the rate of growth and decrease in light intensity decreases the rate of growth.

v) PH:
The PH affects the activity of enzymes which catalyzes reactions in the body. This can result into decrease in growth of an organism.

vi) Carbon dioxide:
In animals, carbon dioxide is a waste product of metabolism. If allowed to accumulate, it can lead to a decrease in the rate of growth while in plants carbon dioxide is a raw material for photosynthesis therefore increase in carbon dioxide concentration increases the rate of growth.

B. Internal factors

i) Hormones:
In animals, the presence of growth hormones and thyroxin in blood increases the rate of growth while in plants the presence of auxins also increases the rate of growth.

ii) Hereditary factors:
Growth is under the control of genes which determines the particular size of an organism.

GROWTH AND DEVELOPMENT IN PLANTS

In plants, growth is continuous processes which occurs mainly at the tips of the root and shoot systems. These regions are called **meristems.** ***A meristem*** *is a group of undifferentiated plant cells which are capable of dividing repeatedly by mitosis.*

Types of meristems

i) Apical meristems
They are located at the tip of roots and shoot. They bring about increase in length or height of the plant. This type of growth which involves increase in length or height of a plant is known as **primary growth.**

ii) Lateral meristems

These are laterally situated in the stems and roots of the dicot plants. It brings about **secondary growth** after primary growth. Secondary growth (secondary thickening) involves increase in girth/thickness in a plant.

Lateral meristems are of 2 types namely:

a) Cork cambium; which forms the secondary cortex
b) Vascular cambium; which gives rise to the secondary phloem and xylem tissues.

SEED GERMINATION

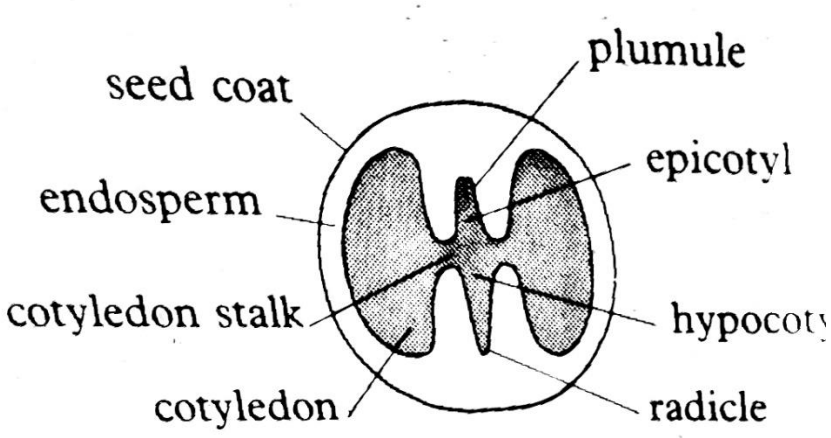
***This is defined as the emergence and development of an embryo into a seedling capable of existing as a new and independent plant under favorable conditions*.**

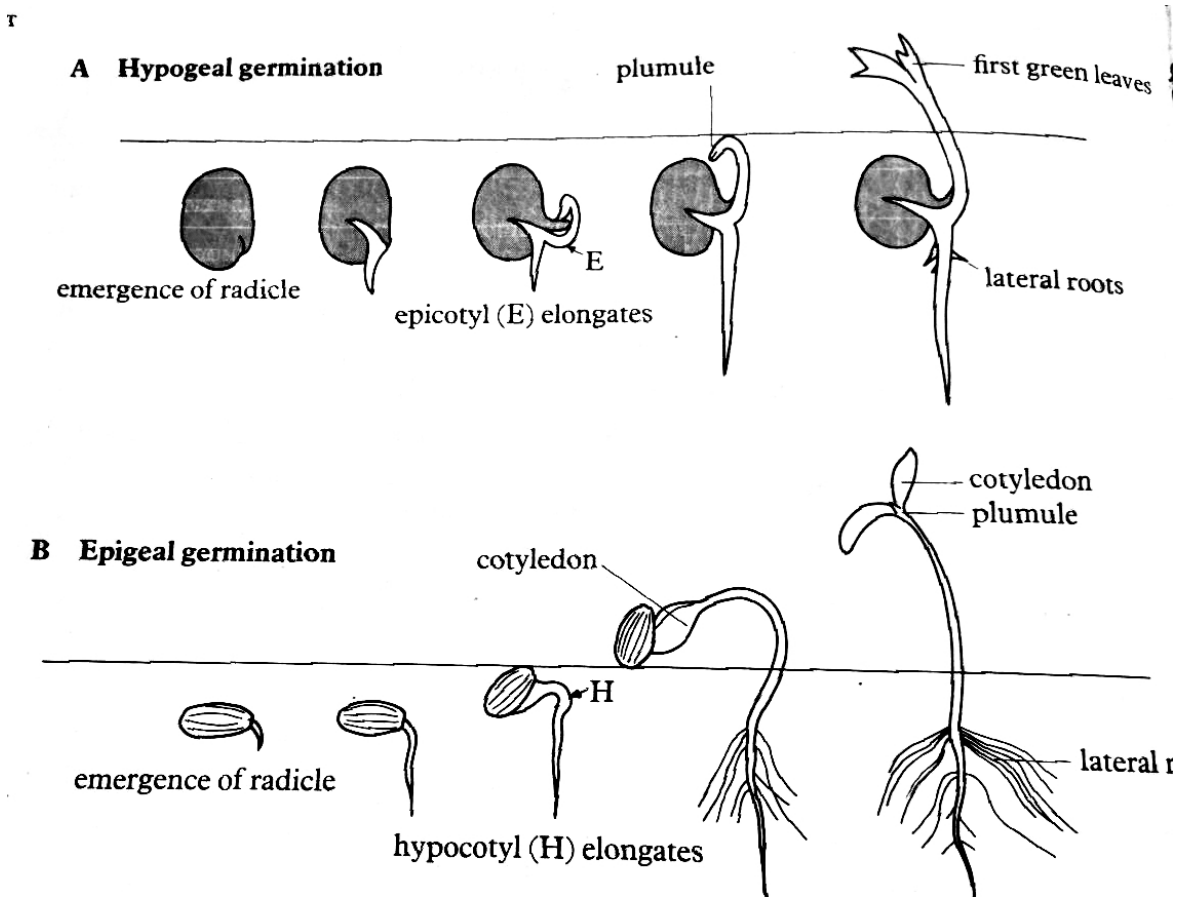
The process of germination

During germination, a seed absorbs water from the soil by imbibition mainly through the micropyle which makes the cotyledons swell and split the testa. The water enables the enzymes in the cotyledons to hydrolyze the stored food into soluble products which are later used by the germinating seed.

The enzymes involved in hydrolysis include diastase, protease and lipase. The soluble food substances diffuse into the cell where it is required for the growing embryo. Simple sugars and fats are oxidized to produce energy. Amino acids are used to make protoplasm of new cells. Absorption of water from the soil results into increase in the size of the seed and growth of the radicles and plumule which brings about rapturing of the seed coat and an embryo emerges.

TYPES OF GERMINATION





1. Epigeal germination:

In this type of germination, the ***cotyledons appear above the ground due to the rapid elongation of the hypocotyl*** (i.e. the portion of the stem below the cotyledons) e.g. in tomatoes, beans, cotton, lettuce.

During epigeal germination the seed absorbs water through the micropyle in a process called imbibition. This softens the testa and makes the cotyledons to swell. The testa splits to allow the radicle and plumule to emerge. The water hydrolyses the stored food reserves and the products are passed from the cotyledons to the radicle and plumule where they are used for growth. The radicle emerges first and the hypocotyls start to elongate pushing the cotyledons upwards. The cotyledons may turn green in some plants and can carry out photosynthesis. The cotyledons open to allow out the plumule. The leaves are formed and they start to photosynthesize.

2. Hypogeal germination:

In this type of germination, the ***cotyledon remains below the ground due to the rapid elongation of the epicotyl*** (i.e. the portion of the stem above the cotyledons) e.g. in broad bean, peas and maize.

During hypogeal germination, the seed absorbs water by imbibition. The radicle appears first bursting its protective sheath called coleorhizae. The radicle produces fibrous roots, which absorb water and anchor the plant. The protective plumule sheath (coleoptiles) opens to allow the plumule out. The epicotyls elongate pushing the cotyledons below the ground.

Conditions necessary for seed germination

1. Water

Water is needed for the following:

- It activates the enzymes within the seed to hydrolyze the stored food.
- It makes the seed swell, soft and the testa to bursts.
- It dissolves the stored food.
- It is a medium in which all the chemical and enzymatic reactions proceed.
- It is a medium of transport of the dissolved food substances to the developing shoot and root of the new plant.
- Water is needed for the development of cell vacuoles. Large cell vacuoles contribute to increase in size of cells.

2. Oxygen

Oxygen is necessary for the process of respiration, the oxidation of food to provide energy required for growth.

3. Warmth

Suitable temperature is important for the enzyme controlled reactions in the cotyledon of the germinating seed. At low temperatures, the enzymes are inactive and at high temperatures, they are denatured hence no germination. Germination will require an optimum temperature which varies from 10℃-50℃ for most tropical seeds.

EXPERIMENTS ON GERMINATION

An experiment to demonstrate the conditions necessary for germination

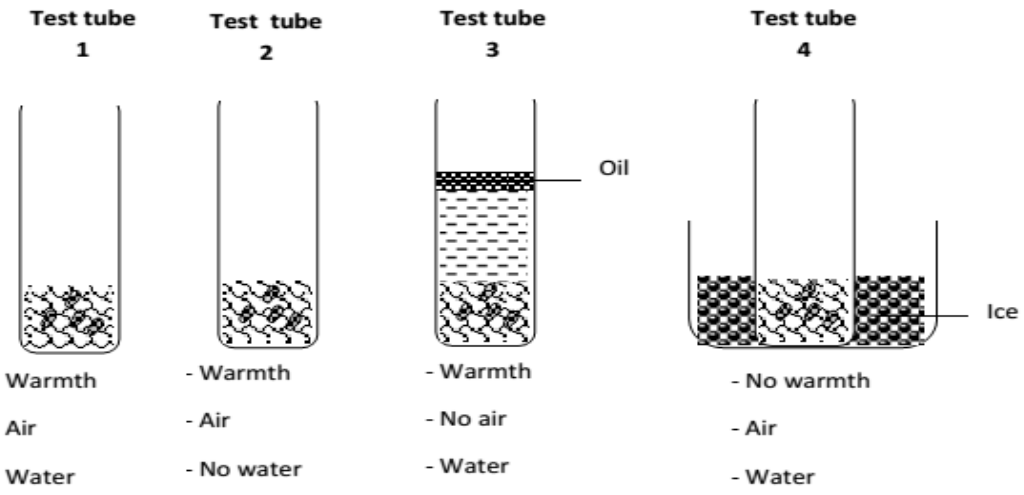
Apparatus:

4 test tubes, Cotton wool, Seeds, Oil and Water.

Procedure:

a) Arrange four test tubes labeled 1-4
b) To test tube 1 add moist cotton wool, seeds and leave test tube open.
c) To test tube 2 add dry cotton wool, seeds and leave test tube open.
d) To test tube 3 add seeds, boiled cooled water and a layer of oil.
e) To 4 add seeds, moist cotton wool, ice and leave test tube open. Leave all test tubes for 3 days.

Setup:



Observations

Seeds germinated in only test tube 1 and those in 2, 3 and 4 did not germinate.

Conclusion:

Air, water and warmth are necessary for germination.

Experiment to show that oxygen is necessary for germination

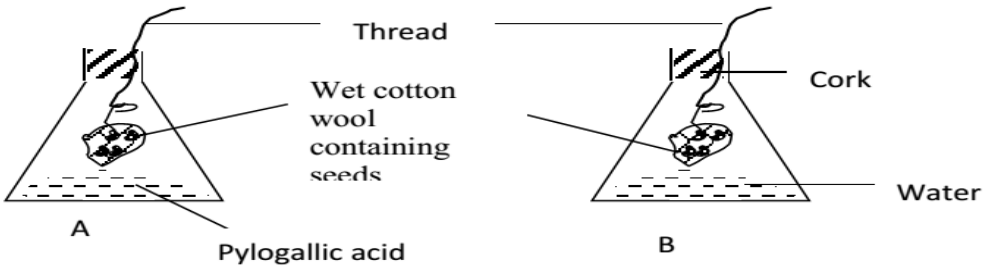
Apparatus:

2 conical flasks, 2 corks, Water, Cotton wool, Seeds and Pyrogallic acid.

Procedure:

- ✓ 1. Pour some water in one conical flask and some alkaline pyrogallol in another conical flask.
- ✓ Tie some seeds in wet cotton wool and suspend the cotton wool in the flasks using a thread.
- ✓ Fix the threads using a cork.
- ✓ Leave the set up for three days

Set up:



Observation:
After a few days the seeds in B germinated while those in A did not germinate.

Conclusion:

Oxygen is necessary for germination.

Explanation:
Alkaline pyrogallol absorbs oxygen from air in flask A thereby preventing germination.

SEED DORMANCY

Seed dormancy is the condition where by viable seeds fails to germinate under certain conditions or resting stage.

Causes of seed dormancy

1. **Immature embryo of the seed**

This may cause dormancy in seed germination since the embryo may undergo development before germination occurs.

2. **Presence of germination inhibitors**

Some chemical substances like acids do not promote germination of seeds when present. They destroy the enzymes.

3. **Extreme temperatures**

These greatly offect the function of enzymes in the seed. High temperatures denature enzymes while low temperatures inactivate them.

4. **Presence of hard impermeable seed coat**

Some seeds have a strong seed coat that does not allow water and gases to enter the seeds. Without water and gases, germination will not take place.

5. Dryness of soil and lack of sufficient oxygen enough for seeds.

If oxygen is absent, seed respire anaerobically and obtain less energy. This will not allow seeds to germinate.

Ways of breaking seed dormancy

1. Harvesting mature seeds. This involves allowing embryos in seeds to develop up to maturity for certain period called ***after-ripening period.*** This allows the seed to develop fully.
2. By providing growth promoters which deactivate germination inhibitors. These are chemical substances that can make inhibitors less acive. They contain nutrients or hormones for proper growth.

3. By exposing seeds to a cool period or chilling to initiate germination. This is common method of breaking seed dormancy in cereals.

4. By providing suitable conditions of oxygen, temperature and moisture which favour germination.

5. Removing the hard seed coat by:

- Soaking seeds in water to soften it.
- Action of fire to burn away the seed coat.
- Passing seeds through animal gut.
- Churning seed coat in concentrated acids.

Physical removal of the seed coat by using the hand or pricking or by action of bacteria in the soil.

Importance of seed dormancy

i) It prevents seed germination in unfavorable conditions e.g. seeds dispersed in winter remain dormant in summer.

ii) It improves the chances of seedling to grow to maturity during favourable conditions.

iii) Dormant seeds can be stored for a long time and the seed dormancy can be broken by giving artificial conditions. This helps in their transportation.

iv) It reduces the risk of seeds being frozen to death during unfavorable conditions.

MEASUREMENTS OF GROWTH

Measurement of growth involves the use of fresh weight and dry weight of a seedling.

1. Fresh weight/mass:

This is the total amount of organic matter and water in an organism.

Advantages of measuring growth by using the fresh weight of an organism

- It does not involve the killing of the organism.
- It is a very method of determining growth.
- It is the most suitable method of determining growth of seedlings.

Disadvantages of measuring growth by measuring the fresh weight of an organism

- It is less accurate since the biggest part of an organism is water.
- It is not reliable because the mass keeps on fluctuating due to water loss by transpiration and evaporation.

2. Dry weight/mass

This is the total amount of organic matter making up the body of an organism after removing water. It involves heating of an organism in an oven to a constant weight.

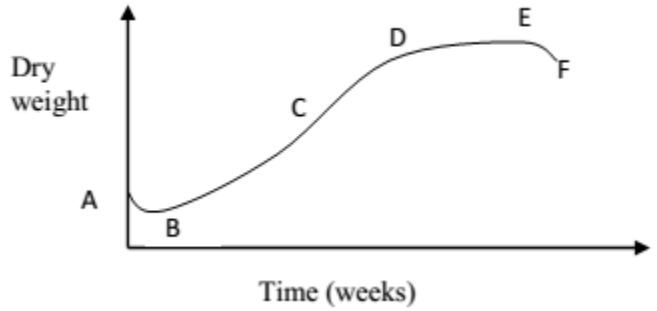
Advantages

- ✓ It is a more accurate method of determining growth.
- ✓ It is reliable because constant results are obtained.

Disadvantages

- ➢ It involves killing of an organism.
- ➢ The volatile tissues may decompose before removing all the water.

CHANGES IN DRY WEIGHT OF A GERMINATING SEED



Description and explanation of the graph:

From point **A-B**, the dry weight of the seed decreases. This is because the stored food in food reserves is hydrolyzed (broken down) to produce energy for germination.

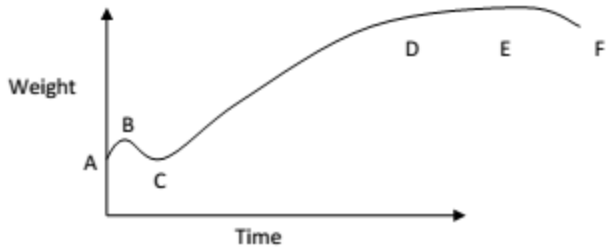
From point **B-C**, the dry weight increases steadily and rapidly. This is because the seed has produced leaves, which are carrying out photosynthesis. It makes food, which causes its dry weight to increase.

From points **C-D**, the growth rate decreases. This is because the plant has matured and preparing for flowering and fruiting.

From points **D-E**, the dry weight remains constant. The plant has produced fruits and no more growth takes place.

From point **E-F**, weight drops because the seed are dispersed, the plant leaves dry and fall off. This causes a reduction in dry weight.

CHANGE IN TOTAL WEIGHT OF A GERMINATING SEED.



Explanation of the graph:

Most of the changes are similar to those in the graph showing changes of dry weight with time in a germinating seed except that for dry weight, the weight of water in the seed is not considered. For the total weight of the seed during germination, water is put into consideration.

The initial slight increase in weight from point A-B is due to imbibition (absorption) of water into the seed. The other changes that follow in the subsequent points on the curve are similar to those in the change of dry weight with time.

EXPERIMENT TO FIND OUT THE REGION OF ELONGATION IN A ROOT

Materials:

- ✓ Water
- ✓ Water proof Ink
- ✓ Cock
- ✓ Seedlings
- ✓ Conical flask
- ✓ Dark cup board
- ✓ Pin and a ruler

Procedure:

a) Take bean seedlings with straight radicles.

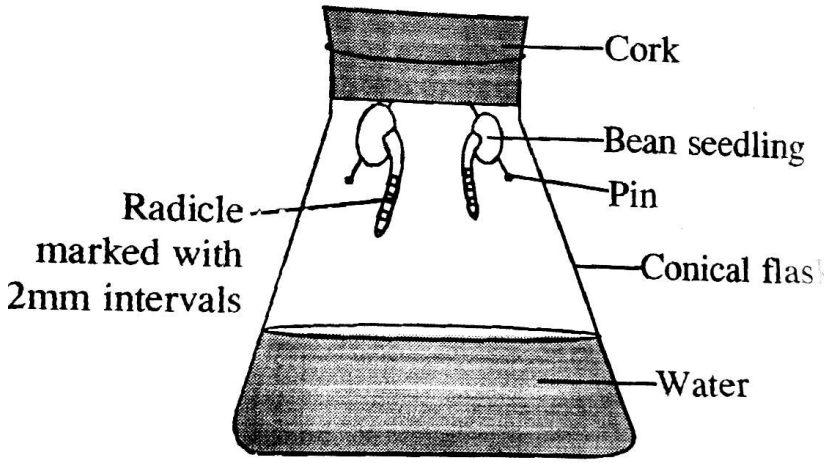
b) On each seedling mark the radicle every 2mm with lines in black ink.

c) Pin the seedlings to the other side of the cork with the radicles hanging down wards.

d) Insert the cork into the neck of the flask containing little water.

e) Put the flask in the dark cup board for 3-4 days.

Experimental set up:

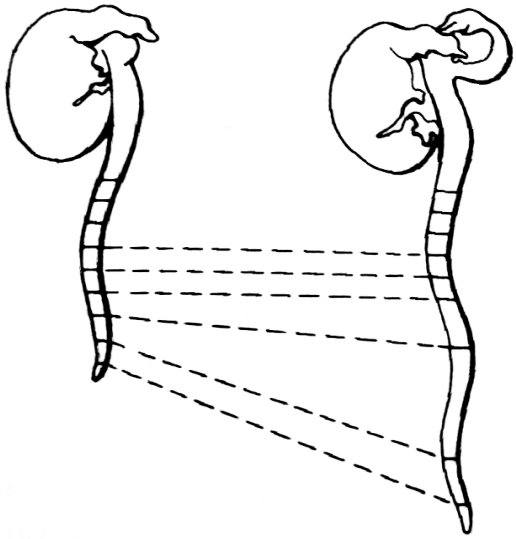


Observation:

Some lines on the radicle are 2mm apart while others are more than 2mm apart.

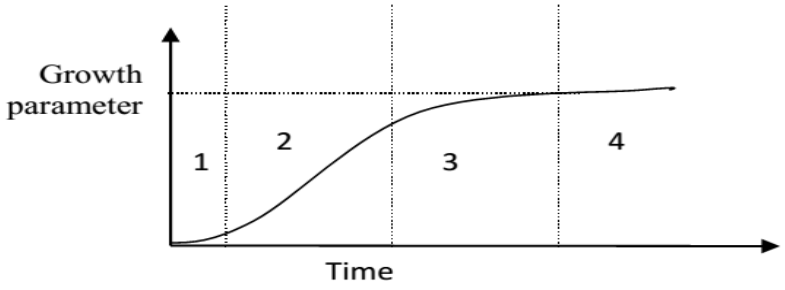
Conclusion:

The region where the lines are further apart is the zone of elongation (region of growth).



GROWTH CURVE

This is a graph which shows the change of a given growth parameter with time. This graph is S-shaped in most living organisms and it is called the sigmoid curve.



The curve shows 4 phases.

1. Lag phase.

This is a period of slow growth. It is the first phase of growth where there are very few cells dividing and the organism is getting used to the environment.

2. The exponential phase.

This is a phase of rapid growth. It is the second phase where the cells dividing are many and the organism is used to the environment.

3. Decelerating growth phase.

This is a period where growth slows down. The deceleration in growth may be due to;

1. Competition for food, space and other resources.
2. The organism is preparing for reproduction.
3. The organism is aging.

4. The plateau phase. /stationery phase.

This is a period where there is no change in the growth parameter under investigation. At this point the number of cells, which die is equal to those produced.

After the plateau, the growth decelerates in seasonal organism due to aging and dispersal. In perennial organisms, growth increases continuously.

GROWTH AND DEVELOPMENT IN ANIMALS

In animals growth occurs throughout the body of the organism unlike in plants where growth is localized in specific areas called meristems. Most animals grow continuously until they reach maturity. This is called continuous growth. In Arthropods like insects growth is discontinuous, i.e. there are periods of growth and no growth.

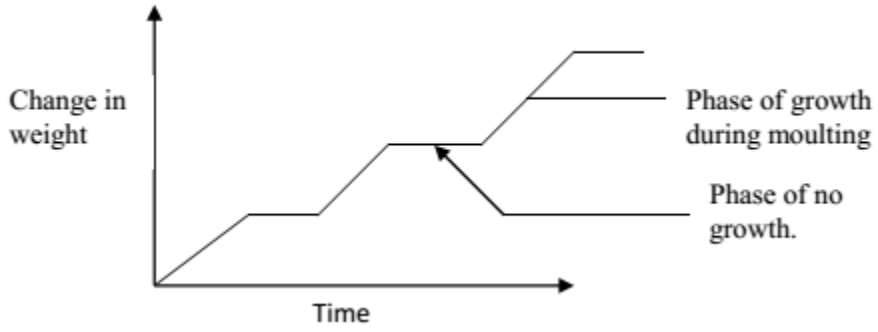
GROWTH AND DEVELOPMENT IN INSECTS

Insects have an exoskeleton which is rigid and prevents expansion of the insect during growth. Before the insect grows, it sheds the exoskeleton in a process called moulting (ecdysis).

Without the exoskeleton, the insect expands and grows. A new exoskeleton then forms and growth ceases. This kind of growth is referred to as intermittent growth or discontinuous growth. Successive moults result

into formation of a new form of the insect. This is called metamorphosis. Metamorphosis has already been discussed under insects.

A graph showing intermittent growth in insects



REPRODUCTION

Reproduction is the process by which organisms multiply to increase in number. This is important in maintaining the life of organisms from one generation to another.

Types of reproduction There are two types of reproduction.

1.Asexual reproduction

2.Sexual reproduction.

ASEXUAL REPRODUCTION

This is a type of reproduction, which does not involve fusion of gametes, and therefore only one individual is involved. This type of reproduction takes several forms, which include the following. **a) Budding.**

This is a mode of asexual reproduction in which an organism develops an outgrowth (bud), which detaches its self from the parent organism and starts to grow as a self-reliant organism. It is common in yeast and hydra.

b) Spore formation

This is a mode of asexual reproduction, which involves production of spores. Spores are microscopic structures, which can be dispersed and have the ability to germinate into a new organism under favorable conditions. This mode of reproduction is common in fungi and some bacteria.

c) Fragmentation

This is a mode of asexual reproduction where an organism breaks into many small parts (fragments) and each is able to grow into a new individual. It is common in tapeworms and spirogyra.

d) Binary fission

This is a mode of asexual reproduction where a single celled organism divides up into two parts, which start to grow as separate individuals. It is common in amoeba and other protozoans .

e) Multiple fission

This is a mode of asexual reproduction where a single celled organism divides into many parts, which grow into separate individuals. This occurs in plasmodium.

f) Vegetative reproduction

This is a mode of reproduction in plants where part of the plant other than the seeds develops into a new individual. This normally takes many forms, which include rhizomes, bulbs, corms, suckers, stolons, runners etc

Table showing various types of vegetative propagation

Name	Characteristics	Examples
Rhizome	Underground stem, swollen with food, has lateral buds, has scale leaves, has nodes and internodes.	Ginger, cannalily, Couch grass, spear grass.

Runners/stolon	Grows on the surface, has fibrous roots, has lateral buds, has scale leaves, has nodes and internodes.	Oxalis,Star grass,straw berry.
Bulbs	Leaves swollen with food, has a short stem, has adventitious roots, has scale leaves, has thick foliage leaves, has lateral buds.	Onions, garlic
Corms	Vertical stem swollen with food, has adventitious roots, has lateral buds, has scale leaves.	Yams
Suckers	New individual plant produced alongside the	Pineapple, banana
	parent plant	

Advantages of vegetative reproduction

- New plants resemble the parent plant and any good quality in the parent is retained.
- The growth of the new plant is rapid.
- The reproductive organ stores plenty of food which the new plant uses.
- It does not involve processes like pollination, fertilization and dispersal agents are not required.
- Large areas can be covered in relatively little time.
- It involved only one individual.

Disadvantages

- Since new plant grows on its parent, it can lead to crowding.
- Shortage of water and mineral salts is likely to occur due to competition.
- Diseases of the parent plant can be transmitted to the young ones.
- If the parent plant has poor characters, they can be maintained by the young ones.

ARTIFICIAL VEGETATIVE PROPAGATION

This is a mode of reproduction where man is involved in the propagation process. It is done in several ways, which include, budding, grafting, layering, cuttings, etc.

1. Budding

This is the process where a bud is detarched from a plant and grown in suitable conditions into a new plant.

2. Grafting

This is the insertion of part of one plant onto another plant so as to come into organic union and to grow as one plant. The part inserted can be a bud or a shoot of a plant and it is called a **scion**. The part in the ground on which the scion is inserted is called a **stolk**. The scion and stolk should be of different varieties but same species.

3. Layering

This is where a branch of a plant is bent to touch the ground and allowed to develop roots. When the roots are developed, it is cut from the plant and it starts to grow as a separate self-supporting plant.

Advantages of asexual reproduction

1. It is reliable because it is less likely to be affected by adverse environmental factors like for the case of seeds.
2. It leads to genetic consistence since there is no mixing of genes during reproduction.
3. It results into early maturity because the organisms produced have enough food reserve from the parent.
4. It is self-sufficient because it does not rely on external processes like pollination, fertilization and dispersal.
5. It does not result in indiscriminate and wide spread distribution like in the case of seeds, which leads to wastage.
6. It does not require formation of sex organs.
7. It is the only means of reproduction in some organisms.

Disadvantages of asexual reproduction

1. It leads to maintenance of bad characters.
2. It does not introduce variations in the offspring since there is no gene mixing.
3. It easily results into competition between offspring due to overcrowding.

4. It gradually results into reduction of the strength and vigour of the succeeding generations.

5. There is a high chance of disease transmission from parent to offspring.

SEXUAL REPRODUCTION

This is a type of reproduction which involves the fusion of male and female gametes to form a zygote.

SEXUAL REPRODUCTION IN NON FLOWERING PLANTS

Reproduction in spirogyra

Spirogyra is a green non flowering plant belonging to a group of plants known as algae. The main type of sexual reproduction in spirogyra is conjugation.

i) The opposite cells of the two different filaments lying side by side develop a swelling or an out-growth which begins to grow towards each other.

ii) On touching they dissolve to form a conjugation tube and at the same time the contents change into gametes.

iii) The gametes from one cell (male gamete) migrate through the conjugation tube to another cell (female) gamete.

iv) The two gametes fuse to form a zygote which develops a thick resistant wall and becomes a zygospore.

v) When the conditions are favorable, the zygospore germinates and grows into another filament.

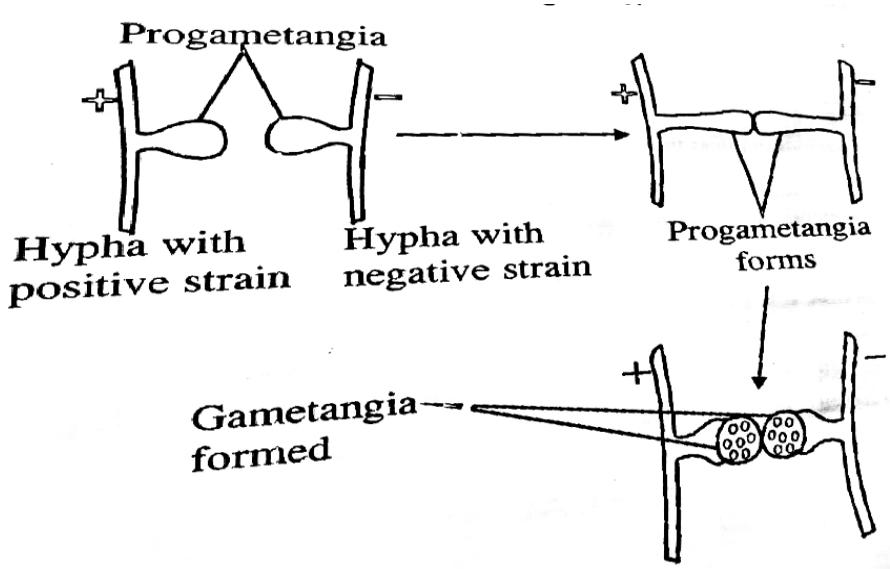
Illustration

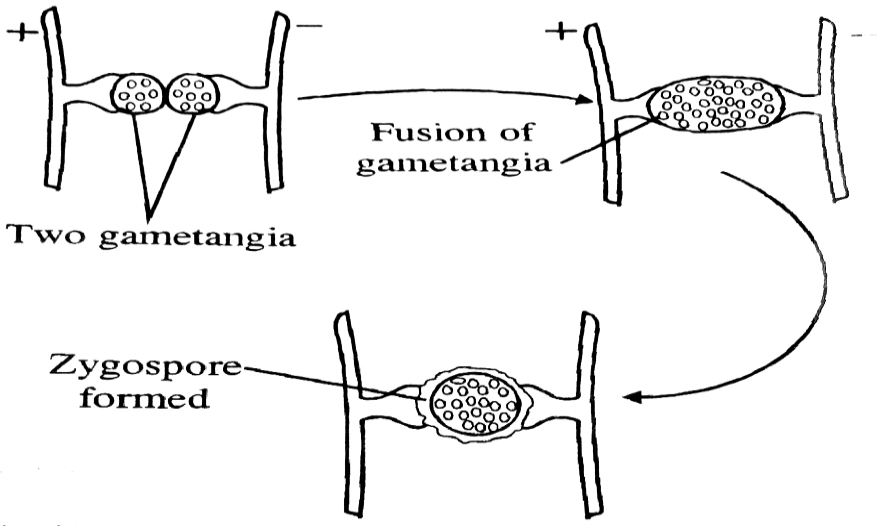
Sexual reproduction in fungi (Rhizopus) E.g. mucor

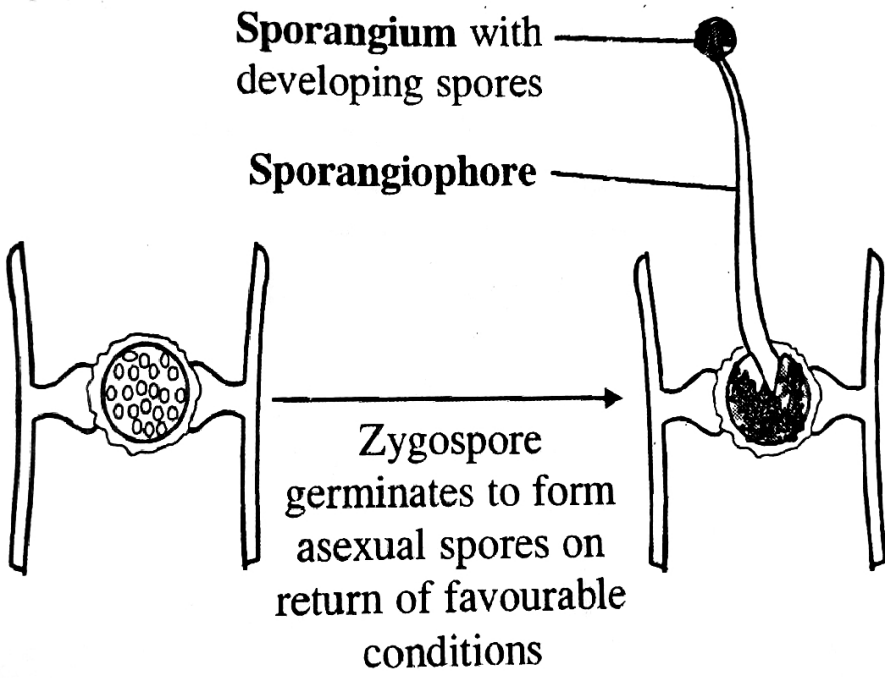
i) The tips of the two hyphae of different mycelia become swollen and grow towards each other until they touch. The two opposite swellings are referred to as positive and negative hyphae.

ii) The swellings are cut off from the rest of the mycelia by a cross wall, nuclear division takes place and each swelling contains several nuclei. iii) When they touch, the wall dissolves and nuclei fuse in pairs. The thick outer cover forms around them to form a zygospore. This remains dormant for as long as conditions are unfavorable but germinate if the conditions are favorable.

Diagram to show sexual reproduction in rhizopus


Progametangia
Hypha with positive strain
Hypha with negative strain
Progametangia forms
Gametangia formed


Two gametangia
Fusion of gametangia
Zygospore formed



SEXUAL REPRODUCTION IN FLOWERING PLANTS

In flowering plants the flower is the reproductive organ.

The male gametes are the male nuclei found in the pollen grains produced by the anthers.

The female gametes are the egg nucleus and polar nuclei found inside the ovules located in the ovary. These two are brought together shortly after pollination.

POLLINATION

Pollination is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or different flowers of the same species.

Pollination is of two types;

- Self-pollination
- Cross pollination

Self-pollination; is the transfer of pollen grain from anther of a flower to the stigma of the same flower.

Cross pollination; is the transfer of pollen grain from anther of a flower to the stigma of another flower of the same species. Flower may or may not be from the same plant.

Features that promote cross pollination

- Brightly colored petals.
- They have a nice scent to attract insects.
- Produce nectar which is food source for the insects.

- Stamen produce sticky pollen grains which adhere firmly to the bodies of visiting insects.
- The stigma are flat, lobbed and have sticky surface to which pollen grain can easily adhere.
- Presence of landing plat form and pollen guide which ensures that insects visit the flower.
- Stamen hanging outside the corolla to ensure that pollen grains are blown away by wind to another flower.

Characteristics of wind pollinated flowers

- Usually not brightly colored Not scented and lack nectar.
- Stamen of wind pollinated flowers produce large quantity of light powdery pollen grains.
- Usually small and inconspicuous but are borne in large inflorescences.
- The stigma are large often feathery and hang outside the flower by long styles. This provides a large surface area on which pollen grains floating in the air may be trapped.

Arrangements that promote self-fertilization (arrangements preventing cross pollination)

i) Maturation of both male and female parts of the flower at the same time.

ii) Flowers borne underground. iii) Flowers being bi-sexual.

iv) Flowers remaining closed.

Arrangements that promote cross pollination (arrangements preventing selfpollination)

i) Possession of unisexual flowers such that both sexes appear on different plants (dioecious). E.g. in pawpaw

ii) Self-sterility in monoecious plants like maize. iii) **Dichogamy,** a condition in which the stamens and pistils do not ripen at the same time. This results in failure of cross fertilization. If the stamens ripen before the pistil the condition is referred to as **protandry** while if the pistil ripens before the stamens it is called **protogyny.**

iv) Stigmas being higher than anthers.

Differences between wind pollinated and insect pollinated flowers.

Wind pollinated	Insect pollinated
1. Produce light pollen grains	Produce relatively large and heavier pollen grains.
2. They produce large quantities of pollen grains	Produce small quantities of pollen grains.
3. They are usually not scented	They are scented.
4. Petals are dull colored.	Petals are brightly colored.

N.B:

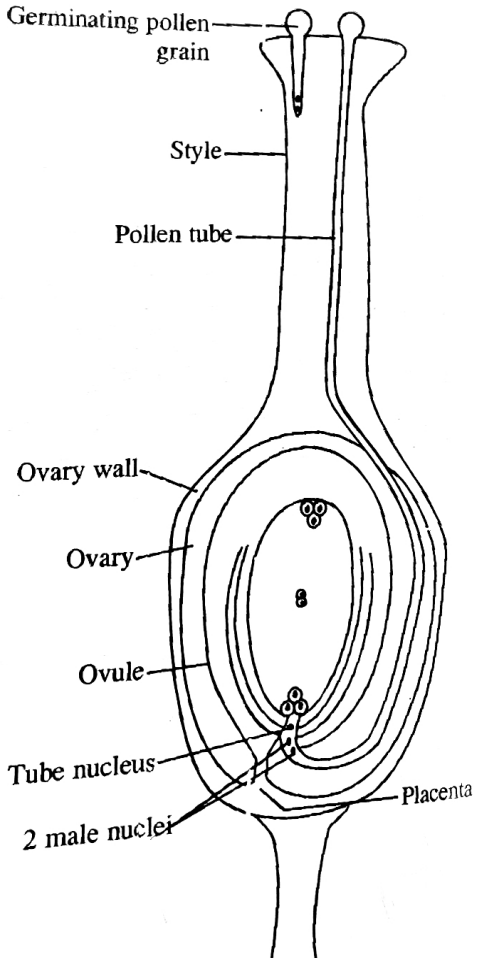
Self-pollination has the disadvantage of failing to introduce variation in the new generation. This results into maintenance of poor characters from one generation to the next.
Cross pollination results into mixing of genetic material which leads to variation. This results into introduction of new character from one generation to the next.

FERTILIZATION IN PLANTS

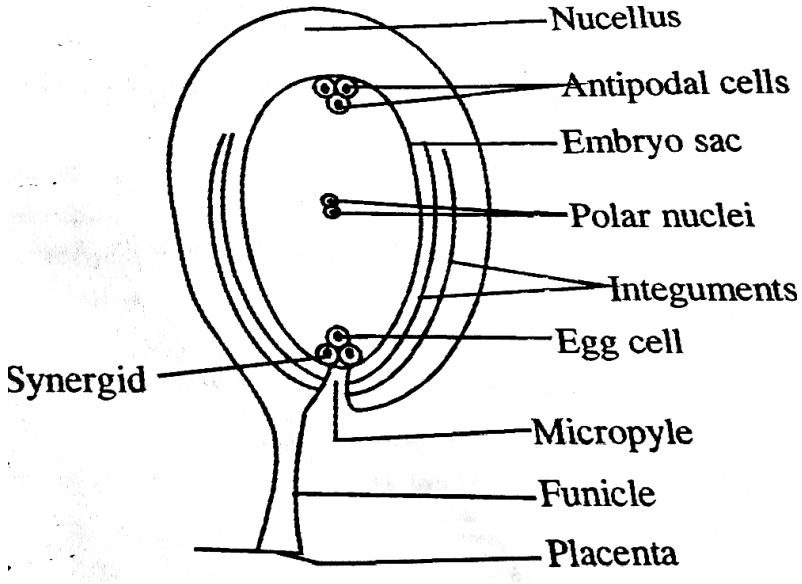
This is the fusion of male and female gamete to form a zygote. Fertilization in plants is internal taking place inside the ovary in the structure called embryosac.

The process of fertilization in plants:

7. Pollen grain lands on the stigma of a flower of the same species.
8. On the stigma, pollen grain absorbs water, nutrients and then germinates to form a pollen tube which grows through the style under the control of the tube nucleus at the tip.
9. Pollen grain has two nuclei i.e. generative nucleus and pollen tube nucleus. The generative nucleus divides mitotically to form two male nuclei which lie behind the pollen tube nucleus.



10. The pollen tube enters the ovary and the tip of the pollen tube breaks. The pollen tube nucleus disappears.



11. One of the male nucleus fuse with the egg nucleus to form a zygote which divides mitotically to form embryo.

12. The other male nucleus fuses with two polar nuclei to form a triploid endosperm which develops into endosperm. This is called double fertilization.

Events after fertilization

7. The zygote divides mitotically followed by growth and development resulting into an embryo.

8. The triploid endosperm divides mitotically to form good solid organs called endosperm.

9. The ovules develop into seeds.

10. The integuments become the seed coat.

11. The ovary develops into a fruit and ovary wall develops into a fruit wall which protects the seeds.

12. Petals, stigma, style and stamen wither and fall off while the calyx may wither and fall off or may remain in shriveled form.

REPRODUCTION IN ANIMALS

Sexual reproduction is the only form of reproduction in vertebrates and few invertebrates. E.g. Arthropods.

For this reason, most of animals have reproductive organs in which the gametes are produced. To adopt various conditions in the habitat in which they live different animals show different forms of fertilization and development.

Reproduction in insects

Insects show internal fertilization and external development with complete and incomplete metamorphosis.

Metamorphosis:

This is the developmental change from the eggs to the adult stage in the life cycle of an organism. It is divided into two, i.e. complete and incomplete metamorphosis.

i) Complete metamorphosis

This is the type of metamorphosis where eggs hatch into larvae, pupa then to adult. It occurs in houseflies, butterflies and moths. Insects which show complete metamorphosis are called holometabolous insects.

ii) Incomplete metamorphosis

This is the type of metamorphosis where eggs hatch into nymph that resembles the adult except that it lacks wings, smaller than the adult and sexually immature. It occurs in insects such as cockroaches, grass hoppers and locusts. Insects which show incomplete metamorphosis are known as hemimetabolous insects.

Sexual reproduction in Bony fish

Like Tilapia, show external fertilization and external development beginning with laying of large quantities of eggs. Mating may follow courtship in some species and the eggs after hatching may get minimum parental care in form of protection from enemies.

Sexual reproduction in amphibians

They show external fertilization and external development. There is some protection offered to the eggs by a jelly but there is lack of parental care to the tad poles.

Sexual reproduction in birds

Birds show internal fertilization and external development. Prior or before fertilization most birds show courtship behavior, nest building and development begins with laying of eggs which hatches into young ones.

Courtship stimulates the female sexually to a point (nest) where the male bird is;

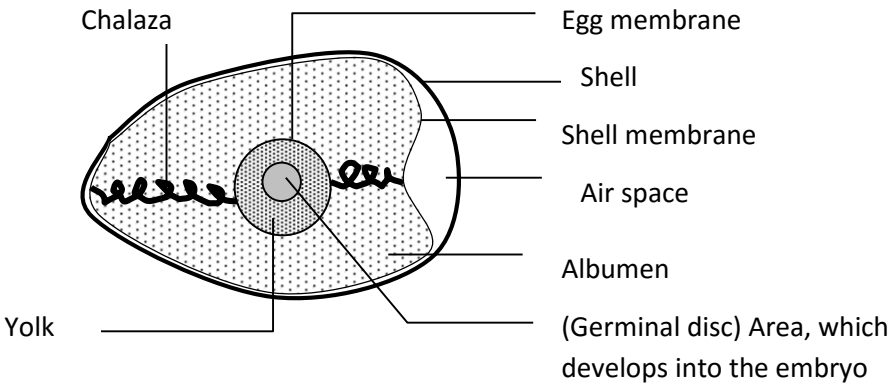
- ✓ On mating, the male presses his cloaca directly against the female's cloaca and sperms are released directly into the oviduct through the cloaca.

✓ The sperms swim up to the oviduct until they come into contact with the eggs without shell. Here internal fertilization takes place.

✓ The fertilized eggs pass to the oviduct where they release albumen and a hard protective shell.

✓ The eggs are laid in the nest and incubation starts after all the eggs are laid.

Structure of the egg.



Parts of the egg

1. **Shell**; this protects the egg and prevents it from desiccation.
2. **Airspace**; this stores air for gaseous exchange of the embryo.
3. **Charaza**; this holds the yolk in position.
4. **Albumen;** this is a source of proteins and fats to the embryo.
5. **Germinal disc**; this develops into an embryo.
6. **Yolk;** this stores food for and surrounds the embryo.

Development:

The living cells in the egg divide to make the tissues and organs of the young birds. The yolk provides the food for this development. The albumen is the source of proteins and water. The shell and shell membrane are permeable to air. Oxygen diffuses into the airspaces and is absorbed through the blood capillaries of the embryo. The blood carries oxygen to embryo and Carbon dioxide is eliminated through the egg shell by the reverse process. When the chick is fully developed, it breaks out of the shell by help of its beak during hatching. **Incubation:**

The female bird is responsible for incubation of the eggs. The function of incubation is to provide the optimum temperature for the embryo's development in the egg. The incubation period differs from one species of birds to another.

Differences between internal fertilization and external fertilization

External fertilization	Internal fertilization
Water as an external factor is necessary	Water as an external factor is not necessary
A lot of gametes are produced and necessary	Less gametes are involved in the process
Embryos develop not well protected and mostly helpless after birth	Embryos develop well protected and normally offered help after birth
A lot of energy is involved since more gametes are produced.	Less energy is involved since fewer gametes are produced
Chances of fertilization occurring are fewer	Chances of fertilization are higher

N: B the above points can serve as advantages of internal over external fertilization.

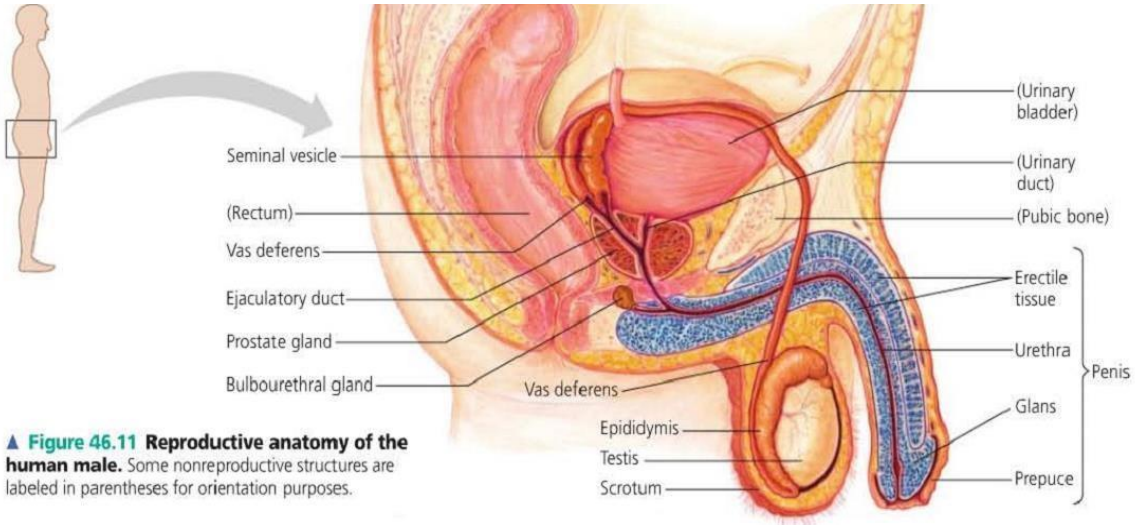
SEXUAL REPRODUCTION IN MAMMALS

Mammals reproduce sexually. They have special reproductive organs that produce the gametes i.e. sperms and ovum.

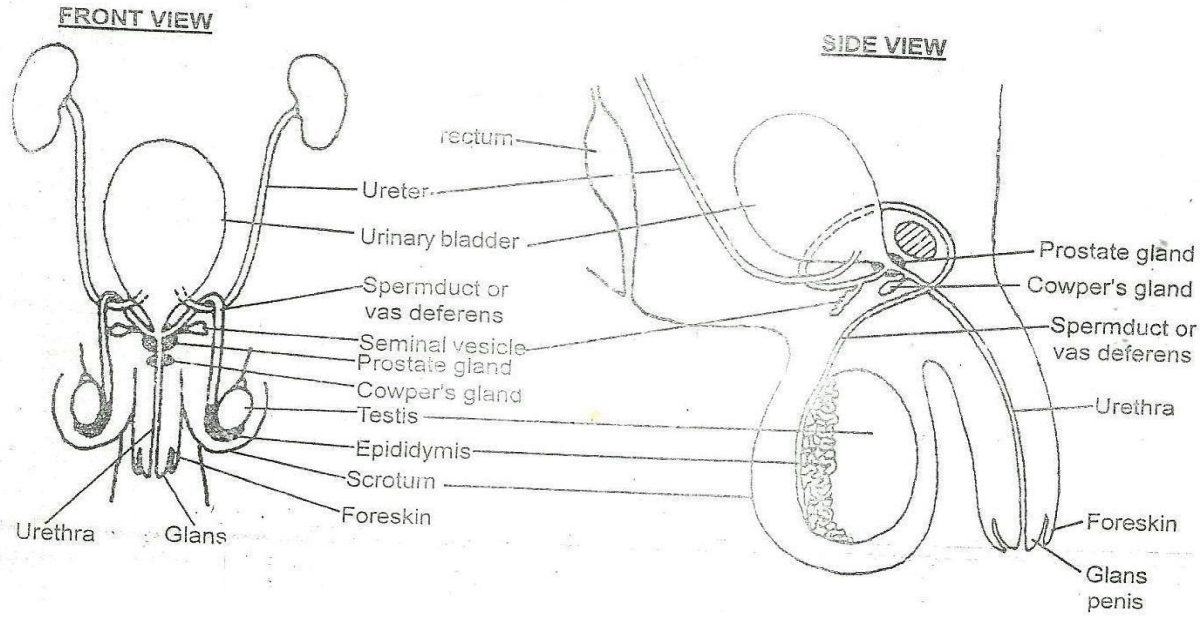
THE MALE REPRODUCTIVE SYSTEM

It consists of the testis, epididymis, seminal vesicles, prostate gland, Cowper's gland and penis.

Vertical section through the male urino-genital system



▲ **Figure 46.11 Reproductive anatomy of the human male.** Some nonreproductive structures are labeled in parentheses for orientation purposes.



Functions of the parts:

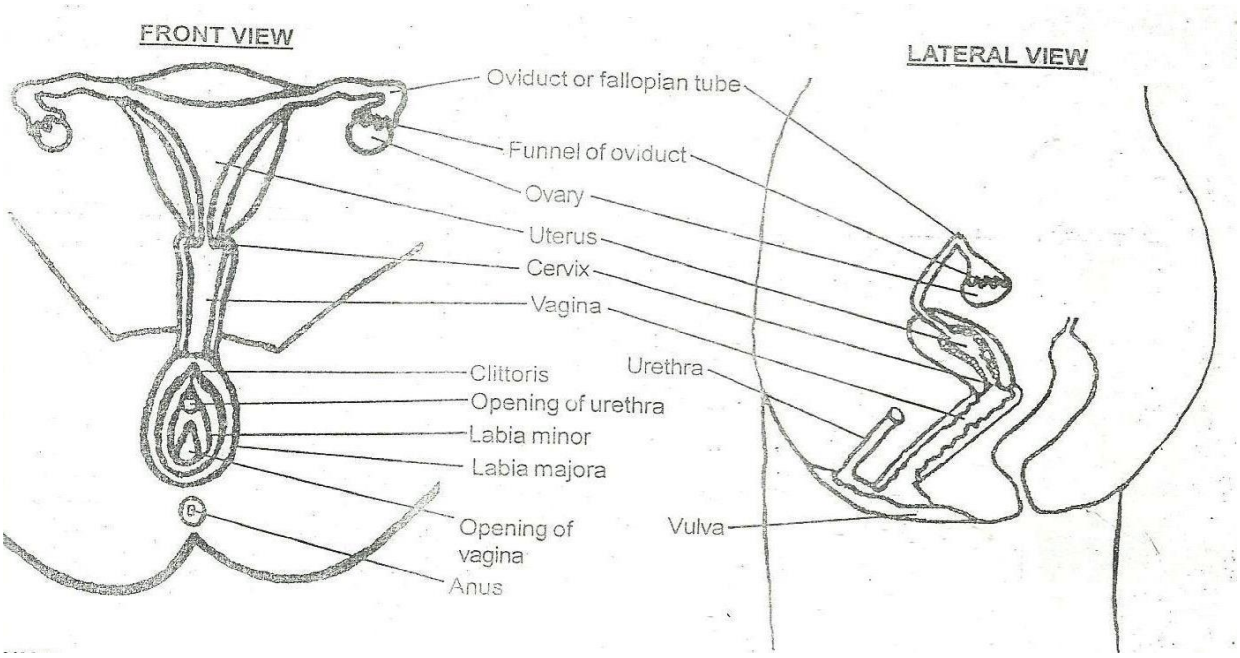
1. **Seminal vesicle;** secrets viscous fluid-containing fructose which acts as a nutrient for sperm cells.
2. **Prostate gland;** this gland secretes an alkaline, milky-white fluid that neutralizes the acidity of the Vagina.
3. **Penis;** delivers sperms into the female reproductive organ.
4. **Testis;** manufactures and store sperms.
5. **Scrotal sac;** protects the testis.
6. **Vas deferens;** conducts sperms from the testis to urethra during ejaculation.
7. **Urethra;** passage of sperms and semen during ejaculation.

8. Cowper's gland; produces mucus for lubrication of both the male and female urethra to ease copulation.

Functions of the male reproductive system

- Used in the delivery of sperms into the female reproductive organ.
- Production and storage of sperms.
- Secrets male sex hormones e.g. testosterone hormone.

FEMALE REPRODUCTIVE SYSTEM



Function of parts:

1. Uterus; provides suitable environment for growth and development of the fetus. It is also an area for implantation.

2. Vagina; it provides the following functions; Passage of sperms to the uterus.

- Passage of blood during menstruation. Allows passage of the fetus at birth.

3. Oviduct (fallopian tube);

- It allows movement of fertilized egg towards the uterus for implantation. It provides suitable place for fertilization.

4. Cervix; contains elastic muscles which allows its expansion during birth and it is the gate way to the uterus.

5. Vulva; This is a collective term for the external genetalia. It is made up of two skin folds that is the inner fold (**labia minora**) and the outer fleshy fold **(labia majora**). Labia minora contains mucus secreting glands which lubricates the vagina during sexual intercourse (copulation).

Labia majora cushion the vagina and helps in sexual arousal. In the place where labia majora and **labia minora** meet is a bean-like structure called **clitoris**. This is the most sensitive part, which brings about sexual excitement in females.

6. Vagina; This is a muscular tube, which connects the vulva to the uterus. It has an average length of 10cm. It secretes acidic mucus, which prevents growth of bacteria and fungi. The mucus also lubricates the vagina. The vagina plays the following roles.

- ✓ It is a passage for menstrual flow.
- ✓ It is a birth canal.
- ✓ It is where the male inserts his erect penis during sexual intercourse.

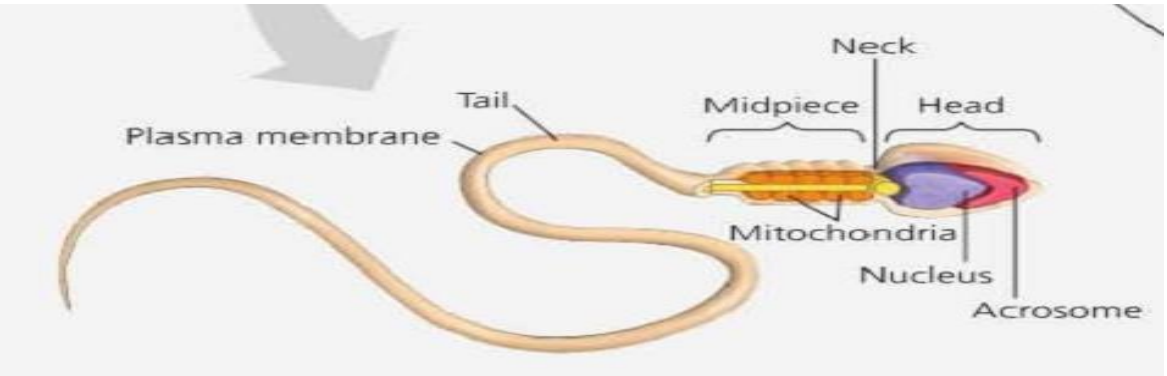
General function of the female urino-genital system

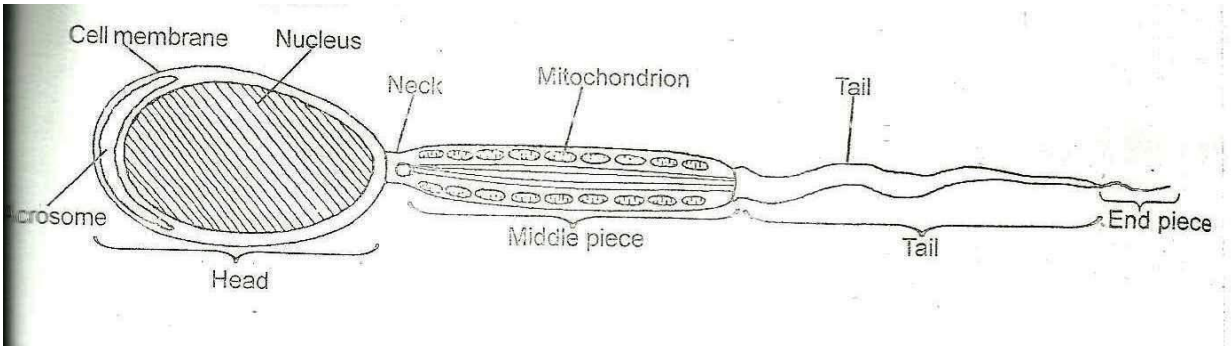
- Production of the female gametes i.e. the ovum
- Reception of the male gametes i.e. the sperm
- Provision of a suitable environment for fertilization
- Provision of a suitable environment for the fetus development.
- Provision of a means for the expulsion of the developed fetus during birth.
- Secretion of hormones like oestrogen

GAMETES

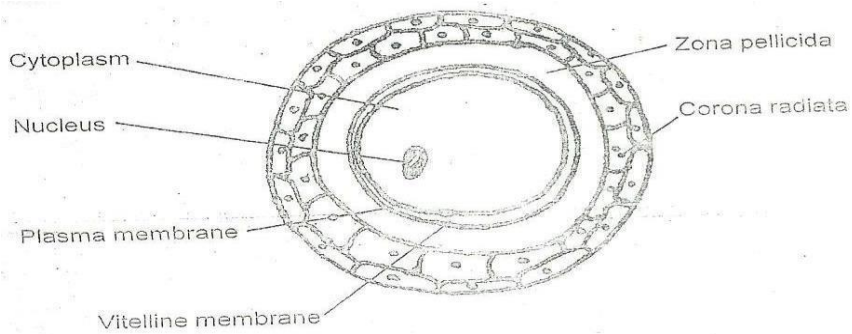
These cannot develop any further until fertilization occurs. There are two types of gametes namely; male and female gametes also known as sperm cells and ova (singular; ovum or egg cell) respectively. Both male and female gametes are haploid.

The structure of a sperm cell (male gamete)





The structure of the ovum



Functions of the parts:

1. **Acrosome;** contains juice together with enzymes which dissolve the egg membrane (Vitelline) to bring about fertilization.
2. **Nucleus;** contains genetic material which is responsible for transmission of characters from the parent to the off spring.
3. **Middle piece;** contains mitochondria which provides energy required for the movement of the sperm.
4. **Tail;** propels the sperm forward as it swims towards the ovum.
5. **Neck;** connects the head and tail of the sperm.
6. **Cytoplasm;** it acts as a food store for the embryo.
7. **Vitelline;**
   - It provides protection to the inner part of the egg.
   - Allows exchange of materials around the egg and its surrounding.

Differences between sperm and ovum

Sperm cell	ovum
Has a tail	It is spherical and has no tail
It is very small	It is big
Has less food store	It has more food store

It is mobile	It is immobile
It has either X and Y chromosomes (XY)	It has only X chromosomes (XX)

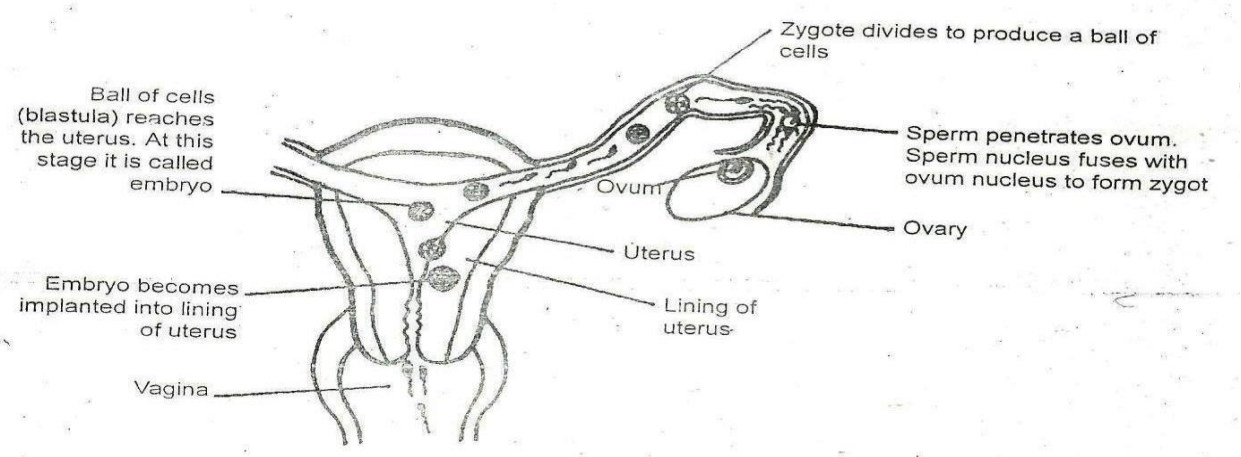
FERTILIZATION IN MAN

Fertilization in man occurs after copulation where erect penis is inserted into the vagina. At orgasm, the penis releases large number of sperms (200-300 millions) near the cervix. The cervix relaxes and opens as sperms swim through its opening to the uterus then to the oviduct where fertilization takes place.

When a sperm get into contact with the egg membrane, it releases enzymes from acrosome which breaks the egg membrane and enable the sperm cell penetrate into the cytoplasm of the ovum.

When the sperm cell enters, the egg membrane becomes thickened to form the fertilization membrane which serves as a barrier preventing the entry of other sperm cells.

The nuclear membrane of the two gametes breaks down and male nucleus fuse with a female nucleus to form a fertilized egg. This process is known as fertilization and the female is said to have conceived.

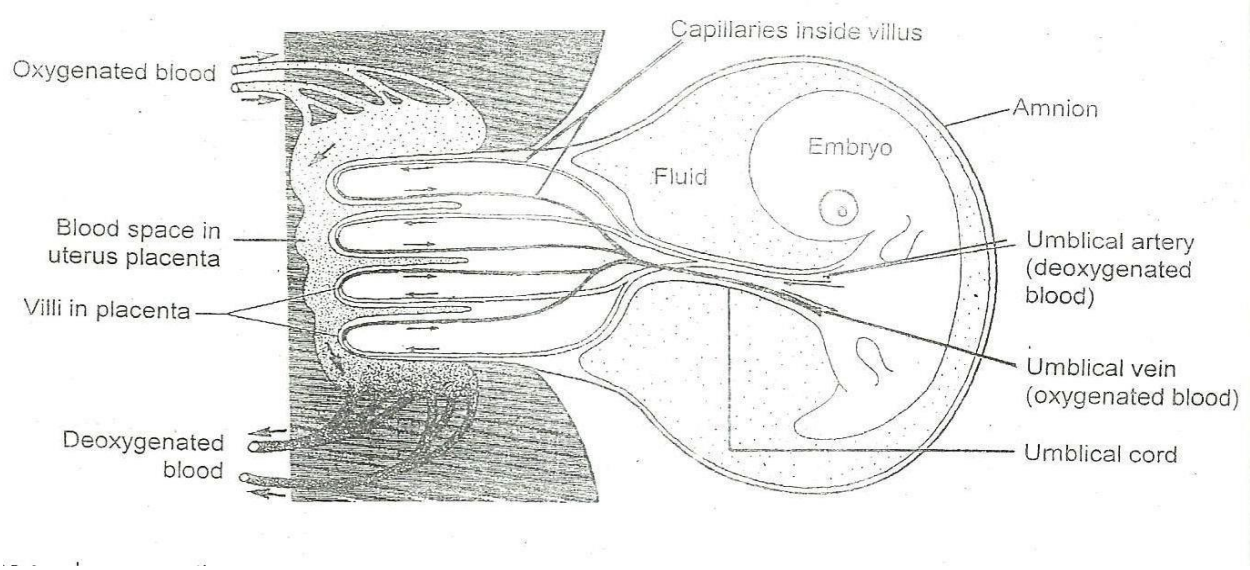


PREGNANCY

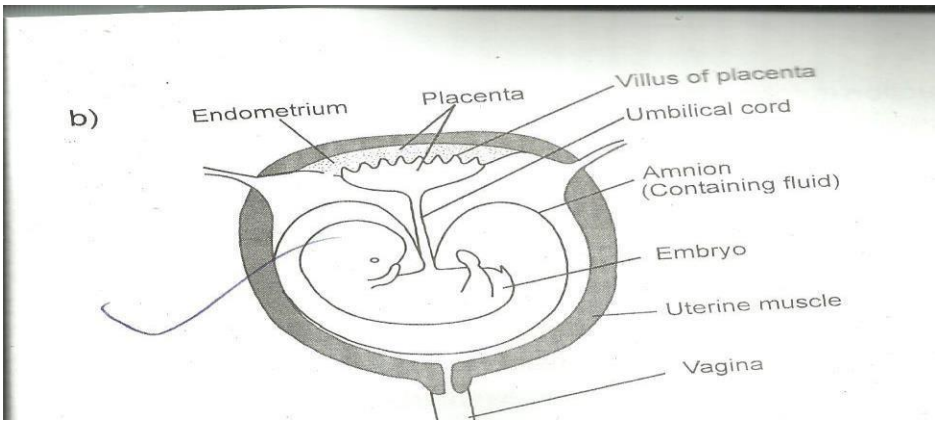
Gestation is the period from fertilization of an ovum to birth. After fertilization, the under goes cell division by mitosis and move down to the uterus. Its movement is aided by constriction of the oviduct and it takes about one week. Finally the fertilized egg (zygote) is embedded in the lining of the uterus a process known as implantation and it continues with its development.

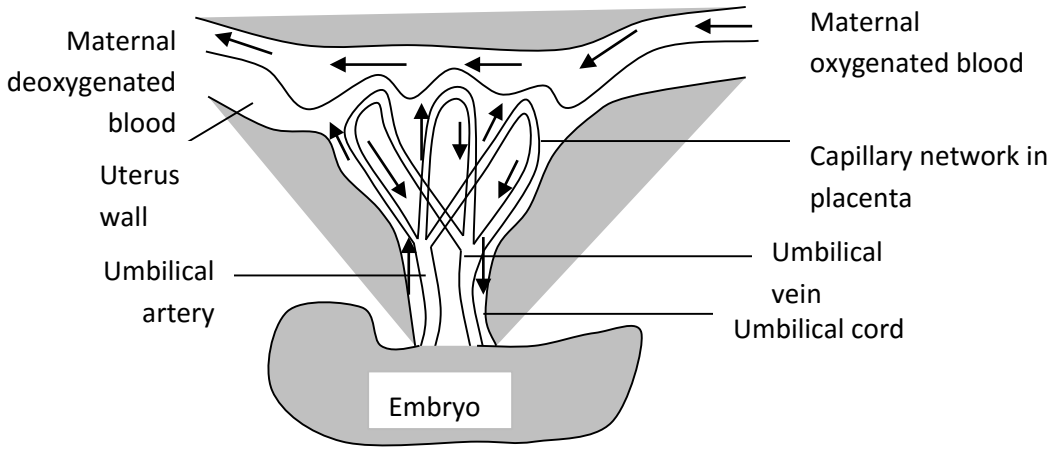
The fertilized egg now becomes known as the fetus. Later, finger like connections develop between the fetus and the mother's blood system. This later unites to form placenta connected to the fetus by umbilical cord.

Diagram showing blood circulation to and from the fetus



Or summarized as below





Major nutrients needed by a pregnant mother

i) Calcium and Phosphates. These are needed for the development of bones and cartilage of foetus.

ii) Iron needed for the formation of foetal red blood cells iii) Proteins needed for the formation of new tissue. iv) Vitamins needed for proper growth.

Functions of the placenta

i) It allows exchange of materials without the mother's blood mixing with that of the fetus.

ii) It allows transfer of oxygen, water, glucose, amino acids and other substances into the fetus which are used as nutrients. iii) Carbon dioxide, urea and other wastes are transferred from blood circulatory system of the fetus to the mother's blood across the placenta.

iv) It protects the fetus by preventing certain toxins and foreign materials from crossing to the fetus.

v) It acts as a barrier to mother's hormones and some other chemicals which may affect the fetus.

vi) It allows anti bodies to pass onto the fetus there by providing immunity against diseases.

Nutrition of the fetus

Soluble food substances, oxygen, water and mineral salt passes across the placenta by either diffusion or active transport from the mother's blood to the fetal blood through the umbilical vein. Waste products such as carbon dioxide and nitrogenous wastes are brought in to the placenta by umbilical artery where they are passed into mother's blood. The placenta is therefore the excretory organ of the fetus as well as respiratory surface and source of nourishment.

Protection of the fetus

The fetus is contained in a sac called the amnion which is filled with amniotic fluid. The amniotic fluid protects the fetus from mechanical shock and drying.

The fetus is warmed by blood temperature all the time and regulated by mother's blood.

The placenta prevents passage of bacteria, other foreign materials, nervous transmissions and maternal blood pressure from affecting fetal circulation and also it keeps out toxins from the fetus.

BIRTH (PARTURITION)

The embryo turns head down wards in the uterus a few days before birth which occurs at approximately 9 months after fertilization. At time of birth, the uterus contracts rhythmically.

The opening of the cervix dilates (relax) to allow the young's head to pass through. The amniotic fluid passes out through the vagina.
The contraction of the uterus pushes the young one through the vagina to the exterior. It takes the 1st breathe of life and usually cries, a sign of changed conditions in its environment. After some time the placenta separates from the uterus and finally expelled as after-birth.

Differences between sexual and asexual reproduction

Sexual reproduction	Asexual reproduction
i) Two parents are involved	Only one parent is involved
ii) Needs males and female gametes	Does not need gametes
iii) Off springs are not identical	Off springs produced are identical
iv) Rate of reproduction is slow	Rate of production is fast
v) Fertilization usually occurs	Fertilization does not occur
vi) Usually few off springs are produced	Usually very many off springs are produced

MALE HORMONES

At puberty, the hypothalamus stimulates the anterior part of the pituitary to release two hormones.

i. The **follicle stimulating hormone (F.S.H)** which stimulates sperm production.

ii. The **Luteinizing hormone (LH)** also known as the interstitial cell stimulating hormone (ICSH) which stimulates the interstitial cells of the testis to release another hormone **testosterone** which stimulates the development of the male secondary sexual characters.

Secondary characteristics in man

- ✓ Deepening of the voice
- ✓ Growth of pubic hair
- ✓ Enlargement of the penis
- ✓ Onset of wet dreams
- ✓ Growth of beards
- ✓ Growth of hair in the arm pits

Secondary characteristics in females

- ✓ Softening of the voice
- ✓ Enlargement of breasts

- ✓ Enlargement of hips
- ✓ Onset of menstruation
- ✓ Enlargement of reproductive organs
- ✓ Growth of pubic hair
- ✓ Growth of hair in arm pits

FEMALE HORMONES AND THE MENSTRUAL CYCLE

When the ovum is released by the ovary, the uterus wall thickens with addition of new layer of cells for the ovum to sink if fertilized. The blood supply also increases at the same time. If the ovum is not fertilized, the new layer of cells breaks down and the unwanted cells, mucus and some blood pass out through the cervix and vagina. This is called menstruation. It takes place once about 28 days, 12-14 days after the release of the ovum.

The menstrual cycle

The menstrual cycle is controlled by four hormones of which two are secreted from **the interior lobe of pituitary gland and the other two from the ovaries.**
The pituitary gland secretes **Follicle stimulating hormone (FSH) and Luteinizing hormone (LH)** and the ovary secretes **progesterone and oestrogen**. The four hormones are secreted in the following sequences. FSH ——————————
Oestrogen———— LH
Progesterone
It is a reproduction cycle occurring in sexually a mature female in absence of pregnancy and involves series of changes in the female reproductive system which is controlled by hormones.

1. Follicle stimulating hormone (FSH)

- ✓ Causes the development of the graafian follicles in the ovaries.
- ✓ It stimulates the ovary to produce oestrogen.

2. Oestrogen.

- ✓ This stimulates the repair of the uterine wall after menstruation.

 When in high levels, it stimulates the pituitary gland to produce LH

 It inhibits the production of FSH from the pituitary gland.

3. Luteinizing hormone (LH)

- ✓ This cause ovulation in the middle of the cycle.
- ✓ It also stimulates the ovary to produce progesterone from the corpus luteum.

4. Progesterone.

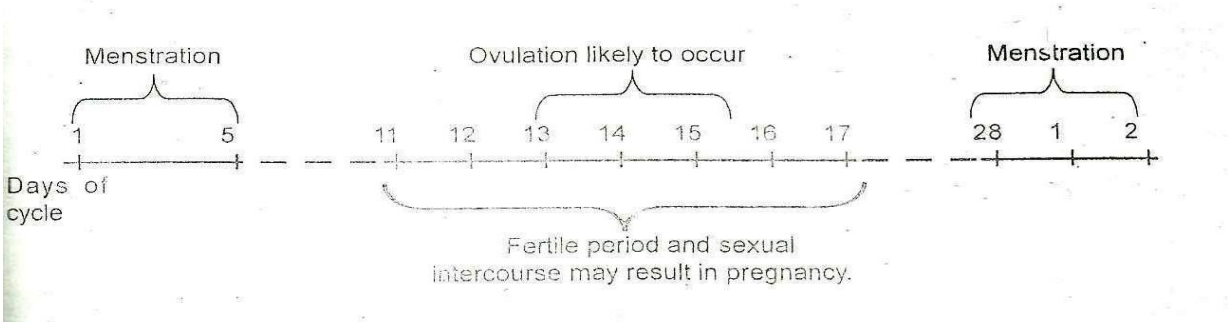
- ✓ This maintains the uterine lining in preparation for implantation.
- ✓ It inhibits production of FSH and LH if its level is high.

This leads to the breakdown of the corpus luteum within 14 days after ovulation and hence stops the production of progesterone.

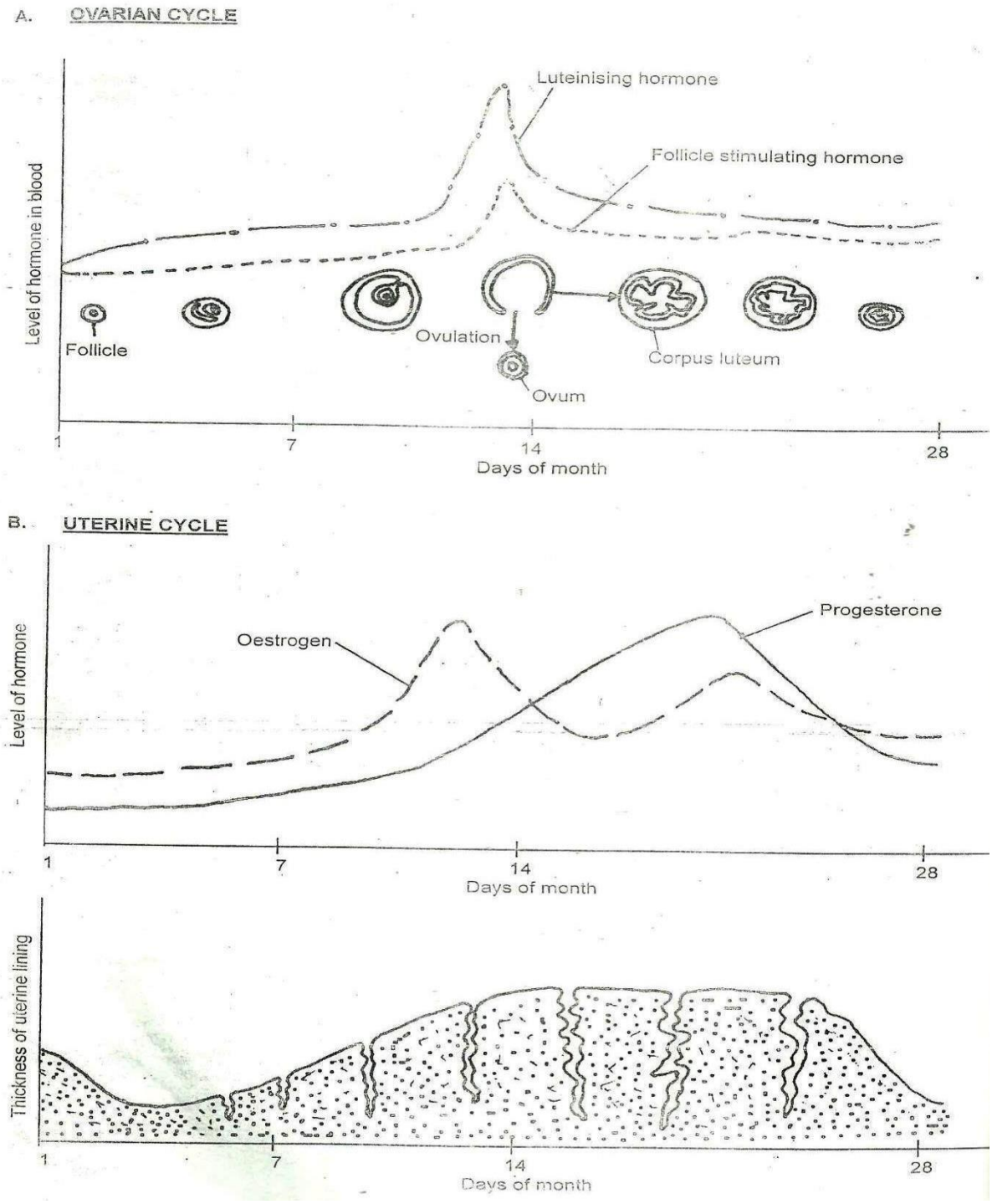
If the ovum is not fertilized;

i) When production of progesterone stops, the endometrium breaks leading to the flow of blood a process called menstruation. ii) If fertilization occurs, the placenta produces the progesterone which prevents menstruation and maintains pregnancy.

Menstruation stops at around the age of 45 years on average and one is said to have reached menopause. At this stage no more pregnancy is possible.



Graph illustrating the hormonal changes in blood during a menstrual cycle.



SAFE PERIODS

It refers to the days within the menstrual cycle when there in no mature ovum in the reproductive system so a female can have sexual intercourse without getting pregnant.

During the first safe period, there is development of a graphiam follicle and takes about 10 days from the end of menstruation.
A female should obtain for first 2 days before ovulation and 2 days after ovulation because the sperm cannot survive for more than 2 days.
The 2nd safe period starts from around the 18th day up to the 28th day. Thus a mature egg dies after waiting in vain.

TWINS

These are two babies produced with in the same time to the same mother as a result of the same pregnancy.

Types of twins

1. **Fraternal twins**. These are twins who arise from the fertilization of two ova produced at the same time and fertilized by two different sperms. The babies are not identical but resembles as normal babies in the family. They may or may not be of the same sex.
2. **Identical twins**. These are two babies, who develop from one fertilized ovum that latter divides into two and the two develop as separate individuals. Such babies look alike and are of the same sex

Multiple births

These are more than two babies produced to the same mother with in the same time as a result of the same pregnancy.

METHODS OF BIRTH CONTROL

1. Coitus interruptus where the penis is withdrawn from the vagina before ejaculation.
2. Rhythmical method where sexual intercourse is avoided at times when ovulation is likely to occur.
3. Use of condoms and diaphragms which prevents sperm from reaching the eggs.
4. Vasectomy where vas deferens are cut by surgical means there by preventing the passage of sperms.
5. Tubal ligation where the fallopian tubes are cut by surgical means there by blocking the passage of the egg.
6. Use of oral contraceptives known as pills, these prevents development of the egg.
7. Use of injectable contraceptives. This is taken every 3 months to prevent ovulation.

8. Intra uterine devices. This prevents fertilized egg from implanting into the uterus.
9. Use of intra-vaginal rings. This ring secretes progesterone like substance which inhibits development of the egg.
10. Use of morning pills which are taken 3 days after sexual intercourse.
11. Abortion which involves termination of viable pregnancies.