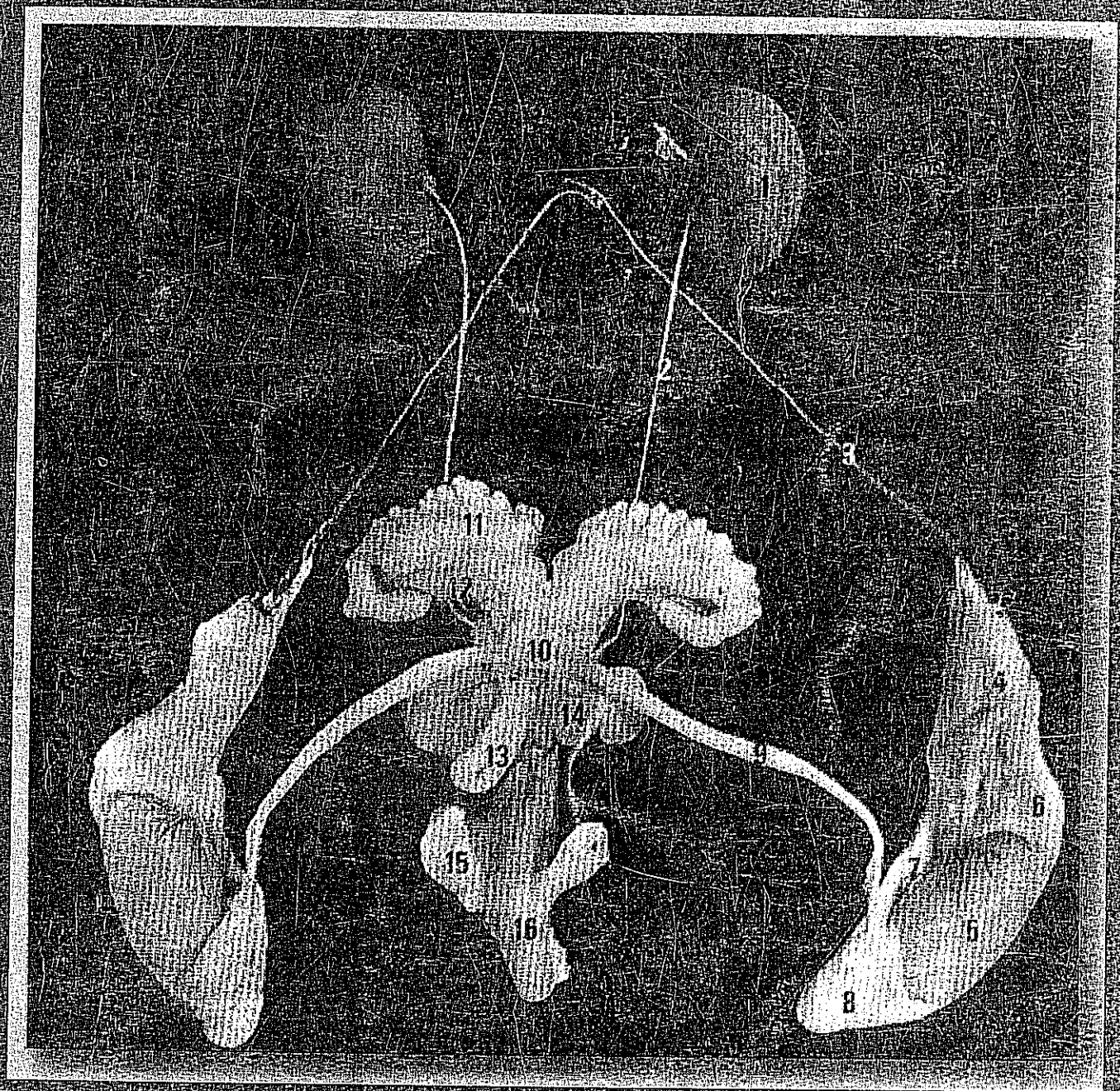
BIOLOGY PRACTICAL

'A' LEVEL STUDENTS' WORK BOOK WITH BASIC NOTES



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"When I hear I foget
When I see I remember
When I do I understand"

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GUIDELINES TO DISSECTIONS

The main objective of dissection is to study anatomy of organisms. This involves studying of the location, structure and functions of each organ of various body systems of an organism e. for example, Organs of digestion, Organs of reproduction, Organs of excretion, Organs of nervous system, and endocrine organs. Then make a drawing basing strictly on the instructions of the question.

The following rules should be adhered to when carrying out a dissection.

- Read the instructions carefully right to the end, then carry out the tasks reading instructions again, item by item.
- Always have with you a complete dissecting kit.
- Ensure the animal is dead before you proceed to dissect.
- Pin the animal on board or on the hard bottom of a dissecting dish with the body well stretched.
- Always keep the organs of the specimen wet using moist cloth or cotton wool.
- Never cut or remove anything without knowing what it is.
- If the animal has a lot of fat, remove it to expose underlying organs without injuring other organs.
- Never allow bleeding of the animal, if it does wipe it thoroughly with wet cotton wool.
- When dissecting long thin structures like nerves, blood vessels, intestines etc. Cut along them but **not** across their length.
- Make sure you display the structures instructed in the question clearly.
- All drawings of dissections should be large, well labeled without label lines crossing each other.
- The magnification should be indicated at the left bottom of the drawing.

Terms used to locate positions of the body structures in dissection.

Dorsal side This is the back side of the body of any structure or organism. In four legged animals, it also means superior.

Ventral side This is the abdominal side of the body of the animal or the inferior.

Anterior side This is the front / head / cephalic part of the animal. If the question requires structures anterior to any part, consider only the structures on the head side of that particular part. But do not include that part in your drawing.

Posterior side This is the rear / tail / caudal part of the animal. Features that posterior to the other, are on the tail side of that particular part. For instance, Features that are posterior to the diaphragm and anterior to the pelvic girdle are the abdominal features without including the diaphragm and the girdles.

Lateral side This is the sideways or away from the middle line of the body.

Median This is the midline or median plane of the body.

SECTIONS:

Longitudinal sections – This is a cut that is made parallel to the long axis of the structure or body.

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Transverse section: This is also known as across-section. It involves a cut being made perpendicular to the long axis.

BODY CAVITIES:

These are important reference points during dissections because most of the organs that are to be displayed are contained in such cavities.

Abdominal cavity This is the cavity posterior to the diaphragm and anterior to the pelvic girdles for mammals. It contains the liver, pancreas, spleen, gall bladder, kidney, stomach, spleen, small intestines, large intestines, rectum, testes, ureter, urinary bladder, ovaries, oviduct and the vessels that supply and drain those features. For the toad, the diaphragm is missing. Thus some thoracic features like the lungs extend into the abdominal cavity. In cockroaches, abdominal region is posterior to third thoracic segment (metathorax).

Pelvic cavity It is posterior to the abdominal cavity at the region of the pelvis. It contains the cloaca into which the terminal parts of the alimentary canal and the urinogenital ducts open in amphibians like toads. Placental mammals have a separate anus and urinogenital opening. The vagina of the mammals is found in the pelvic cavity.

Thoracic cavity It contains organs like heart, lungs, and the vessels that drain and supply them. It is enclosed by the rib cage in the mammals. The amphibians lack ribs. In cockroaches it stretches from prothorax to metathoracic segment. It consists of organs like gullet, thoracic ganglia, thoracic muscles, respiratory trunk, salivary gland and salivary reservoir.

Oral (Buccal) cavity This is the cavity of the mouth.

Neck region This region ranges from the jaws to the head end the ribs in the mammals.

According to the syllabus, there are three animals considered for dissection. These are toad or frog, cockroach, and rat or rabbit. When studying those animals for the dissection, the following points should be considered.

Classification of the animal under the following normal levels of classification, Kingdom, phylum, class, order, family, Genus and species. Give the reasons that qualify the organism in the phylum or class given.

Study the external features of the animal and explain how they have made the animal successively survive in its habitat or environment. These features should be clearly described by considering the following parameters. The shape, colour, smooth or rough, hairy or hairless, location, surface texture, length, and size.

Brief study of some body systems

Digestive system This is the system of organs that are involved in the process of digestion, storage, absorption, egestion and ingestion. It is divided into two parts, the alimentary canal (gastrointestinal tract) and associated organs. The alimentary canal is made up of digestive organs starting from the gullet to the anus. Associated organs consists of organs that functionary help the alimentary canal to carry out digestion by producing juices containing substance like enzymes which enhance digestion. Such organs are the liver, pancreas, gall bladder, and salivary glands. Other structures that do not produce juices but help in digestion are the tongue, and teeth. The spleen though physically attached to the stomach, it is not among associated organs because it has no digestive function. It just stores blood.

Reproductive system This is a system of organs that carry out the function of sexual reproduction. For the male mammal, it consists of testes, epididymis, vas deferens (sperm duct), seminal vesicles, prostate gland, urethra, Cowper's gland, and the penis.
For the female mammal, it consists of vagina, uterus, fallopian tubes, and ovary.
For flowering plant, the reproductive system is found in the flower and consists of the stamen (male organs) and carpel or pistil (female organs).
Excretory system This involves organs that remove metabolic waste products from the body. The specialized organs for excretion in animals are the kidneys, malpighian tubules and lungs. In addition, mammals excrete small amounts of urea, salt, and water from the skin in sweat as well. The excretory organs are connected to numerous tubules and urinary bladder through which the wastes pass to external environment. The tubules together with the excretory organs form excretory system.
Circulatory system This involves a net work of vessels and the heart that pumps the blood. The vessels that carry blood from the heart to the body tissues or supply the body tissues with blood are called the arteries. The ones that drain or remove blood from the body tissues and carry it back to the heart are called the veins. The vessels that remove blood from the heart or drain the heart are the arteries and the ones that supply the heart with the blood are the veins.

THE COCKROACH

Classification of a cockroach

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Dictyoptera
Family:	Blattidae
Genus:	Periplaneta
Species:	P americana, (africana)

Identification

The phylum of a cockroach is an **Arthropoda** due to the possession of **exoskeleton, segmented body** and **jointed limbs.** Segmentation increases flexibility. Its class is Insecta due to the possession of **three main body parts** (Head, Thorax and Abdomen), **three pairs of limbs, a pair of antennae,** and **three thoracic segments** (pro-thorax, meso-thorax and metathorax)

Shape and appearance of the body:

Shape:

The body is dorso –ventrally flattened and its abdomen is expanded in the middle. The significance of flattened body easily enter cracks or crevices to escape predation

Appearance:

The animal is pale brown in colour on the dorsal surface beneath the wings, and dark brown on the ventral surface. Its exoskeleton is waxy and glossy (smooth). The significance of the brown colour is for camouflage in order to escape predation. The waxy nature of its body surface prevents desiccation, as it is water repellent. The glossy exoskeleton is for easy escape from the enemies.

Habitat and habits:

Habitat:-

Dark cracks and crevices of walls especially in the vicinity of warm places.

Habits: They are nocturnal, emerging to feed only at night. They feed on a variety of organic materials including household property like paper and cloth. Cockroaches run very fast and they can fly due their long hind limbs.

Adaptation of the cockroach to its environment:

- Body is dorsoventrally flattened to enable it enter into small cracks to avoid predation.
- The sharp hard claws and arolium ensure firm grip on rough and smooth structures respectively.
- Their dark brown colour is for camouflage
- The long antennae are sensitive to touch in a large area around the body.
- Mandibles are hard, sharp and toothed to cut food.
- The body cuticle is waxy, preventing desiccation of the animal.
- The spines on the limbs for protection.
- The hind legs are long for fast movement.
- The broad membranous inner wings for easy flight.
- The thick outer wings for protection against physical injuries.
- The segmented body for increased flexibility.
- The compound eyes for increased sensitivity to sight.

The head and mouth parts

Head:

The head is small and clearly viewed from the ventral side. It is separated from the thorax by a short neck and limited in movement posteriorly by an enlarged tergum of prothorax.

It has compound eyes which are in meshes of ommatidia, large, kidney shaped, black in colour and are situated dorsolaterally at the head. The location of the eyes gives the animal a wide field of view in its habitat. The eyes are enlarged to increase the surface area for receiving light. The black colour of the eyes increases the ability of the eyes to absorb light for easy seeing.

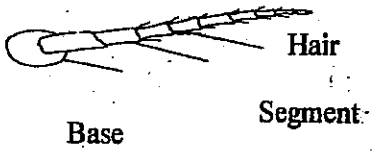
The head bears one pair of antennae which is characterized by having abroad base, being hairy, long to the length of the whole body, segmented, and tapering anteriorly.

Adaptation of antennae to their function

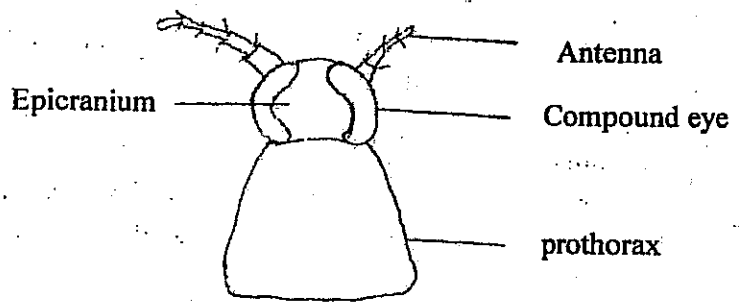
- They are long to sense a large area around the body.
- They are hairy to increase sensitivity.
- They are jointed / segmented to increase their flexibility.
- Are tapering for balance.
- Broad base for firm attachment.
- It has socket at the base for increased flexibility.

Note Segmentation of the antennae at the base is uneven for females and even for males. The anterior end of the male cockroach is pointed while that of the female is blunt.

The drawing of the antenna

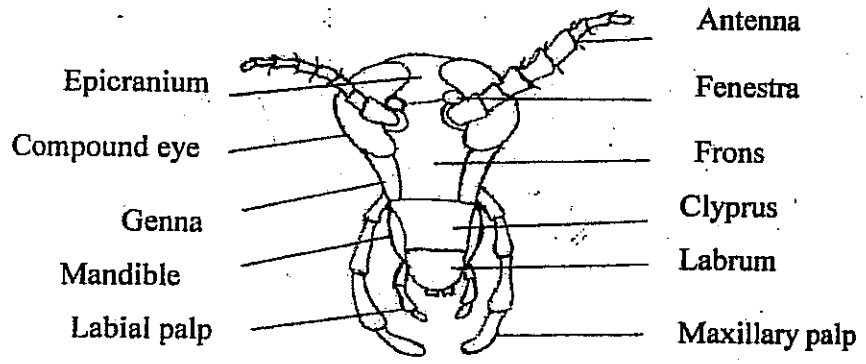


The drawing of the dorsal view of the head and prothorax of the cockroach



When the head is viewed from the dorsal side, the base of the antennae and their first segments are not observed. But the kidney shaped black compound eyes are observed clearly.
Note. When the specimens are viewed from the dorsal side, the sides of the specimen match with those of the observer. In other wards, the right side of the specimen is on the right side of the observer.

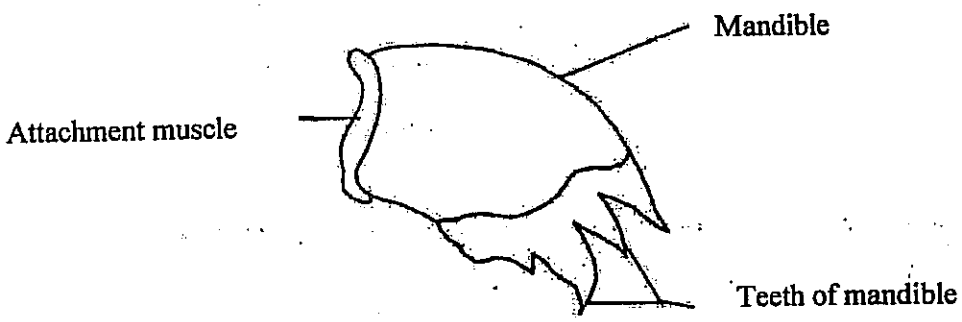
The drawing of the ventral view of the head of the cockroach



When the head is viewed from the ventral side of the animal, the base of the antennae is observed with their first segments covering part of the compound eye.

Mouth parts:
It consists of a pairs of the mandibles and maxillae. It also consists of a labium (lower lip) and a labrum lower lip).
The Mandibles: They are two in each animal. They are hard, attached to the body by a tough muscle, and have a toothed sharp edge. The sharp toothed edge of the mandibles is for cutting and crushing the food materials.

Structure of mandible

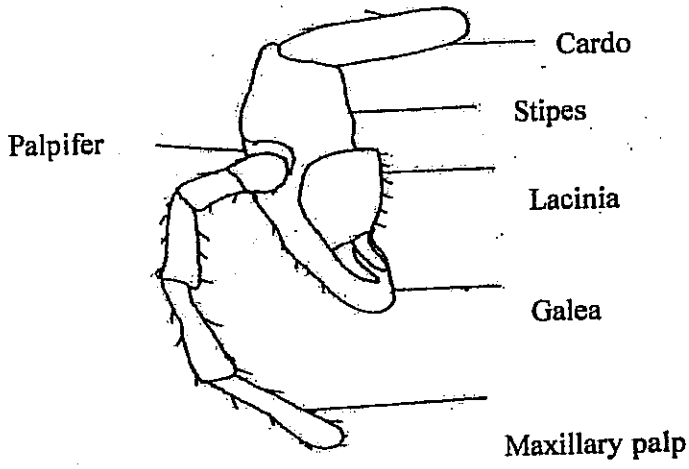


Maxillae

These occur immediately behind the mandibles and consist of hairy, segmented and long maxillary palps. It also consists of sharp edge, hooked galea and lacinia, cardo and stipes. Its function is to sense hold and push the food into the mouth. It is adapted to its function by; having;

- Having segmented and long palps for pushing / grasping food into the mouth.
- Being hairy to increase its sensitivity to food
- Having the lacinia and galea are hooked for holding food
- Having lacinia has sharp edges for cutting food

Structure of the maxilla



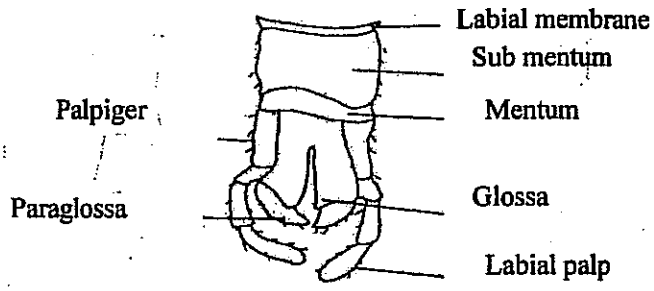
Labium

This is made up of three proximal segments called submentum, mentum, palpiger, glossa and paraglossa. It is used to sense, cut and pushing food into the mouth.

It is adapted to its function by;

- Having hairy labial palps to increase sensitivity to food
- Having sharp glossa for cutting food
- Having segmented labial palp for flexibility

Structure of the labium



The thorax and abdomen

The Thorax:

The thorax is divided into three segments, the **prothorax, mesothorax,** and **metathorax,** in that order from anterior to posterior, each bearing a pair of limbs.

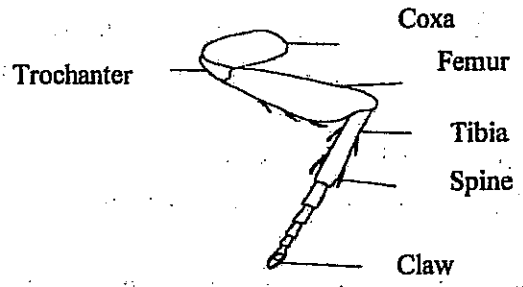
Each limb consists of Coxa which is broad, muscular and flattened, the small triangular trochanter, a long and muscular femur, tibia, and a distal foot consisting of five jointed tarsus of varying length which reduces downwards.

The foot bears spines for attachment. It is segmented for increased flexibility. Each of the first four segments bears sticky pad called plantula for easy moving on slippery surface. The last foot segment bears arolium located between the claws. The glandular pad called arolium is enlarged to provide a large area for attachment / gripping on the slippery surfaces. Arolium also produces sticky substances for attaching on slippery surface. The claws are long, pointed and tapering, hard, and curved for easy attachment on rough surfaces and defense.

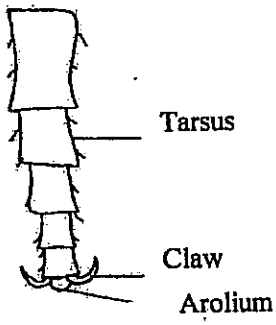
The lower side of the femur bears spine which are arranged in rows. The tibia bears also the spines which are randomly distributed.

The spines are long, pointed, and curved inwards. The spines are long and pointed for easy defense by pricking the enemy.

Structure of the hind leg of a cockroach:



Front view of the foot **Posterior view of the foot**



The mesothorax and metathorax each bears a pair of wings. Those on the mesothorax are brown, opaque and thick to offer protection to the wings on the metathorax. Mesothoracic wings are called **outer wings (elytra)** due to their position while the Metathoracic wings are called **inner wings (flying wings)** for a similar reason.

The outer wings have three main veins branching into small parallel veins which are spread allover the wings. It has few net works of veins at lower distal end of the wings.

The wings on the metathorax are broad, notched, folded, membranous/ thin and net veined. They are supported by a network of veins. Inner wings have three main veins that branch into a net work of veins which are spread allover the wing. The veins also allow circulating of air hence making the wings light for flight.

Two pairs of spiracles exist on the thorax; one pair between the prothorax and mesothorax and the other between the mesothorax and metathorax.

NB; The wide spread of the veins provides enough support and a large surface area for circulation of gases.

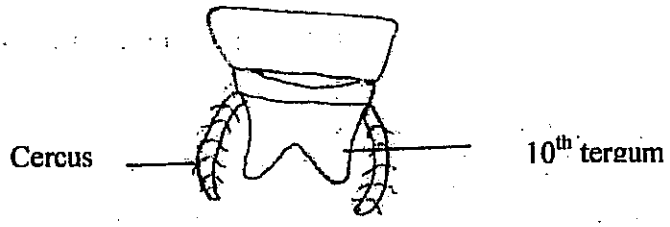
The Abdomen:

The abdomen consists of ten (10) segments, though not all are visible.

The first seven segments are easily visible in both sexes; the 7^{th} tergum almost completely overlaps the 8^{th}. The 9^{th} tergum is narrow compared to the 7^{th}. The 10^{th} tergum is flat and broad and divided. From the base of the 10^{th} tergum, a pair of segmented, hairy, tapering and elongated cerci project

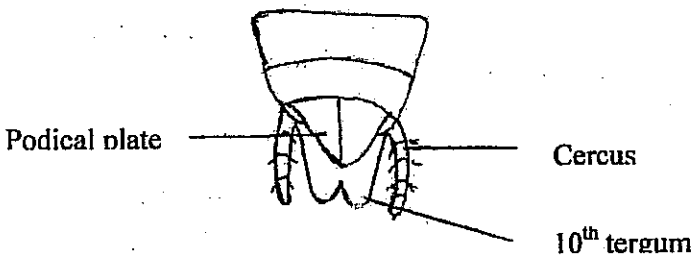
- The abdomen of the male cockroach is narrow compared to that of the females.
- The 9^{th} tergum of the males bares a pair of external genetalia called styles which are absent in the females.
- The female cockroach bears Podical plates which are visible on the ventral side of the abdomen. The Podical plates are missing in the males.
- When the 10^{th} tergum is lifted upwards, reproductive gonapophyses structures are exposed. The shape of the gonapophyses varies with the sex. They are pointed in the males and blunt in the females. The gonapophyses are external structures. They are just covered by the 9^{th} and 10^{th} segments in the males, or covered by 10^{th} and Podical plates in the females.

Dorsal posterior end of the abdomen



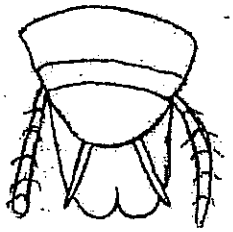
From the dorsal view, podical plates of the female cockroach are not seen. But however the styles of a male cockroach protrude beneath the last abdominal segment.

Ventral posterior end of the abdomen of a female cockroach



From the ventral side the attachment of the cerci is not visible. Podical plates are seen. The podical plates protect the cacoon. The abdominal end of the female cockroach is broader than that of the male cockroach.

Ventral posterior end of a male cockroach



Body systems of the cockroach

Digestive system

It consists of the alimentary canal / gut and the associated. Alimentary canal starts from the gullet down to the anus. It consists of gullet, crop, and gizzard, digestive caeca, mid gut, ileum, hind gut (colon), and the anus.

The gullet

It is a tubular and elongated structure. It is made up of muscular wall with a smooth inner lining. The longest part of it is found in the thoracic region. The contraction of muscular wall moves the food to the crop. The smooth lining eases movement of the food.

The crop

The gullet dilates to form the crop. It is found in the abdominal region. It is enlarged, conical shaped and consists of elastic muscular wall with smooth folded inner lining and wide lumen.

Its functions are storage and for preliminary digestion and absorption of food. The crop is adapted to its function by having;

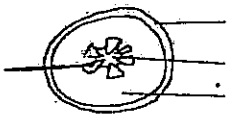
- Folded inner lining is to increase the surface area for digestion of food.
- Elastic muscles to increase storage of food.
- Smooth inner lining for easy passage of food.

The gizzard

It is a short, round, and muscular organ with a narrow lumen. It has many extensions called digestive caeca. Its inner lining is folded and ridged /rough. The gizzard is adapted to its function by having;

- Folded inner lining to increase the surface area for digestion.
- Six ridges /teeth like structure for physical digestion of the food.
- Muscular wall to generate powerful contraction during crushing of the food.

Cross section of the gizzard



The digestive (mesenteric) caeca

These are many, tubular, long, cylindrical, flexible, and anteriorly tapering structures projecting from the gizzard. Their functions are secretion of digestive enzymes for digestion of food and absorption of digested food. It is adapted to its functions being long and many to increase the surface area for digestion and absorption of digested food.

The mid gut

This is the thin walled long tubular organ attached to the gizzard. It is the place where most of the digestion and absorption of digested food takes place. The thin wall eases absorption of digested food. Its length provides a large surface area for digestion and absorption of digested food.

The ileum

It is short and thin. It bears numerous thin tubules called malpighian tubules which do not have any digestive function. It is used for removal of excretory waste products
From the haemolymph and empty it into the gut where is removed together with the faeces. Thus malpighian tubules are not part of the alimentary canal; they are just accessory to it (just attached to it without having any digestive function). Ileum connects the mid gut to the hind gut. It is still used for digestion and absorption of digested food.

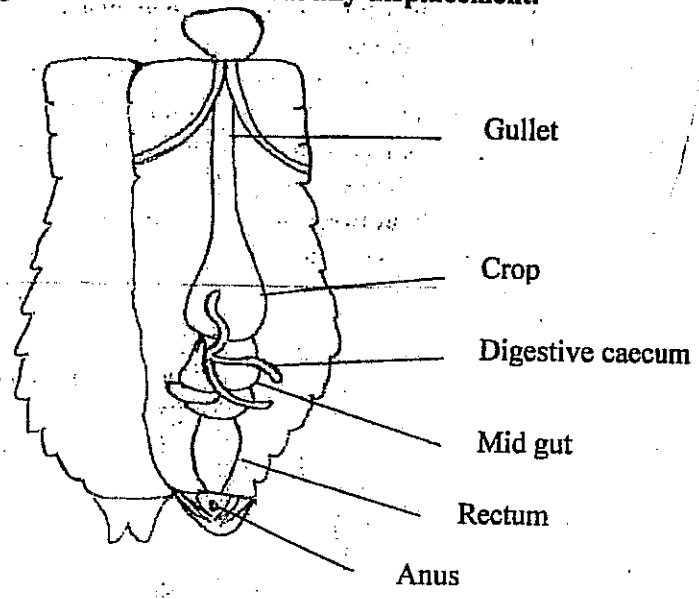
The hind gut (colon)

This part of the gut contains waste materials. There is neither digestion nor absorption of digested food. It is only water absorbed from the colon to increase water conservation. The function of the colon is to allow water absorption and for sto passage of wastes. The colon is long to increase surface area for water absorption. It has a large lumen for easy passage of wastes.

The rectum

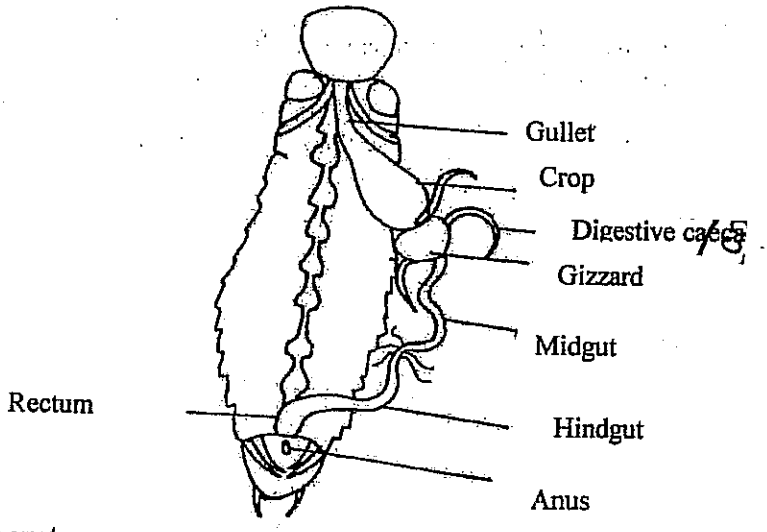
It stores wastes. Contraction of its wall leads to removal of unwanted materials from the body through the anus. Anus is an external part of the alimentary canal. Rectum has a wide lumen to increase storage of the wastes.

A drawing of the cockroach showing features of alimentary canal after opening the cuticles and clearing all the fats but without any displacement.



Without any displacement, gizzard, hind gut and ileum are not observed. Thus they should not be included in the drawing. Inclusions of any or all the three features make the drawing null and void (NA) and hence lose all the drawing and labeling marks.

Structure of the alimentary canal after displacing it to its right



Circulatory system

The cockroach has simple circulatory system made up of the long tubular heart, aorta, and the alary muscles. The alary muscles control blood movement through the heart. All those structures are found on the dorsal cuticle.

The nervous system

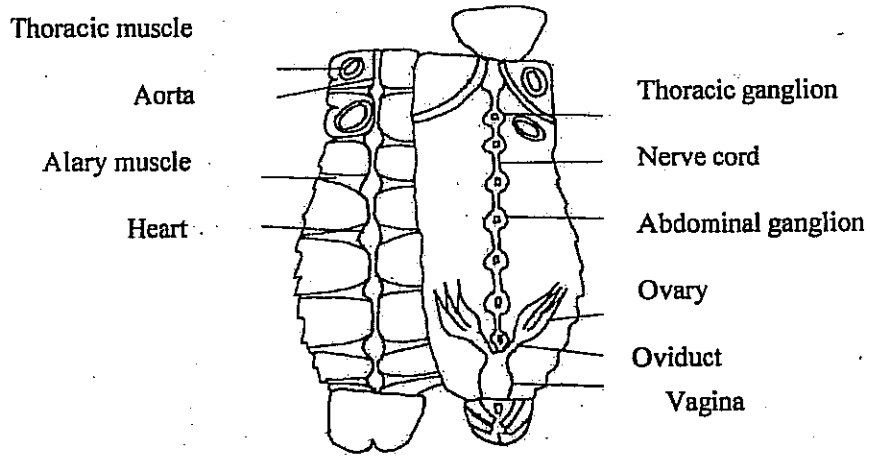
It is the simple system consists of the nerve cord and ganglia. Three ganglia are found in the thoracic region and six of them are found in the abdominal region. The nervous system is found on the ventral cuticle.

The reproductive system

The male reproductive system consists of the mushroom shaped gland which produces the male gametes, and ejaculatory duct for passage of the gametes.

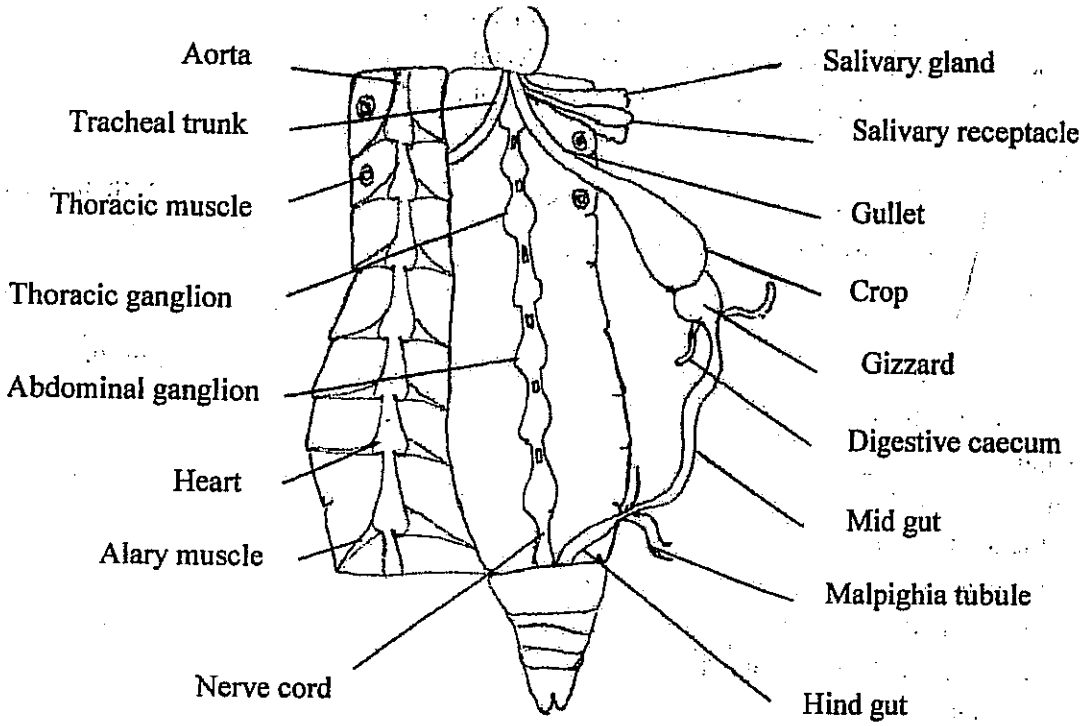
The female reproductive system consists of the vagina which receives the male gametes, The vagina branches into two oviducts, the left and right oviduct where fertilization takes place. Each oviduct divides into eight ovaries which produce the ova. The fertilized ova are wrapped into a cacoon called ootheca which is stored and carried by the Podical plates. The reproductive system is found on the ventral cuticle.

A drawing showing internal structures on the dorsal and ventral cuticle after removing alimentary canal of a female cockroach



The cuticles may not be fully opened. It is thus necessary to master the location of each and every feature in the cockroach. This helps to draw correctly in case a part of the cuticles is to be opened. For example the thoracic cuticles and the five adjacent abdominal segments can be opened to expose the internal structures as indicated in the drawing bellow.

A drawing of the cockroach showing internal structures after opening thoracic and the five adjacent segments and displacing the gut to right side

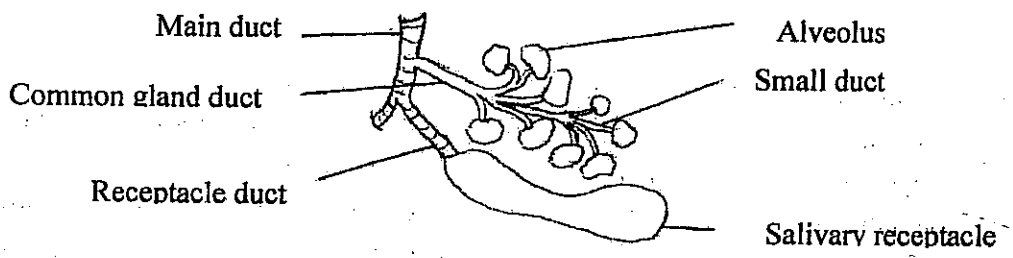


Note inclusion of the rectum and reproductive structures, gonapophyses, styles and circus makes the drawing null and void (NA given for drawing)

Salivary gland

It is found in prothoracic region and it consists of salivary receptacle, salivary gland, and salivary ducts. Salivary gland is divided into numerous, round, and small alveolar shaped secretary parts. The numerous secretary parts increase the surface area for secreting digestive juice (saliva). The common duct of the salivary gland, branches into numerous small ducts which are spread allover the salivary gland. This arrangement increases the surface area for collecting saliva. The main common duct for receptacle branches into two large ducts. Each duct collects the saliva from the salivary receptacle. Salivary receptacle is structurally elongated and large in order to store much saliva.

A drawing of the salivary gland under medium power



Adaptations of salivary gland to its function

- It consists numerous secretary parts (alveoli) to increase surface area for secreting saliva
- It consists of large salivary receptacle for storing more saliva
- It consists numerous ducts to easily collect more saliva
- All ducts fuse into one main ducts to control flow of saliva

AMPHIBIANS

The frog and the toad are selected for study of amphibians because of their relative abundance and convenient size. They have both aquatic and land characteristics.

Habitat:

Frog:

It is usually found in grass near water or in damp places and frequently swimming in ponds or slow flowing streams.

Toads:

They are usually found in the ponds and moist places of land environment. Thus the habitat of the toads is aquatic and damp land areas.

It is aquatic habitat due to the following reasons.

- Its body is streamlined to reduce water resistance during swimming.
- Eyes are dorso-laterally located to maintain aerial contact when the body is submerged in water.
- The digits of hind limbs are webbed to increase the surface area for swimming.
- Nostrils are anteriorly located on the top of the head to maintain breathing when the body is submerged in water.

The habitat is damp terrestrial areas due to the following reasons;

- The body is streamlined to reduce air resistance during locomotion.
- The eyes are dorso-laterally located for wide field of view on land.
- The hind limbs are muscular and long for leaping long distance.
- The moist skin for ease cutaneous breathing on land.
- Its skin is dark brown for comouflage

N.B Toads and frogs are called amphibians because they have moist skin and webbed toes of hind limbs. However, the toads are more adapted to land than the frogs, only going into water during breeding seasons. On the other hand, most frogs live in water for the rest of their life.

Adaptations of the toads for survival in its habitat:

All structures of the toads and frogs are modified to make living of the animals in their habitat a success.

The Skin:

- It is thin and moist to allow gaseous exchange.
- It is warty and slimy making it slippery to touch and hence allowing the animal to escape easily from predation.
- The dull colour (green for frog and dark brown on the dorsal part and pale brown on the ventral part of the toad) helps them to camouflage efficiently in their environments escaping predation.

- It is tough for protection
- It contains poison glands all over the body, with two main ones on the head, for protection against predators.

Skin attachment to the body wall:

- The skin is loosely attached to the body wall by loose areolar connective tissue, containing fluid filled large spaces. This increases gaseous exchange over the skin. The loose attachment is mainly on the ventral abdominal region
- The skin is firmly attached to the head and at the limb joints for support during locomotion.

The nature of the skin

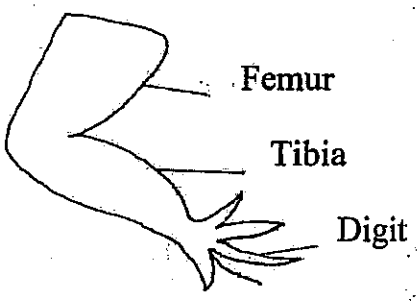
- It is thin to ease diffusion of gases.
- It is moist to ease gaseous exchange by dissolving the gases.
- It has numerous capillaries on inner surface to increase the surface area for gaseous exchange. The pattern of the blood vessel is that the one main blood vessel, musculo cutaneous vein, emerging from the arm pits divides into numerous capillaries which are spread all over the skin. The nature of blood vessels is that the small vessels are closely attached to the inner surface of the skin to shorten the diffusion distance hence easing gaseous exchange.

The Limbs:

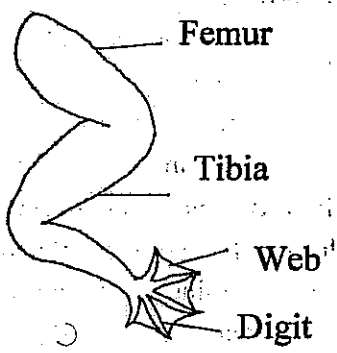
Differences between fore and hind limbs:

FORE LIMB	HIND LIMB
Short and stout	Long and folded
bears in four digits	bears in five digits
No webs between the digits	Toes have webs between them
Divided into two regions	Divided into three regions
Less muscular	more muscular

Drawing of the fore limb



Drawing of the hind limb



Adaptations of the limbs to their functions:

- The fore limbs are short and muscular to absorb the shock on landing. They also support the body off the ground during resting.

- The hind limbs are long, muscular and highly folded into three regions to provide a great forward thrust to the body during long jumping on land and swimming in water.

  The length is for long jumping. The muscular nature is for greater thrust force.
- The hind limbs have webbed digits to provide a large surface area, for easy swimming.
- The hind limbs have long claws firm gripping on land.

NB; Each limb has a foot at its distal end. The hind feet are characterized by having; Webbed toes to increase the surface area for swimming. Five and long toes for firm gripping. Toes with claws for firm gripping on rough surface Jointed digits for flexibility.

The Head:

Shape and position:

- It is triangular with narrow apex and broad posterior and joined to the trunk directly (lacks a neck).
- It is dorso- ventrally flattened and tapers interiorly.

Significance of the head shape:

The triangular shape and position of the head gives the animal a streamlined body that reduces water and air resistance during movement.

It is dorsal-laterally flattened for floating.

The Head features:

Nostrils:

The nostrils are a pair of small rounded openings located interiorly on the head and above the mouth. This allows smelling and ventilation when the rest of the body is submerged in water.

The Eyes:

The eyes are large, round and protruding / bulging or dorso laterally located at the head anterior to the each ear drum. They have poorly developed eyelids. The upper one is stiff and immovable while the lower one is modified by developing a third membrane which is thin, transparent and movable called **nictitating membrane.**

Significance of the eyes:

- The dorso lateral location of the eyes gives the animal a wide field of view in its habitat.
- The nictitating membrane cleans the eye and gives added protection without interrupting the continuity of vision.

The Ear-Drum / Tympanic Membrane:

Shape, Structure and Position

It is a prominent, circular, tough, and stretched membrane, which is laterally located at the posterior end of the head posterior to each eye.

Significance of the ear drum:

Its tough nature makes it resist external pressure without rupturing.

Its being circular gives it a wide surface area for receiving sound waves.

It is stretched to easily vibrate upon receiving sound waves to make hearing easy.

The mouth

It is anteriorly located on the head. It has a wide gape for ingesting prey of large size

It has teeth which are uniform in size and a tongue.

The Tongue:

The tongue is long, muscular, flat, elastic, forked anteriorly and sticky. It is attached interiorly to the floor of the buccal cavity and folds to the posterior of the buccal cavity. It is used for trapping insects for food. It has a wide base. On its ventral surface, it has a tributary of lingual vein running in the middle along the tongue. The main vein branches into smaller veins on either side.

Adaptation of the tongue to its function:

- Long and elastic to trap insects at relatively far distances for food.
- Sticky to trap small animals (insects) easily, which are not able to escape once, they fall on it.
- It is muscular to easily stretch out (flick out) and trap insects.
- Flattened to increase the surface area for trapping the prey.
- It has numerous glands that secrete sticky mucus to easily trap the prey.
- It is forked anteriorly to easily trap the prey.
- Has a wide base for firm attachment.
- It is attached to anterior end of the lower buccal floor to easily flick out and trap insect at a long distance.

Sex identification:

Distinction between the sexes is not very obvious since there are no external genitalia. However, males and females can be distinguished by the following characteristics.

Characteristics of Males:

- Usually slender – bodied
- Skin underlying the throat is usually white.
- Develop a rough black, warty patch on the ventral surface of the first (pre-axial) finger on the forelimb called the nuptial pad.

Characteristics of females:

- Broad abdomen, bloated with eggs especially during the breeding season.
- Skin underlying the throat is creamy white /grey.

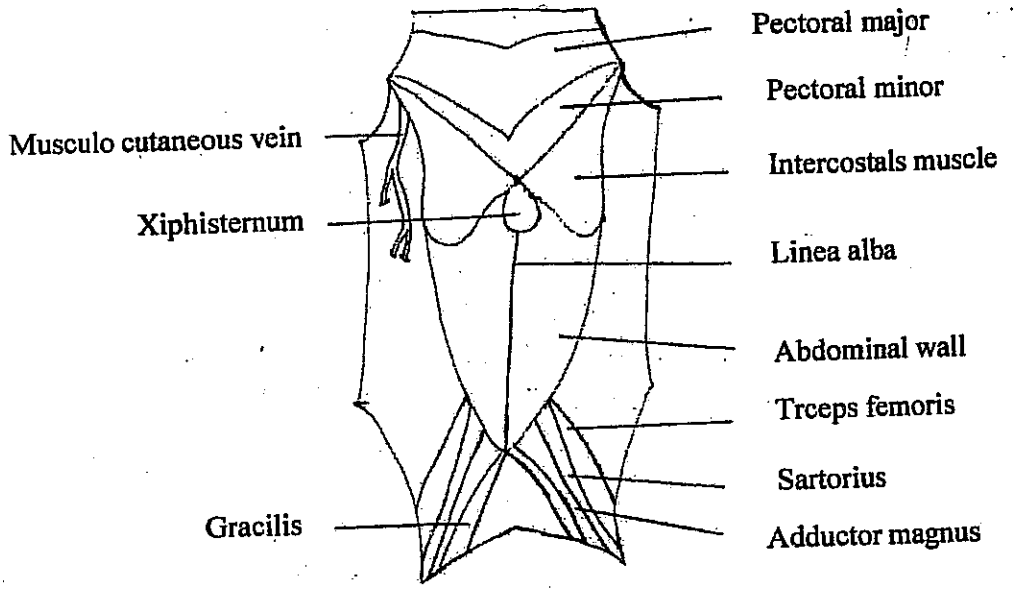
N.B Don't write 'no nuptial pad' on first finger even when it is true that it is absent except when you are comparing the two specimens.

Classification:

	Frog	**Toad**
Kingdom:	Animalia	Animalia
Phylum:	Chordata	Chordata
Class:	Amphibia	Amphibia
Order:	Anura	Anura
Genus:	Rana	Bufo
Species:	tempolaria (Common Frog)	regularis (Common Toad)

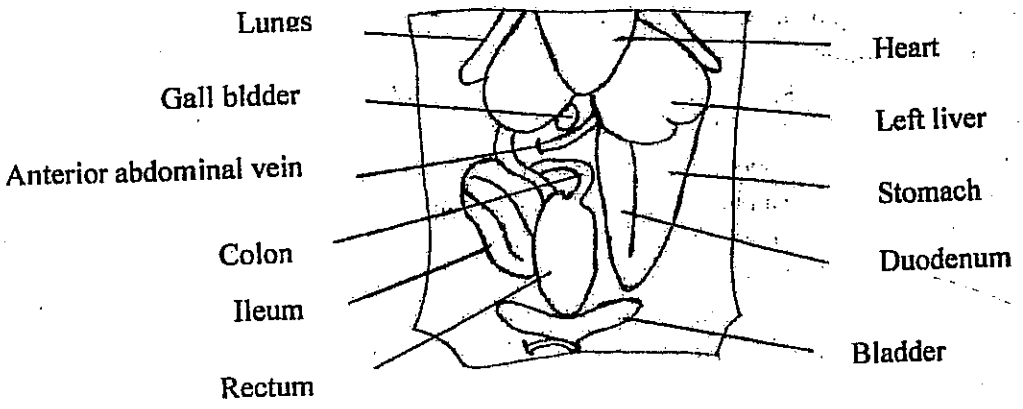
To dissect the toad, lay it on the board with the ventral side upper most. Stretch the limbs and pin them firmly on the board. Open and loosen the skin off the underlying body muscles. Pin the skin to the sides. Take note of the exposed thoracic muscles, xiphisternum, linea alba, abdominal wall, thigh muscles and cutaneous vessels. The neatly draw and label the dissection.

A drawing of a toad showing the body muscles and cutaneous vessels that is posterior to fore limbs and anterior to knee joint of hind limbs



When you open the animal to expose internal thoracic and abdominal features, note the absence of the ribs. This leads to overlapping of some thoracic and abdominal features. Without displacement, the thoracic observed features are only the heart and lungs and the abdominal features observed are liver, gall bladder, anterior abdominal vein, ileum, stomach, duodenum, rectum and bladder. Without displacement of any feature draws and label the dissection.

A drawing of the visceral features that are between fore and hind limbs without displacement of any feature of the toad



NB From the drawing above, the stomach and duodenum are found on the left side of the abdomen. Other organs found on the left side but not visible without displacement are spleen, left kidney, left testis / ovary, ureter, ovisac/ vesicular seminalis and oviduct.

The digestive system:

It is divided into two parts, the alimentary canal and associated organs. The alimentary canal starts from the gullet up to the anus. The associated organs involves any structures that functionary help the alimentary canal to digest and absorb the digested food like the pancreas, liver, and the gall bladder.

Mouth and Buccal Cavity

The mouth is terminal and very wide, extending back as far as the tympanic membrane on each side. This provides a wide gape for the ingestion of large pieces of food material.

The upper jaw bears a row of numerous maxillary teeth which are structurally uniform, small, pointed, conical shaped and curved inwards. The maxillary teeth are used for holding and preventing the prey from escaping. They are adapted to their function by being pointed numerous and curved inwards.

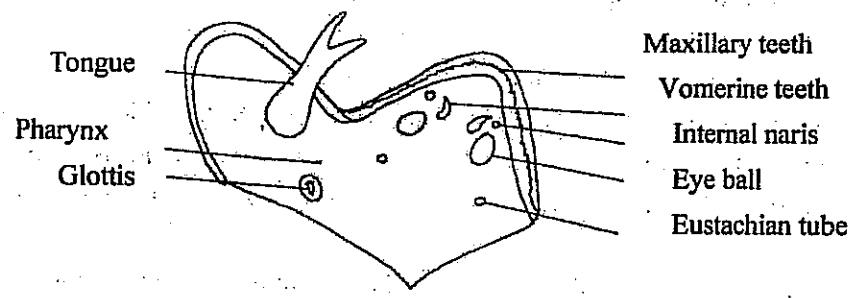
The upper floor bears pores called **internal nares** (singular; **naris**). They are two small round openings, guarded by valves, through which air enters the buccal cavity. Each is found on the sides of the vomerine teeth.

The vomerine teeth protrude out of the upper buccal floor above the eye balls and between the internal nares. They are many / crowded, pointed, and curved inwards. Their function is to prevent escape of the prey.

The buccal cavity consists of strong jaws which grip the large prey to prevent it from escaping.

Two large oval protrusions on the roof indicate the positions of eyeballs, which play a part in swallowing.

Drawing showing the internal structures of the buccal cavity



The alimentary canal

Parts of alimentary canal and their characteristics

The Oesophagus

This is a narrow tubular long feature with thin elastic wall. Its inner lining is smooth and ciliated for easy swallowing.

Adaptation of gullet its function

It has smooth inner lining for easy passage of food materials.

It has thin and elastic walls to extend easily to allow passage of large prey.
It has narrow lumen for easy swallowing.

Stomach:

- It is elongated and thin walled
- Internally, it is folded longitudinally, both to allow distention and to increase the surface area for secretion of gastric juice / digestion.
- Posteriorly, a slight constriction indicates the position of the pyloric sphincter and marks the end of the stomach. This controls the exit of food from the stomach.
- Anteriorly, the constriction that controls the entry of food into the stomach is called cardiac sphincter.

The ileum

It is very long, coiled, narrow, and tubular and made up of thin walls. It has numerous capillaries which closely attach to it. The numerous capillaries join up to form one intestinal vein which is a branch of hepatic portal vein. Ileum is used for digestion and absorption of digested food. It is adapted to its function by having;

- Narrow lumen for easy absorption by reducing diffusion distance.
- Numerous capillaries to increase the surface area for absorption of digested food.
- Thin wall to ease absorption of digested food.
- Coiled and long tube to increase the surface area for digestion and absorption of digested food.

The colon

It is a short, less coiled, thin walled, narrow tubular organ with a few capillaries. It used for passage of wastes and absorption of water molecules. It is adapted to absorption of water molecules by having thin walls and blood capillaries. It is also long to increase surface area for absorption.

The rectum

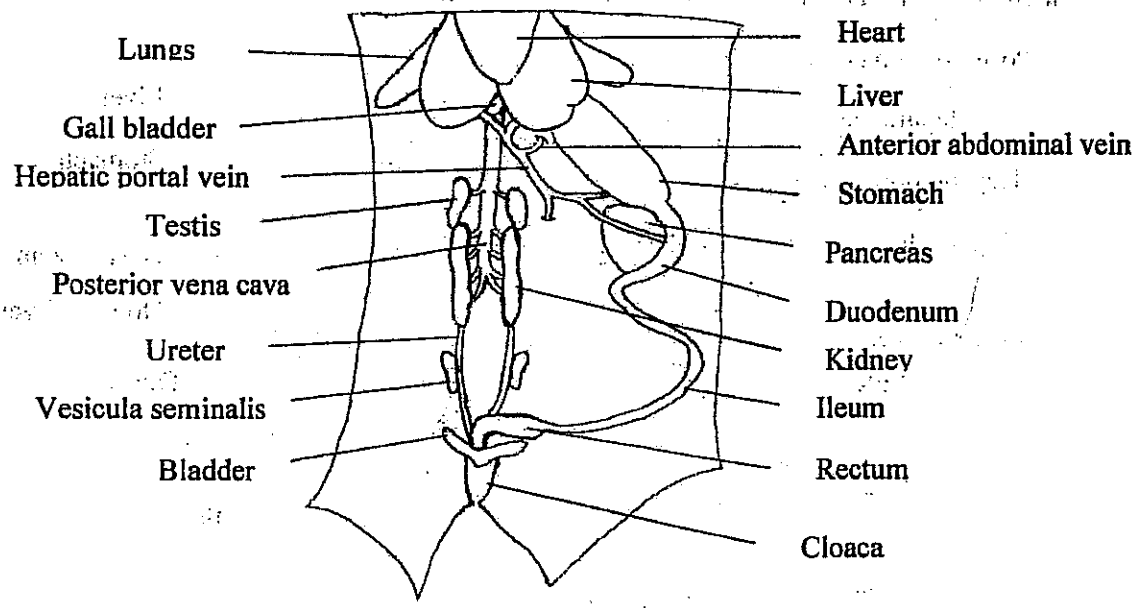
It is a short, thick walled, enlarged, and wide tubular organ found between the colon and the cloaca. It is used for storage of wastes / faeces / unwanted materials prior to elimination. Contraction of its walls causes egestion of the wastes.

NB The gullet, stomach and the duodenum are found on the left side of the animal (toad) while the ileum and the colon belong to no particular side. The rectum is in the middle way. The associated organs of the alimentary canal on the left side are the pancreas, and the left liver lobe.

Other organs that are found on the left side of thoracic and abdominal region which are not part of the digestive system are the spleen, left kidney, testis, ureter, vesicula seminalis, ovary, oviduct, ovisac and left lung.

Stretch the stomach and pin it to the left of the animal without tearing the pancreas and mesentery of the duodenum. Loosen the ileum and rectum by cutting their mesentery. Stretch the ileum and pin it to the left of the animal. Open pelvic girdle, clear off unnecessary materials to expose the features. Draw and label the dissection.

A drawing showing thoracic and abdominal features after cutting mesentery of ileum and rectum, opening of pelvic girdle and displacing the gut to the left of the toad



Vessels draining the alimentary canal and associated organs

Alimentary canal is drained by **hepatic portal vein** which branches into gastro duodenal vein which further divide into gastric vein draining the stomach, and duodenal vein draining the duodenum. Hepatic portal vein further gives another branch of intestinal veins draining the ileum, the splenic vein draining the spleen, and rectal vein draining the rectum. The hepatic portal vein divides into two branches, each of them joining a liver lobe. The liver lobes are drained by the hepatic vein which joins the posterior vena cava through which blood enters the heart.

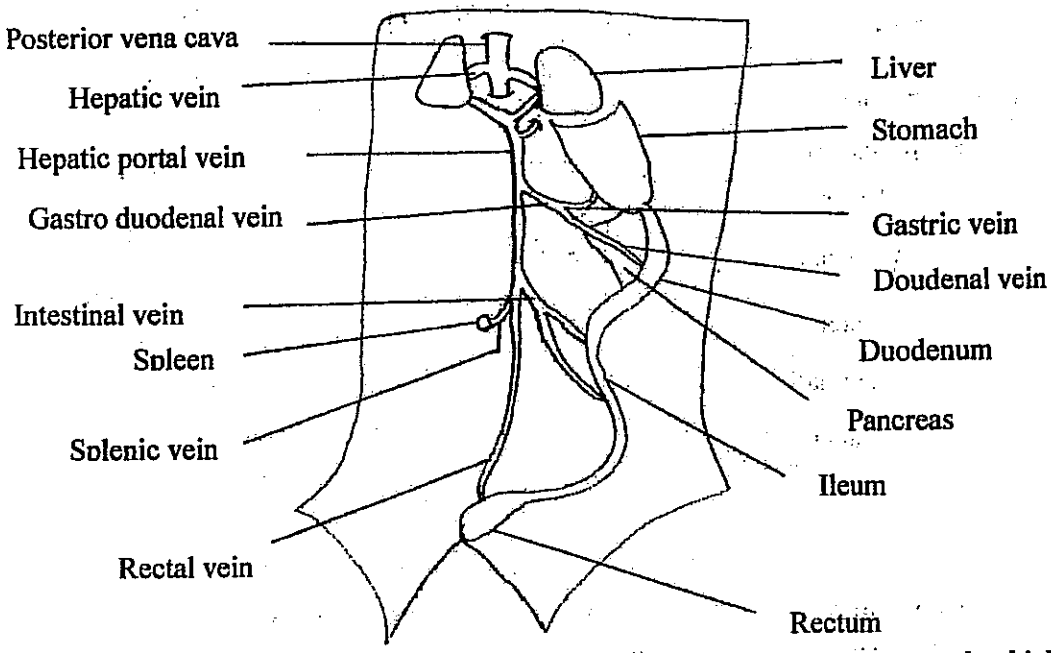
NB The hepatic portal vein has other branches which do not drain the digestive system, the splenic vein draining the spleen and anterior abdominal vein which drains the thighs. Intestinal vein of hepatic portal vein divides into numerous small capillaries which are spread along the long ileum to increase surface area for absorption of digested food.

Vessels supplying alimentary canal and associated organs

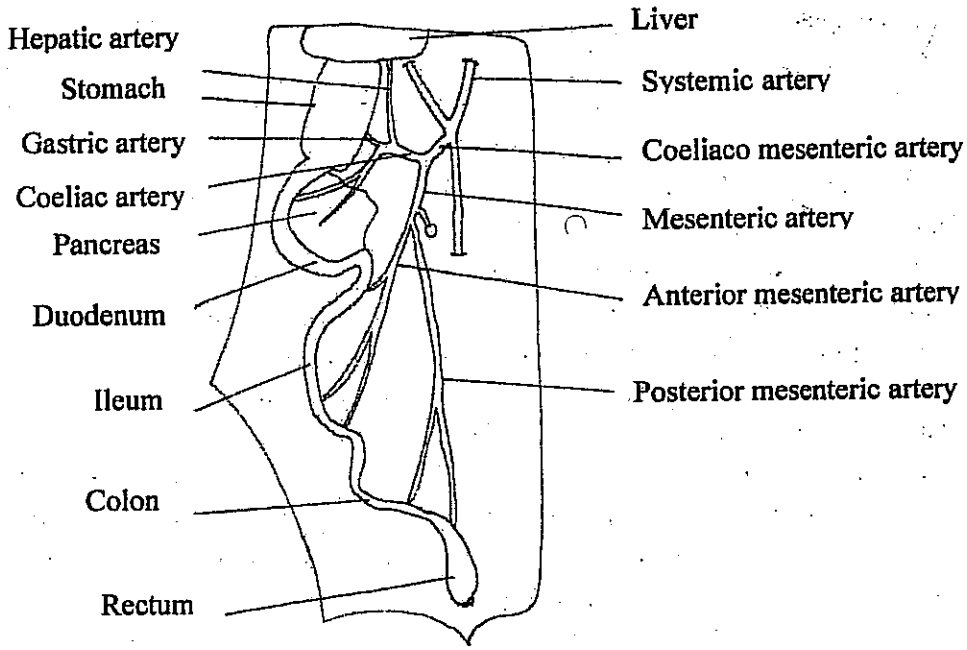
The main artery supplying the alimentary canal is the **systemic artery** which branches into coeliaco-mesenteric artery which future divides into coeliac and mesenteric arteries. The coeliac divides into hepatic artery supplying the liver lobe, gastric artery supplying the stomach, pancreatic artery supplying the pancreas, duodenal artery supplying duodenum. Mesenteric divides into splenic artery supplying the spleen, anterior mesenteric supplying the ileum and posterior mesenteric supplying the colon and the rectum.

NB The splenic artery supplies the spleen which has no digestive function. Thus should not be included in the drawing.

A drawing of the vessels draining alimentary canal displaced to the left and its associated and accessory organs in visceral region of the toad.



A drawing of a toad showing the vessels supplying the alimentary canal which is displaced to its right with its associated organs



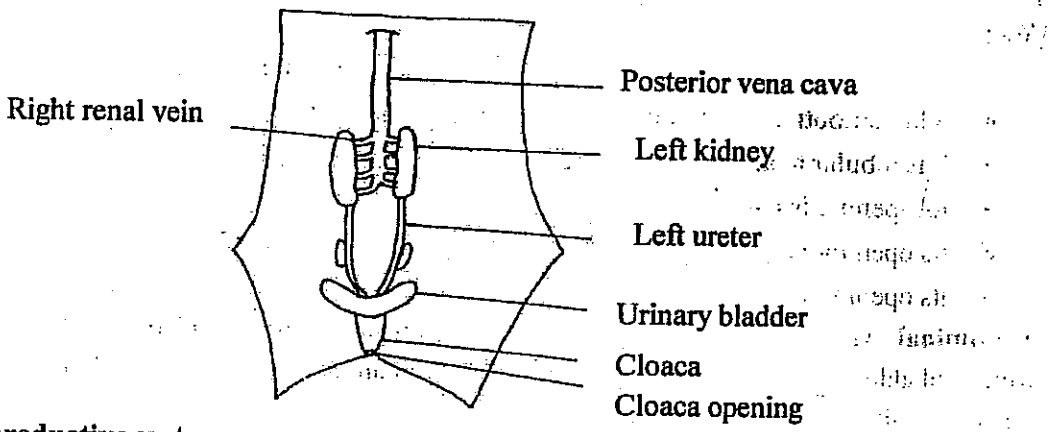
Excretory system

This is the system of organs that removes metabolic waste materials from the body. It consists of the following organs or features. The kidney, lungs, ureter (Wolffian duct), urinary bladder and cloaca.

The enlarged and elongated kidney filters the wastes from the blood to form urine. Urine flows through the long, tubular and thin ureter into the urinary bladder. The urinary bladder

which is membranous, broad and lobed allows temporary storage of urine before it passes into the cloaca. Then urine is then eliminated from the body through the cloaca opening which is narrow and constricted.

A drawing of the excretory system posterior to the liver and the vessels draining it



Reproductive system

This is the organs used for sexual reproduction. It involves the following features which vary with the sex of the organism.

The male reproductive system involves the testes, vasa efferentia, kidney, ureter, Vesicula seminalis and cloaca.

The ovoid, cream testes produce the gametes which pass through the vasa efferentia to the kidney tubules. The kidney tubules empty the gametes into the ureter then get stored in the vesicula seminalis until breeding occurs.

NB Some of the organs are used for excretion and reproduction hence they follow in both systems.

The female reproductive system is made up of the ovaries, oviducts/fallopian tube (mullerian ducts), ovisac and cloaca.

The membranous numerous flattened and irregularly lobed ovaries produce the ova. Thin long and coiled oviducts for passage of ova. Enlarged short ovisac stores ova before are laid. The cloaca is the passage for the ova to the exterior

NB The urinary ducts are separated from the reproductive system except the cloaca

NB A combination of the reproductive and excretory systems form urinogenital system

The body cavities

Body cavities of the toad are not distinctively separated. This leads to extending of some organs from one cavity to another. The toad is divided into four body regions the Head, Thoracic, Abdominal and Pelvic region.

The pelvic region This region mainly contains the pelvic cavity containing the cloaca. The region also contains vessels like the pelvic veins which fuse to form the anterior abdominal vein which pours blood from the thighs into the hepatic portal vein. It is not a so clear a region.

Characteristics of cloaca

It has narrow lumen, muscular elastic wall, smooth inner lining and narrow moist and constricted cloaca opening / aperture. Cloacal opening is dorsal laterally located at the posterior end of the middle line of the body trunk.

Adaptations of the cloaca to its function

- It has elastic muscular wall to allow passage of large materials.
- It has smooth inner lining for easy passage of materials.
- It is tubular to allow passage of materials.
- Its opening is narrow to regulate egestion.
- Its opening is constricted / folded to allow egestion of large of large size.
- Its opening is moist for easy egestion.

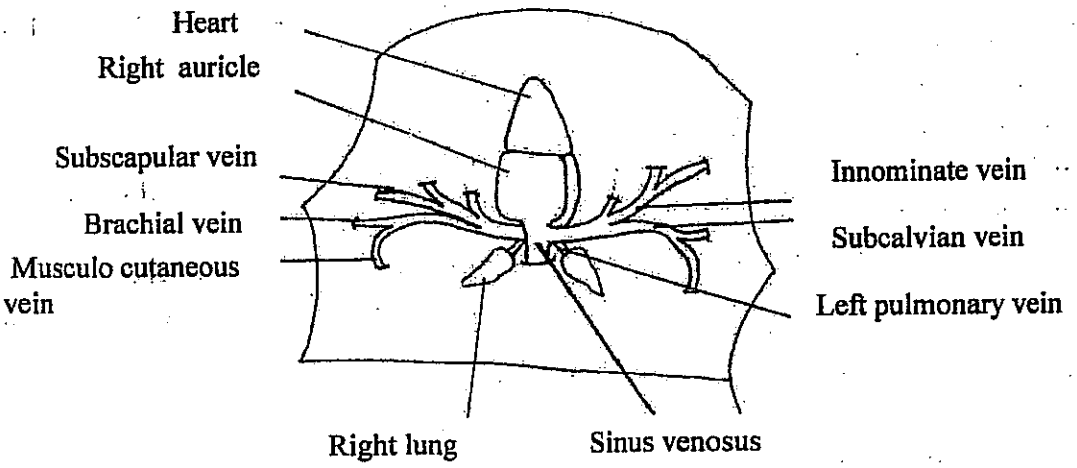
Abdominal region It stretches from the liver down to the urinary bladder. The liver and urinary bladder and other many organs between them are found in the abdominal region and hence are called abdominal features.

The thoracic region It mainly contains the heart and the lungs and the vessels found within the region. The vessels within the thoracic region are both veins that drain the region and the arteries that supply the region. Thoracic region lacks a diaphragm and the rib cage that would separate it from the abdominal and the head regions. Thus the lungs which are found in the thoracic region overlaps with the liver lobes which are found in abdomen

The vessels that drain the thoracic region are;

Pulmonary vein draining the lungs. Sinus venosus supplying the heart. Anterior vena cava, innominate vein, subscapular vein draining the shoulders, subcalvian vein, brachial vein draining the fore arm and the musculo-cutaneous vein draining the skin.

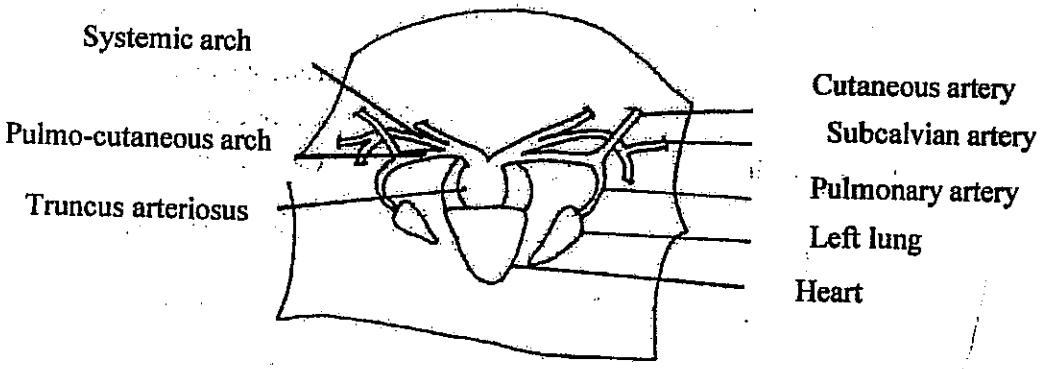
A drawing of thoracic organs and vessels draining the thoracic region with the heart displaced upwards



The vessels supplying the thoracic region are;

Truncus arteriosus, Pulmo-cutaneous arch, pulmonary artery supplying the lungs, cutaneous artery supplying the skin, Systemic arch, and subcalvian artery supplying the fore arm.

A drawing of thoracic organs and the vessels supplying the thoracic region



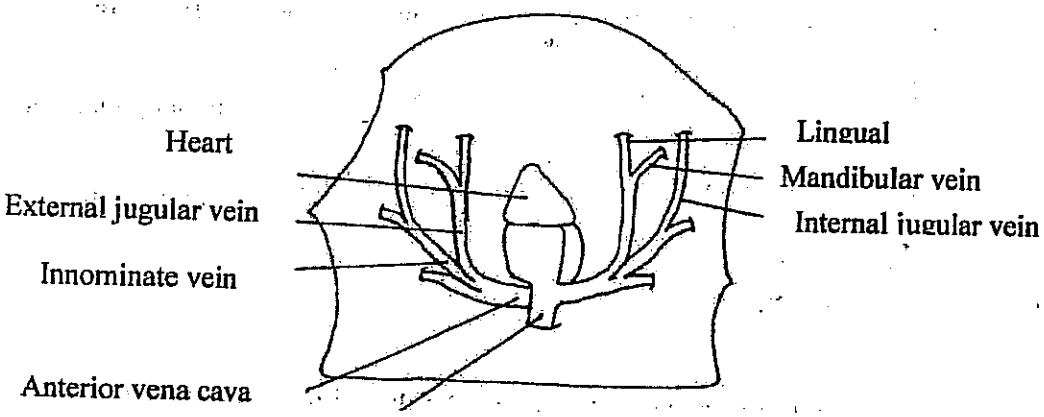
The head region

The toad lacks the neck. Thus there is no clear cut line between the thoracic and the head regions. However the head region starts from the jaws upwards.

The vessels draining the head region are;

Sinus venosus, anterior vena cava, Innominate vein, internal jugular vein draining the brain, eye and dorsal side of the head. External jugular vein, Lingual vein draining the tongue and Mandibular vein draining the lower jaw.

A drawing of the vessels draining the head region



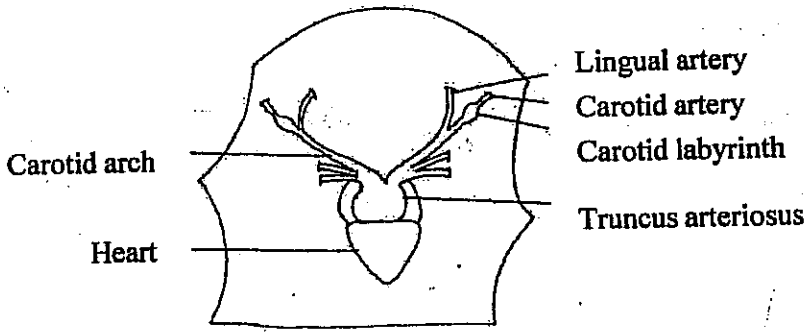
The vessels supplying the head region are;

Truncus arteriosus, Carotid arch, Lingual artery, the Carotid labyrinth, and Carotid artery.

The lingual artery supplies the lower floor of the mouth and the tongue.

The Carotid artery supplies the upper floor of the mouth and the brains.

A drawing of the vessels supplying the head region



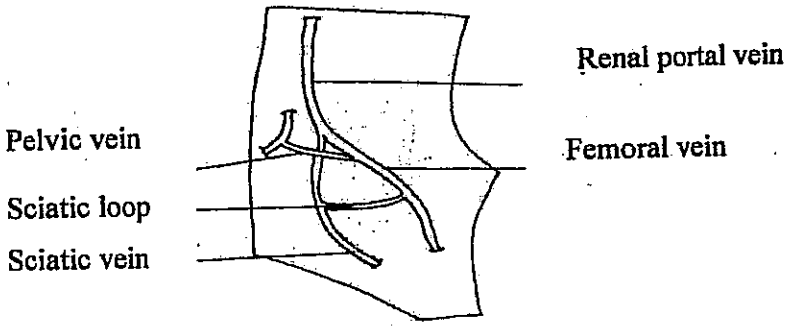
The hind limbs / thighs

The left and the right hind limbs have the same vessels or blood circulation. They are drained by the outer femoral and inner sciatic veins which are cross connected by sciatic loop. The femoral and sciatic veins join just inside the abdominal cavity to form renal portal vein which joins the kidney.

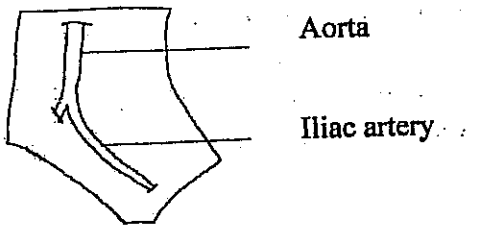
Another alternative route is a branch of the femoral veins, the pelvic veins, which join to form anterior abdominal vein. This passes forward in the mid line of the body just beneath the skin to join the hepatic portal vein immediately before its entry to the liver.

Hind limbs are supplied by the iliac arteries, branches of aorta, which eventually pass into the hind limbs, where are called sciatic arteries.

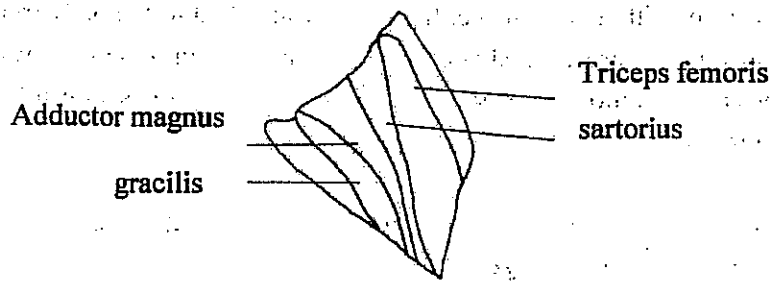
A drawing of the vessels draining the left hind limb back to the heart



A drawing of the vessels supplying the left hind limb from the heart



A drawing of the left hind limb muscles



The nervous system

It consists of the main spinal cord with 10 nerve fibers projecting from either side of it. The first nerve fiber, hypoglossal nerve, is connected to the head. The next two nerves are found in thoracic region (thoracic nerves). The next three are found in the abdominal region (abdominal nerves). The last four nerves connect to hind limbs. They join in the thigh to form sciatic plexus from which emerge the outer main sciatic nerve and the inner small cuccygeal nerve. All the spinal nerves are connected to the sympathetic cord from the brains at the sympathetic ganglia by the loop called ramus communicans

THE RAT

Classification

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Rodentia
Family: Muridae
Genus: Rattus
Species: norvegicus (Albino rat)

The rat is;

An animal (kingdom Animalia) due to the following reasons

- It has eyes
- It has a mouth

A chordate (phylum Chordata) due to the following reasons

- It has incisor teeth (bones)
- It has pentadactyl limbs
- It has post anal tail

A mammal (class Mammalia) due to the following reasons

- Possesses external ear lobes/ pinnae
- Body /skin is covered with hairs /fur
- Possesses external genitalia, like vaginal opening (vulva), clitoris and nipple for females, and scrotal sac and prepuce opening for males.
- Possession of the diaphragm which is an internal structure.
- Possession of Heterodont teeth which is a set of different type of teeth.

The head

It is tapering anteriorly with a cone shape. It is loosely attached to the body trunk by a neck. The tapering head forms a streamlined body for easy entrance into the burrows or to reduce air resistance for easy locomotion. It is hairy. The use of the hair is to insulate the animal from the cold environment.

The head features

The head has various features which include the pinnae (external ears), eyes, external nares (nostrils), mouth, and vibrissae (whiskers).

The pinnae

- It is dorsal-laterally located at the posterior end of the head and posterior to the eyes, flexibly attached to the head and expanded out ward (funnel shaped). Its funnel shape eases trapping of sound waves for easy hearing. To increase its sensitivity to sound
- It has little fur to encourage heat loss.
- They are one pair.
- Its capillaries are close to inner surface to encourage heat loss.

The eyes

- They are one pair and are sensitive to light.
- They are small and bead-shaped with hairy eyelids.
- They are dorsal-laterally located in the middle length of the head for wide vision / to increase the field of view.
- It is anterior to the ears

The external nares / nostrils

They are narrow opening, one pair, comma shaped, surrounded by smooth skin and anteriorly located on the head. Its location is for easy smelling and breathing. Thus are sensitive to smell.

The mouth

- It is ventrally located on anterior end of the head below the nostrils for easy ingestion of food materials.
- It is cone shaped with the sides of upper lips folded inside into the diastema for easy nibbling. The upper lip also has a cleft to expose the incisors for easy nibbling /gnawing.
- It has protruding sharp chisel shaped, hard, long, and curved in wards incisor teeth. Each jaw has one pair of incisors. The lower incisors are long than the upper ones. The incisors are used for gnawing /nibbling of food and for defense by biting the enemy. Incisors are found at the front / anterior end of the jaws to ease nibbling / gnawing / cutting food

The vibrissae / whiskers

These are many bristle / stiff, long hairs arranged in rows along the sides of the anterior end of the head. The length and brittle nature of the whiskers makes it easy to detect the diameter of the burrow. Thus are sensitive to touch.

The trunk features

These are features found on the main body apart from the head. These features include the limbs, tail, and external sex features / genital.

The limbs

The rat has two pairs of limbs, a pair of fore limbs and a pair of hind limbs.

The fore limbs have the following characteristics

- They are short and stout to absorb shock on landing.
- They are less muscular.
- They have four well developed digits with the fifth greatly reduced to a small stub
- They have hairless sole with many pads (digital and foot pads) to reduce the noise when moving for easy escape.
- They have curved, hard, elongated and pointed claws for defense by scratching the enemy and digging burrows for protection or breeding. Claws are also used for firm gripping on the rough surface during locomotion.

The hind limbs have the following characteristics

- They are long muscular for fast and sudden movement to escape enemies (darting-hopping movement).
- They have curved, hard, elongated and pointed claws for defense, digging burrows, and for firm gripping on the rough surface.
- They have hairless sole with many pads (digital and foot pads).

The fore and hind limbs share many features in common. They both have claws, smooth sole, digits/ toes, sole and digital pads and joints.

Characteristics of the toes

- They are jointed for flexibility during movement.
- They have soft pad to reduce the noise when moving for easy escape
- They have pointed claws for easy holding of food or digging burrows.
- They are well spread out for support.

Difference between fore and hind limbs

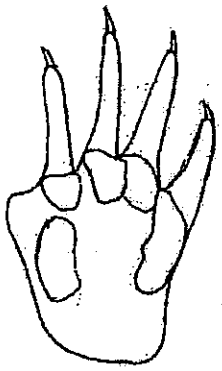
Fore limb	**Hind limb**
It is less muscular	It is more muscular
It is shorter	It is longer
It has four developed digits	It has five developed digits

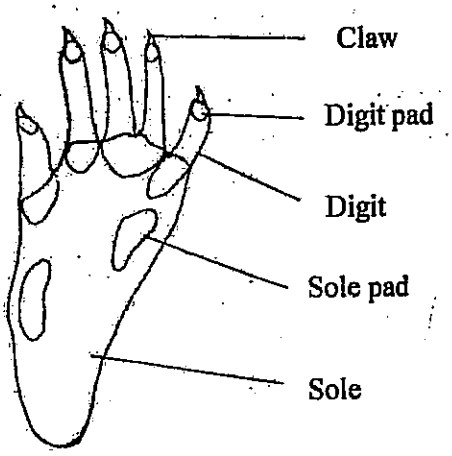
The use of joints in the limbs is to increase their flexibility.

The length of the hind limb doubles that of the fore limb. This great length together with its muscular nature, give a rat a greater forward force during darting- hopping movement.

The fore and hind feet have many structures in common. Both feet have digits, sole and digital pads, hairless sole and claws. However the hind foot has five digits while the fore one has four fully developed digits. The hind foot also has longer sole than the fore foot.

The ventral surface of the left fore foot **The ventral surface of the hind foot**





The tail

It is attached to the posterior end of the body trunk. It is characterized by;

- Having rows of scales around, which are closely packed for protection against physical injuries and for reducing water loss / prevent desiccation.
- It is solid / hard, flexible and long for defense by whipping / lashing the enemy.
- its length equals to the rest of the body for support / balance / maintain raised head when moving. Or for defense by whipping the enemy at the distance.
- It is tapering interiorly for balancing.
- It has short, stiff / bristle hair projecting from beneath the scales for increased sensitivity to touch.
- Scales are interiorly attached and overlaps posteriorly to allow heat loss

SEX IDENTIFICATION

Characteristics of Females:

- Have a vulva on the ventral side in the groin area
- Have the clitoris on the ventral side in the groin immediately above the vulva.
- Have teats / nipple on the ventral side of the abdomen, which bear outlets of mammary glands. The dorso posterior (ramp) end is tapering.

The vulva in adult rats is open, smooth, moist and folded / constricted. It is found in the middle cross length between the hind limbs on the ventral side. It is close and posterior to the clitoris. It is folded to allow passage of large fetus. It is moist and open for easy passage of materials.

The clitoris is pointed and bears little fur. It is close and anterior to the vulva.

The teats are in six pairs on ventral side of the thorax and abdomen. Three pairs are thoracic, one is abdominal and two inguinal (found in groin region). The teats are at the same distance from the longitudinal mid-line of the ventral side.

Characteristics of Males:

- Have a projection of prepuce covering the penis.
- Have the scrotal sacs protecting the testes.

- The dorso posterior end is round due to expanded testes on the ventral side.

The prepuce has a narrow opening. It is smooth, folded and moist. The moisture makes passage of the penis easy. It is folded to allow passage of large penis. It is narrow to regulate passage of the penis.

The scrotal sacs are enlarged / dilated and elongated to accommodate large testes

General adaptations of a rat to surviving in its environment

- Has thick fur to reduce water loss/ conserve heat/ temperature regulation.
- Expanded external ears for easy hearing / trapping sound waves.
- Has long, and bristle vibrissae for increased sensitivity to touch / detecting the size of the burrow.
- Has elongated, pointed claws for firm gripping on the rough surfaces or for digging burrows / tunnels or for holding food or for defense.
- Has dorsal –laterally located eyes for wide vision.
- Has long tail for balancing during movement or for defense at a long distance.
- Has two pairs of muscular limbs for support or for locomotion.
- Has open nostrils for easy breathing or for easy smelling.
- Has scales on the tail to reduce desiccation.
- Has sole pads to reduce noise making when moving for easy escape.
- Has streamlined and flexible body to easily enter the burrow.

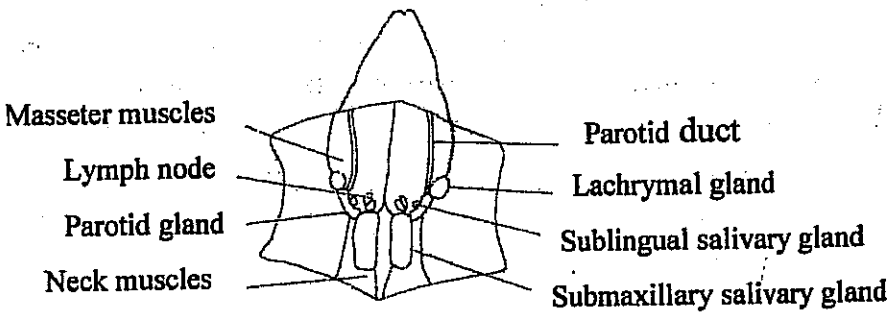
Body systems

The boy systems are exposed for study by opening internal cavities. Before the internal cavities are opened, the skin has to be removed first by using a blunt knife or scissors. The features exposed on the body wall by removing the skin are called **superficial structures** like the neck glands, masseter (jaw) muscles, pectoral muscles, neck muscles, shoulder muscles, rib/intercostal muscles, abdominal muscles, and cutaneous nerves radiating from the arm pits, lymph nodes in the arm pits, thigh muscles, preputial glands, femoral nerves, and femoral vein. If it is a female, the thoracic, abdominal and inguinal mammary glands are exposed. For the male the scrotal sacs are exposed.

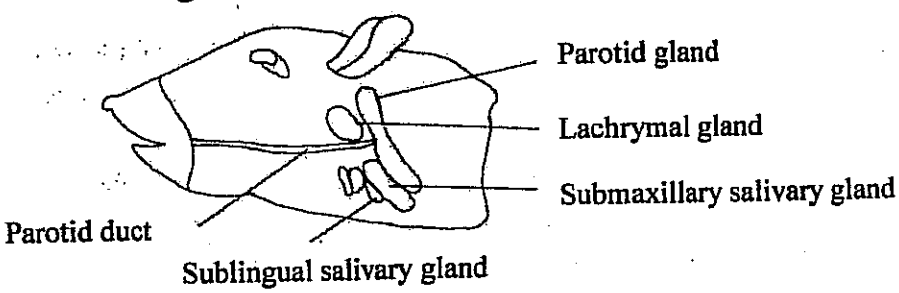
The neck glands

These include four types of glands which exist in pairs ie lachrymal gland, lymph nodes, parotid gland, and submaxillary gland. All are salivary glands except the lymph nodes and lachrymal which are for immunity and tear secretion respectively. Lachrymal and submaxillary are enlarged and muscular. The parotid is spread and membranous and its secretion, the tear, is voided/ empted into the mouth cavity through the duct seen on the body surface. The lymph nodes are small bean shaped and exist in two pairs.

A drawing showing the superficial structures in the ventral neck and lower head region of the rat

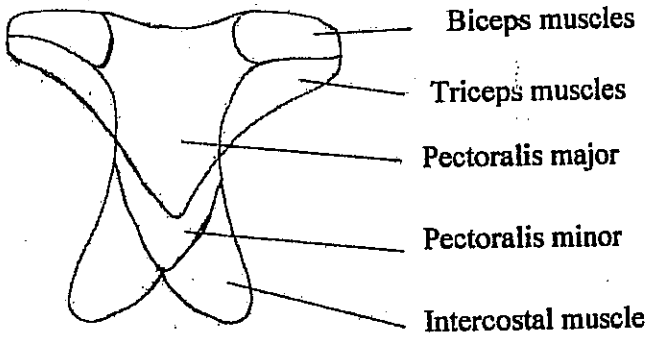


A drawing showing the features for secretions and passage of materials in the lateral neck and head regions



NB. The incisor teeth and the tongue are not superficial because are not exposed by removing the skin but by the opened mouth.

Superficial muscles of the thoracic region



The common body systems studded after opening the animal are the, digestive system, circulatory system, reproductive system and excretory system.

The digestive system

This consists of the alimentary canal and its associated organs.

The alimentary canal:

This shows greater differentiation into regions than that of lower vertebrates. It consists of the, esophagus, stomach, duodenum, ileum, caecum, colon, and rectum.

Structure in relation to function:

The oesophagus

It is a long tube that leads through the neck and thorax to the stomach. It is muscular with smooth inner lining. The smooth lining and contraction of muscular wall ease swallowing. Longitudinal folds close the lumen except when swallowing. At the distal end, the muscles constrict to form cardiac sphincter that control flow of food into stomach.

The stomach:

It is an enlarged ovoid sac lying transversely across the abdomen beneath the diaphragm which separates the thoracic cavity from the abdominal. Diaphragm is membranous, broad, elastic, and thin (transparent). The stomach is used as';

- A temporary store of food, giving chance for action of enzymes
- A site of digestion of food.
- A site of absorption of digested food.

The inner lining of the pylorus stomach is folded and smooth. The folds increase the surface area for digestion and absorption of digested food. The folds also allow extension of the stomach to increase storage. The wall of the pylorus stomach is thick / opaque. The lining of cardiac stomach is smooth, and not folded. The wall of the cardiac stomach is thin/ transparent.

The anterior end of the stomach constricts to form cardiac sphincter which controls inflow of food. Its posterior end constricts into pyloric sphincter that control empting of the chyme. The stomach wall has many capillaries to the surface area for absorption of digested food.

Duodenum

It is a short tubular feature which bends into a V shape. Between its bend lies a membranous pancreas. The function of the duodenum is used for digestion and absorption of digested food.

Bile ducts from the gall bladder and pancreatic ducts from pancreas open into the duodenum to release bile and pancreatic juices that enhance digestion of good.

Ileum

It is a very long greatly coiled tubular organ made up of thin wall. It is greatly attached to by numerous capillaries which are tributaries of hepatic portal vein.

It is used for digestion and absorption of digested food. It is adapted to its function by;

- Having numerous capillaries to increase surface area for absorption.
- Having thin wall to ease diffusion of digested food.
- Being very long and coiled to increase surface area for digestion and absorption of digested food

Between the ileum mesentery and colon but so close and along the colon, lies a chain of seven lymph nodes.

Caecum and appendix

Appendix is an extension of the caecum which is between the ileum and the colon.

Both are enlarged and are used for digestion and absorption of food mainly the cellulose. They contain bacteria that can digest cellulose.

Colon

It is short and enlarged. It is used for storage of wastes. It also allows absorption of water. It is enlarged to increase storage of wastes. It bears capillaries for faster water absorption.

Rectum

It stores wastes (un wanted materials) and also allows absorption of water to increase water conservation. Contraction of rectal muscles removes un wanted materials (faeces) from the body.

GLANDS ASSOCIATED WITH THE ALIMENTARY CANAL:

The Liver

It is the largest gland in the body. It has many functions in the body. Its digestive function is the production of the bile which is directly empted into the duodenum because it lacks the gall bladder. Bile contains bile salts that emulsify fats. It also contains sodium hydrogen carbonates which provide a suitable medium for the enzyme action.

It is slung from the diaphragm by a double sheet of peritoneum, which encloses the whole organ. It is divided into four (4) lobes, which include two on the right, one in the centre, and one on the left.

The Pancreas

This is endocrine and exocrine organ that appears as small-scattered masses of membranous pink tissue, in the mesentery, between the loops of the duodenum. Its ducts open into the duodenum, secreting pancreatic juice, which contains enzymes that digest food, together with bicarbonate ions that make the pH suitable for the enzymes action.

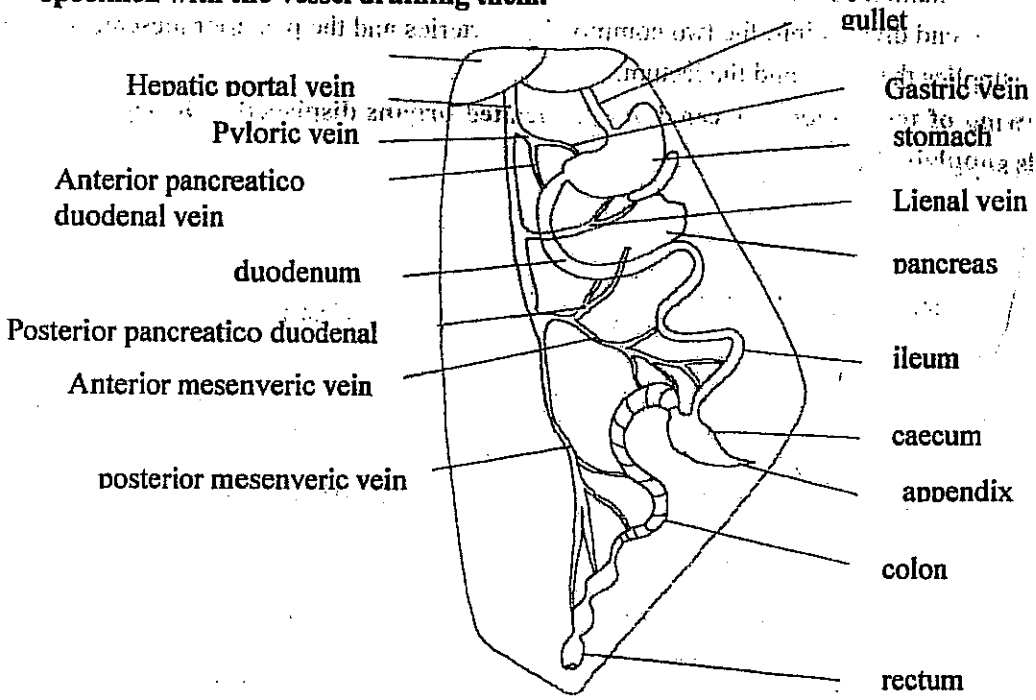
Vessels draining the alimentary canal

The alimentary canal is drained by a main one large vein called **hepatic portal vein** which drains blood from the alimentary canal into the liver. Hepatic portal vein branches into;

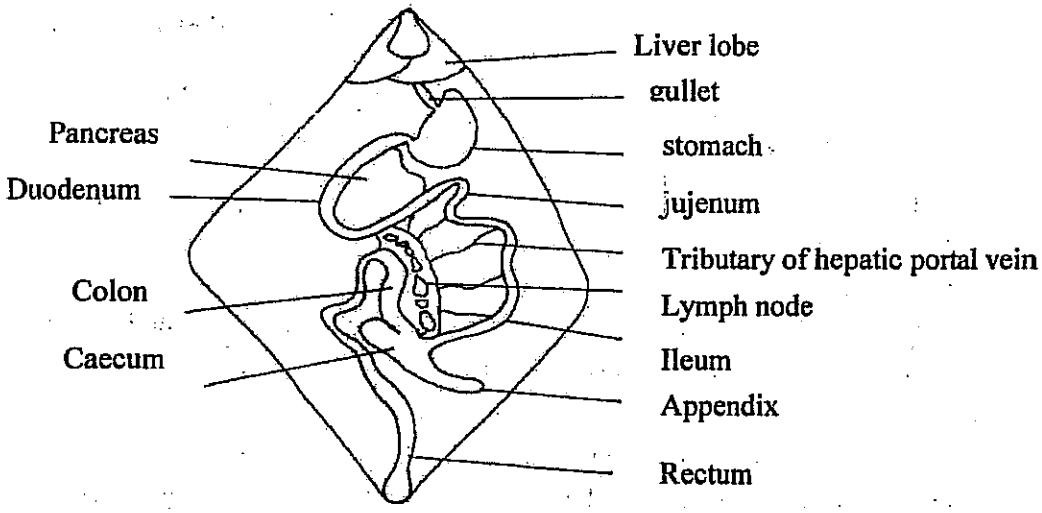
- Pyloric vein which divides into gastric vein draining the stomach, anterior pancreatico-duodenal vein draining the pancreas and the anterior part of the duodenum.
- Lienal vein draining the cardiac stomach and the spleen.
- Posterior mesenteric vein that drains the posterior colon and the rectum.
- Posterior pancreatico-duodenal vein that drains the pancreas and the posterior part of the duodenum.
- Anterior mesenteric vein draining the ileum, caecum and the anterior part of the duodenum.

Anterior mesenteric vein divides into numerous small capillaries embedded in mesentery. The numerous capillaries attached to the ileum increase the surface area for absorption of digested food.

A drawing of the alimentary canal and associated organs displaced to the left of the specimen with the vessel draining them.



A drawing of alimentary canal and associated organs with the duodenum displaced to its right and ileum displaced to its left without destroying the mesenteries

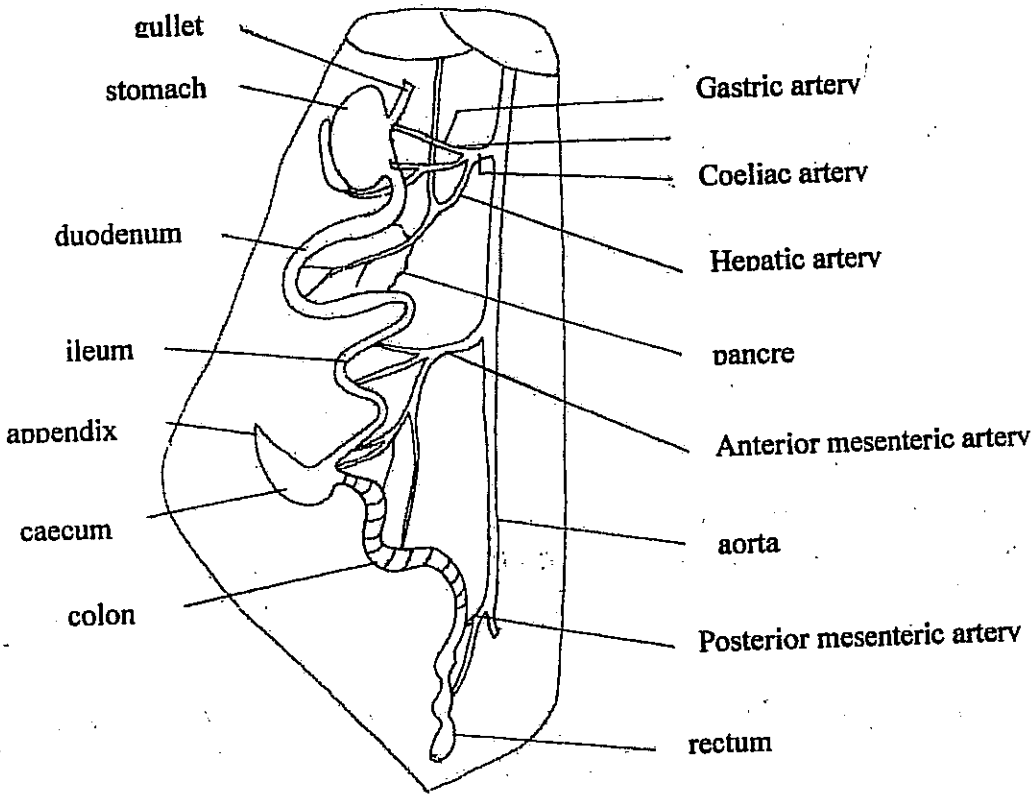


Vessels supplying the alimentary canal

The alimentary canal is supplied by aorta which branches into the coeliac artery that in turn divides into hepatic artery that splits into two vessels, one supplying the liver and the other supplying the pancreas, duodenum and pyloric stomach. The middle branch of the coeliac artery called lienal artery divides into two to supply the pylorus stomach and the spleen. The upper branch of the coeliac artery called the gastric artery supplies the cardiac stomach. The branch of the hepatic artery that supplies the liver passes beneath gastric and lienal artery

Aorta also close to the left kidney branches into the anterior mesenteric artery which in turn divides into numerous capillaries supplying the duodenum, the ileum and the caecum. The aorta at the end divides into the two common iliac arteries and the posterior mesentery artery which supplies the colon and the rectum.

A drawing of the alimentary canal and associated organs displaced to its right and the vessels supplying it.



Mouth / buccal cavity

It consists of;

The tongue, which is

- Broad/ flat to increase the surface area for tasting and rolling food.
- Long to roll food easily for swallowing.
- Flappy (flat) and flexible for easy rolling of the food.
- It has a large base to increase surface area for firm attachment.

The rugae (folds / ridges) of hard plate, for gripping food during grinding

Soft plate, which is smooth for easy swallowing

Flat topped molars, with cusps and ridges to increase the surface area for grinding food. There are three molars on either side of each jaw located at the posterior end of the jaws for easy chewing.

Cleft upper lip, to expose the incisors for easy gnawing

Folds of the skin in the diastema, for easy gnawing and grinding of food

Flaps of the lips, to enclose food from falling or dropping when chewing

THE RESPIRATORY SYSTEM:

Structure in relation to function:

Trachea:

It is cartilaginous, rigid, ringed, hollow / open / tubular, and cylindrical. It is used as the passage for gases. It is adapted to its function by;

- Having rings of cartilage to keep it open for easy passage of gases.
- Being hollow to allow ventilation.
- Having muscle connection between the cartilage for flexibility.

Lungs

It is spongy, pink in colour and consists of numerous air sacs. It is adapted to its function by;

- Being spongy to allow easy distention with more air.
- Pink colour indicates a rich supply of capillaries that offer a large surface area for gaseous exchange.
- Numerous air sacs increase the surface area for gaseous exchange.

THE BLOOD VASCULAR SYSTEM:

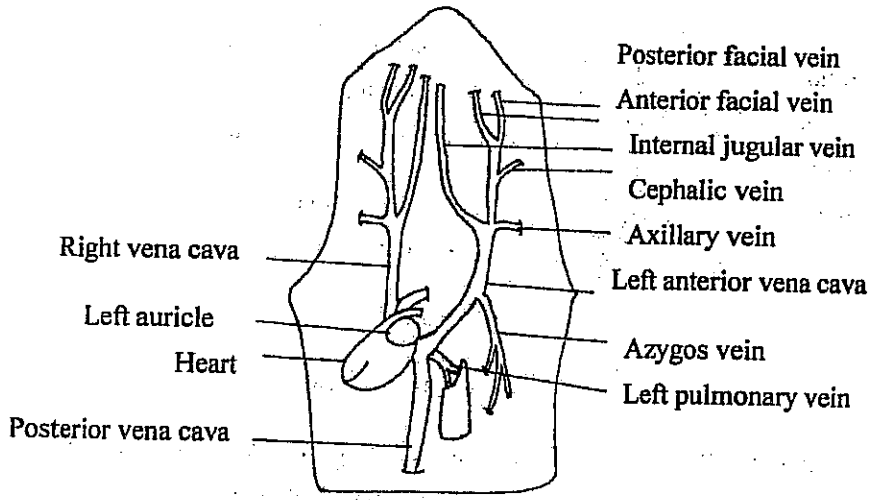
It consists of arterial and venous systems. Arterial system consists of vessels that supply the body tissues and are called arteries. Venous system consists of the vessels draining the body tissues back to the heart.

The blood vessels that drain the thoracic, neck regions, and head region

The main large one vessel, the vena cava, draining into the right atrium, divides into three vessels.

- The posterior vena cava draining organs posterior to the heart.
- The right anterior vena cava draining the right side of the thoracic, neck and head regions.
- The left anterior vena cava draining the left thoracic, neck and head regions.

A drawing of vessels draining the head, neck, and thoracic regions with the heart displaced to its right.



The vessels draining thoracic region are; posterior vena cava, pulmonary vein, left and right anterior vena cava, subcalvian veins, axillary veins, cephalic veins and azygos vein.

The cephalic vein drains the shoulder region; the axillary vein drains the arm through brachial vein and the arm pit, and azygos vein occurs on the left side of the thorax only and draws blood from both sides of thorax.

The vessels draining the neck region are; left and right anterior vena cava, subcalvian veins, external jugular veins, and internal jugular veins.

Posterior facial vein and anterior facial vein draw blood from the head. The anterior facial vein draws blood from the internal parts of the head and the posterior facial vein draws blood from the external parts of the head.

Vessels supplying the thoracic, neck and head regions

The aorta from the left ventricle of the, heart branches into three arteries. Ie the innominate on the right, left common carotid and left subcalvian.

Innominate artery gives rise to the right subcalvian artery and the right common carotid artery. The subcalvian artery turns into the right axillary artery after giving off intercostal and vertebral artery. The axillary artery divides into brachial artery supplying the arm and cervical arteries supplying the neck muscles and the neck vertebrae. The right common carotid artery elongates further up and divides into internal and external carotid arteries. The internal carotid artery supplies the brain and internal parts of the head. The external carotid artery supplies the external parts of the head.

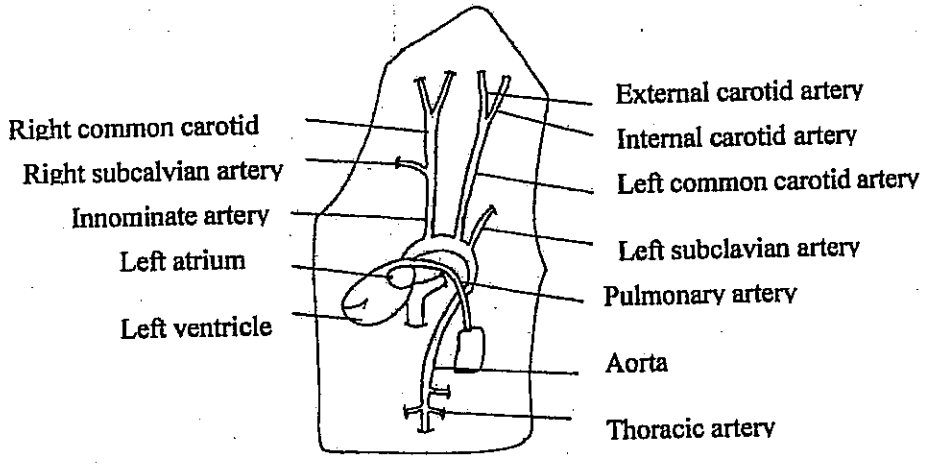
The left common carotid artery also elongates up to divide into internal and external carotid artery.

The left subcalvian artery divides like the right subcalvian artery.

The aorta continues down beneath the left anterior vena cava to supply the organs posterior to the heart. It also gives off numerous intercostal arteries that supply the intercostals muscles.

From the right ventricle, arises pulmonary artery which supplies the lungs.

A drawing of the vessels supplying the thoracic neck and head region

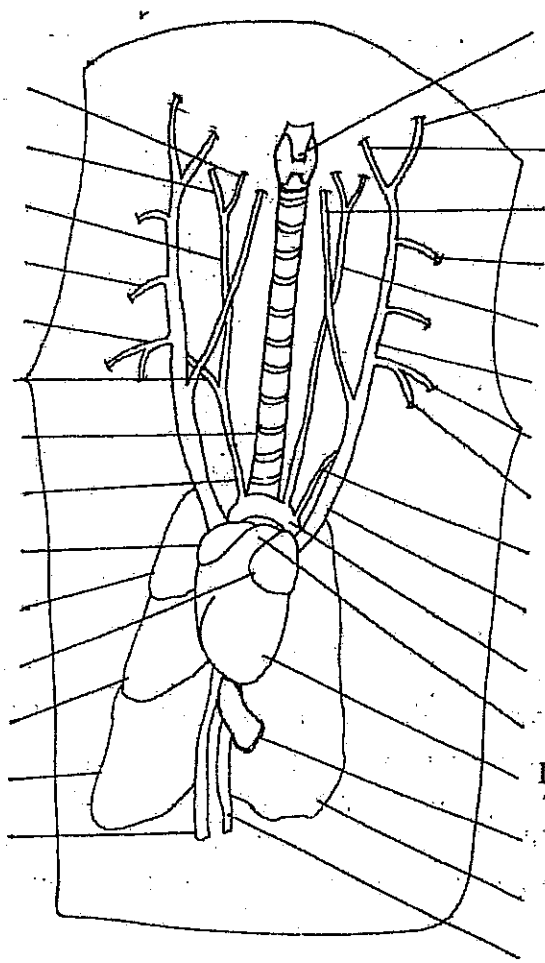


The vessels supplying the thoracic region are; aorta, thoracic artery (intercostals arteries), innominate artery, right subcalvian artery, left subcalvian artery, axillary arteries, brachial arteries and pulmonary artery.

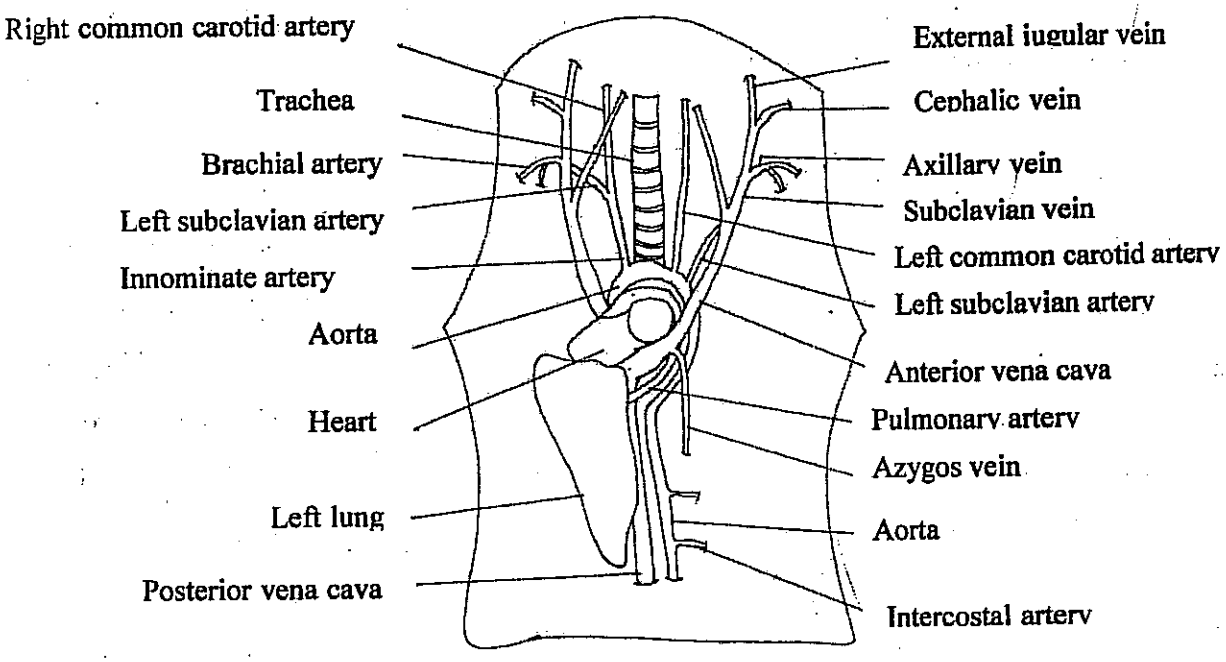
The vessels supplying the neck region are; aorta, innominate artery, subcalvian arteries, vertebral arteries, and cervical arteries.

The right and left common carotid arteries divide into internal and external carotid arteries that supply the head.

A drawing showing the features for blood circulation and ventilation in the regions anterior to the diaphragm with un displaced heart after removing the rib cage, shoulder and neck muscles of the rat



A drawing showing features for ventilation and blood circulation in the regions anterior to the diaphragm with the heart and left lung displaced to the right of the rat



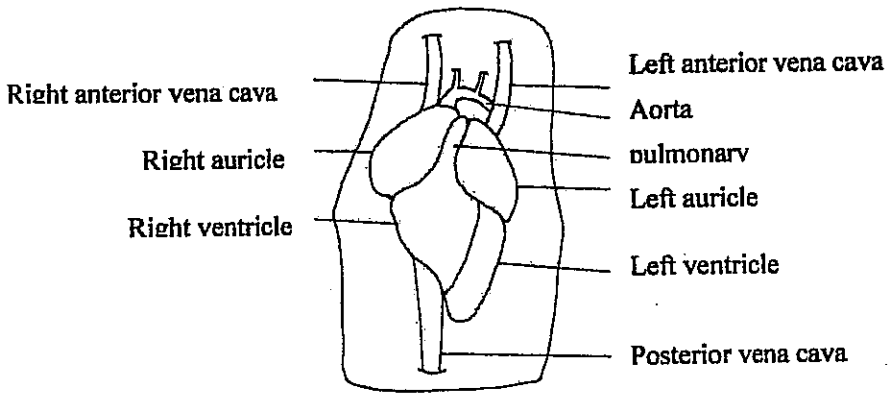
THE HEART AND THE GREAT VESSELS:

Position and Shape:

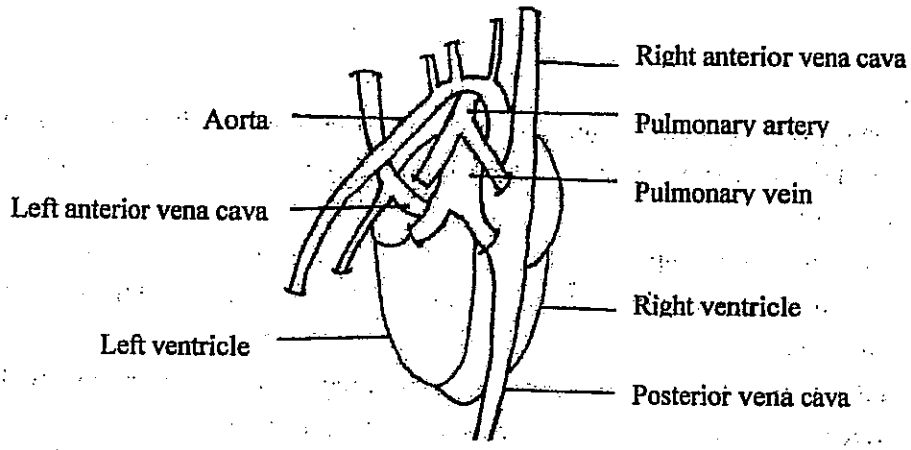
The heart lies ventrally in the thorax. It is pear shaped, with the apex posterior and tilted to the left and the base, anterior giving way to the origin of the great vessels.

The heart is divided into four chambers with the ventricles appearing much larger than the auricles because of their thick muscular walls that provide a strong force in pumping blood.

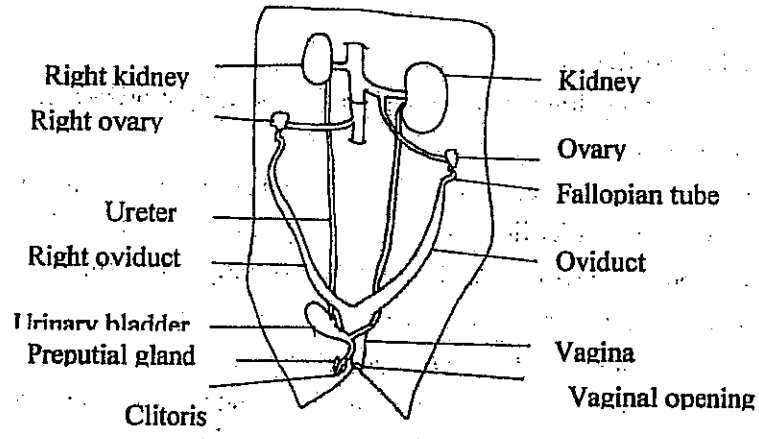
A drawing of the ventral view of the heart and associated vessels



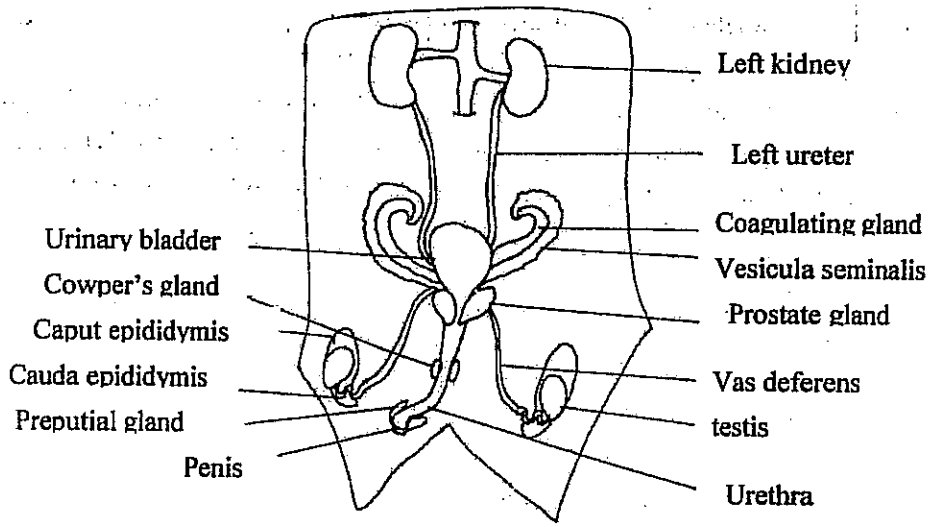
A drawing of the dorsal view of the heart with associated vessels



A drawing of urinogenital system of a female rat



A drawing of urinogenital system of a male rat



Note, Remember you need to learn how to draw the urinary and reproductive systems separately.

Hind Limbs:

The **dorsal aorta** divides terminally into two branches, **the common iliac,** arteries which give several branches to supply organs **in the groin and hind limb** on the respective side. The branches include;

- **Vesico-uterine artery** supplying the urinary bladder and the uterus
- **Internal iliac artery** supplying the groin (muscles of dorsal region of the pelvis)
- **External iliac artery**
- **Pudental artery,** which supplies the pubic area of the pelvis and external genitalia.
- **Epigastric artery,** supplies posterior muscles of the abdomen
- **Femoral artery,** which supplies the thigh and continues as the **popliteal** artery to supply the leg.

Principles of a biological drawing

- Body out line must be drawn with continuous lines without breaking.
- Drawing must be neat
- Label line must touch the exact part being labeled. If the part is hollow, the label line must just touch the boarder line without entering or crossing its boarder line.
- Magnification must be written on the right side slightly below the drawing.
- The label lines must not cross each other.
- The drawing must not cross the boundaries of the question.
- The drawing must have a title indicating the parts and the specimen drawn.
- Never use an arrow on the label line
- The drawing must be large enough and clear
- A drawing must be labeled unless indicated otherwise
- A sharp pencil must be used

Note When an animal you are dissecting is lying on its dorsal side with its ventral side upper most, its left side is your right side and its right side is your left side. But if it is lying on its ventral side with its dorsal side upper most, its left side is your left and its right side is your right side.

Guiding questions about dissection

1. You are provided with specimen K (cockroach).

(a) Examine the specimen and name the external features which are characteristic of the class to which the specimen belongs. (03 marks)

.....

.....

(b) From your observation of the external features, state with reasons the sex of the specimen. (02 marks)

.....

.....

(c) Place the specimen ventral side uppermost. Draw and label the end of the abdomen. (05mks)

(d) Using a hand lens examine one antenna and draw. Do not label. (02 marks)

(e) Place the specimen dorsal side uppermost and dissect to expose the structures within the abdominal and thoracic cavity.

(i) Displace the structures to display the salivary glands on the left of specimen.

(ii) Displace the alimentary canal to the right of the specimen. Remove all unnecessary tissue to display all the parts of the alimentary canal and the structures on the ventral cuticle. Draw and label. (24marks)

2. You are provided with specimen **S** (cockroach) which is freshly killed.

(a) Examine the antennae and describe how they are adapted to their function. (3 marks)

.....

.....

(i) Carefully cut off the whole left maxilla. Observe using a hand lens. Draw and label. (6 marks)

(ii) Give three adaptations of the maxilla to its functions. (3 marks)

.....

.....

(b) (i) Place the specimen dorsal side uppermost. Cut along one lateral line of the specimen to display the heart. Draw and label the circulatory system. (8 marks)

(ii) Then proceed to display the structures responsible for food storage and digestion and displaced to one side. Draw and label. (10 marks)

(c). Remove both the crop and the gizzard. Cut them open longitudinally. Wash out the contents and examine the inner surfaces using a hand lens.
(i) Describe the appearance of the inner surface of: (4mks).

Crop.....

Gizzard.....

(ii) How are the inner surfaces of the crop and gizzard related to the functions of the two organs? (4 marks)

.....

.....

.....

3. You are provided with specimen K (toad) which is freshly killed.
(a) Examine the head of the animal provided. Describe the shape of the head and show how the shape relates to the mode of life of the animal. (2 marks)
(i) Description of the shape.

.....

.....

(ii) Relationship between shape of the head and the mode of the life of the animal.

.....

.....

(b). Lay and pin the animal on its back. Turn the board so that the head faces you. Insert one blade of the scissor into the mouth on this side and cut through the jaws up to the level of the fore limbs. Continue dissecting to display the Oesophagus.
(i). Describe the structure of the oesophagus. (03mks)

.....

.....

(ii) Relate the structure of the oesophagus to its main function.

.....

.....

(c). Examine the tongue.
(i). Draw the tongue in ventral view when fully stretched and label. (07 mks)

(ii) Mention three adaptations of the tongue for feeding. (03 mks)

(d). (i) Dissect the specimens and take the routes of blood flow from the heart to the alimentary canal and associated organs. Draw and label fully.

(23 mks)

(ii) By further dissection display the blood circulation in the left thigh and foot. (Observe the foot using a hand lens) Make labeled drawings to show the blood network in the two regions.

(07mks)

4. You are provided with a freshly killed specimen labeled **R** (rat).

(a) Study the external features of the specimen and list three observable features that enable the specimen to colonize land. (03 mks)

(i) .....

(ii) .....

(iii) .....

(b). (i) Measure the length of the tail and that of the tail plus the rest of the body.

Express your results as a ratio of,

Tail: tail + rest of the body.....(01 mark)

(ii) Suggest the significance of this ratio in the life of the animal.

(02 marks)

.....

.....

(c) (i) Dissect the specimen to clearly display the structures lying posteriorly to the diaphragm without displacing any organs. Draw and label your dissection. (16 mks)

(ii) Dissect the specimen further to display the blood vessels that drain blood from the thigh of the left hind limb and kidney back to the heart. Draw and label. (15mks)

5. You are provided with specimen **T** (rat). Carry out the dissection of the specimen using the following procedure.

Pin the animal with ventral side uppermost. Remove the skin of the thoracic region including the neck. Lift the xiphoid cartilage and cut along the lower edge of the rib cage. Tie the xiphoid cartilage. Pull it back and pin it down. Cut along the sidewall of the thorax on both sides to remove the rib cage.

(i) Draw the thoracic region without displacing any organ and label fully. (07 mks)

(ii) Locate the trachea and examine it. Describe its structure.

.....

(b) Now dissect the specimen further into the neck to display the glands, organs and their accessory structure that can be seen from the ventral side of the neck region, anterior to the forelimb.

(i) Make an accurate, well labeled drawing of the dissection.

(ii) Briefly state the functions of each of the structures you have labeled in (b) (i) above.

.....

.....

.....

.....

(6). You are provided with specimen **Q** (toad) which is a freshly killed animal.

(i) Examine the head and describe its shape.

.....

.....

(ii) Measure the thickness, width and length of the head.

Thickness.....cm

Width .....cm

Length .....cm

(iii) State the ratio of

thickness to width .....cm

thickness to length.....cm

(iii) What is the significance of the shape and proportions of the in head relation to its mode of life?

.....

.....

(i) Examine the limbs of the specimen and draw a fore limb and hind limb to the same magnification, in the space below.

Fore limb. **Hind limb**

(ii) Explain the significance of the difference between the **fore limb** and the **hind limb** to the mode of life of the animal.

.....

.....

.....

(d). Dissect the animal to display the heart and the associated blood vessels that drain blood from the fore limbs, head region and skin in the thoracic region. Draw and label the heart and the associated vessels on one side of your dissection.

7. You are provided with a freshly killed cockroach labeled specimen **K.**
Examine the specimen using a hand lens and answer the following questions:-
(a) Stating two external features in each case, classify the specimen into two named groups. (4 mks)

GROUP:-
EXTERNAL FEATURES

1. 2.

GROUP:-
EXTERNAL FEATURES:

1. 2.

(b) (i) State three observable structures the specimen uses for sensitivity. (3 mks)

1.

2.

3.

(ii) For each of the structures stated above give two adaptations to function.(6 mks)
STRUCTURE 1
1.

2.
STRUCTURE 2:
1.

2.

STRUCTURE 3:
1.

2.

(b) You are provided with nutrient solutions A and B and extracts **F** and **M** prepared from the fore gut (**F**) and mid gut (**M**) of a cockroach respectively. Carry out the following experiments:

(i) Using the chemicals and reagents provided, establish the identity of nutrients **A** and **B.**

TESTS	**OBSERVATION**	**CONCLUSIONS**
STARCH	A -	
	B-	
REDUCING SUGAR	A-	
	B-	

PROTEIN	A-	
	B-	

(ii) Set up tubes 1 – 4 at temperatures 35 – 40^{0}C for 1 hour.

TUBE	CONTENTS
1	1cm^3 of nutrient A + 1cm of extract F
2	1cm^3 of nutrient A + 1cm of extract M
3	1cm^3 of B+ 1cm of extract F
1	1cm^3 of nutrient B+ 1cm of extract F

(iii) After incubation divide the contents of each tube into two equal proportions. Repeat the test in c(i) for nutrient identification in solution A on contents of tubes 1 and 2 plus nutrient identified in solution B on contents of tubes 3 and record your test and observation in table II below: (10 marks)

TEST	OBSERVATION
	TUBE 1
	TUBE 2
	TUBE 3
	TUBE 4

(c) (i) Suggest a confirmatory test you would carryout on the contents of tube 1 and 2 to determine the nature of product formed. (02mks)

(ii) Carry out the test you have stated in C (i) above and record your results in table III below: (08mks)

TEST	OBSERVATION	CONCLUSION
	TUBE 1	
	TUBE 2	

(d) From table I, II, III:

A. Give two properties of the active substance in extract F. (3 mks)

1.

2.

B. Account for the difference (if any) in result of contents of tubes 3 and 4. (4 mks)

8. You are provided with specimen P (toad).

(a) Examine the specimen and give observable adaptive features that enable the specimen to survive in its habitat. (5 mks)

(i) .....

(ii) .....

(iii) .....

(iv) .....

(v) .....

(b) Dissect the specimen to display the:

(i) Blood vessels taking blood to the left lung of the animal. Draw and label. (08mks)

(ii). blood vessels returning blood from the right side of the head and chest region of the animal to the heart. (16mks)

9. You are provided with specimen W (toad).
   a. Examine the external structures listed below and for each structure.
      (i) Describe the position: - (04 mks)
      CLOACAL APERTURE-

      EAR DRUM –

      HIND FEET –

      (ii) Give two descriptive features: - (03 mks)
      CLOACAL APERTURE
      1 –

      2 –

      EAR DRUM
      1 –

      2 –

      HIND FEET
      1 –

      2 –
   b. Relate any one of the descriptive features given in (a) (ii) to the role played by the structure. (03 mks)
      CLOACAL APERTURE

      EAR DRUM

      HIND FEET

c. (i) Dissect the specimen and trace the routes of blood flow to the heart from organs found in the left half of the abdominal region.
Draw and label without displacing the heart. (18 mks)

(ii) Proceed to strip off all the skin from the left hind limb. Using a blunt knife, isolate the muscles that are visible from the ventral view. Draw to show the arrangement of the muscles in the thigh. (5mks)

10. A freshly killed cockroach is provided

(a). Measure the following:

(i) Length of a cockroach in cm.
.....

(ii) Width of the specimen in cm.
.....

(iii) Ratio of length: width
.....

(iv) State the ecological importance of that ratio to the cockroach.
.....
.....

(b). Describe the antennae and explain how it is adapted to its function.

c. (i) Carefully cut off the whole Right maxilla. Observe using a hand lens. Draw and label.

(ii) Give three adaptations of the maxilla to its functions.

(d). Place the specimen dorsal side uppermost. Cut along one lateral line of the specimen to display the digestive system. Draw and label.

(i) State the function of each part you have labeled above,.

12. (a) Using a magnifying lens, examine the structures found on the head region of specimen **E** (cockroach) provided.
(i). State three features observed from head region used to classify the specimen (04 mks)

(ii). Using low power magnification, observe the left compound eye and the first three segments at the base of the antenna.
Make accurate drawings and don't label. (06 mks)

(iii). Suggest the significance of the observed prominent features of the base of the antenna. (02 mks)

(iv). Give three descriptions of the compound eye and relate each description given to the role of the compound in the specimen. (06 mks)

DESCRIPTION	ROLE
1-	
2 –	
3 –	

(b) Detach all the legs by carefully cutting at the point of attachment to the thorax. Then observe the structures found in the anterior half of the specimen using magnifying lens. [Take note of the segmentation / divisions of the structures].
(i). Make an accurate drawing showing the structures in the anterior half from the ventral view. Label only the segmented / divided structures. (15 mks)

(i) Suggest two roles of segmentation to specimen E. (02 mks)
1-

2 –

Cut off the left wings of the specimen. Using the Low Power Magnification, observe the major pattern of veins on each wing.

(i) Concisely, describe the major pattern of veins on the wings: (04 mks)

FORE WING –

HIND WING-

(ii) Drawing the outline (margins) of the two wings at magnifications x 2 in the space below. [The hind wing must be unfolded] work out the surface area of the two wings in cm^2. Show your working.

FORE WING HIND WING

Express the surface area of the fore wing and hind wing as ratio.

(iii) Suggested the ecological significant of this ration in the life of specimen E.
(02 mks)

13. You are provided with specimen **T** (toad) which is freshly killed animal.
(a). Examine the head, abdomen and hind limbs.
(i). Describe concisely the shape and appearance of each of these body parts.
(05 mks)

HEAD

.....

.....

.....

ABDOMEN

.....

.....

.....

.....

HINDLIMB

.....

.....

(ii). Relate the shape and appearance of each structure in (a) (i) above to the role played in the animal. (08 mks)

HEAD

.....

.....

.....

ABDOMEN

.....

.....

.....

HIND LIMB

.....

.....

(d).Dissect to display the venous circulation on the left side lying posteriorly to the heart plus the associated organs. Draw and label without displacing the heart

(22mks)

14. You are provided with specimens **Q** (cockroach) which are freshly killed.

(a). Using a hand lens, examine the left compound eye of the specimen including the first three segments of the antenna, from the base. Draw the structures observed. Do not label. (05mks)

(b). By further dissection, cut and remove the whole alimentary canal to clearly display the structures on the ventral cuticle (keep the alimentary canal for **Q_2**). Draw and label structures associated with the ventral cuticle, anterior to the last abdominal segment.

15. Cut off the legs and wings of the specimen **K** (cockroach) provided.
(a). using a hand lens, examine the upper and lower abdominal cuticles.
(i). give two major differences and similarities between the two cuticles.

Lower cuticle	Upper cuticle

Similarities

(ii). Account for each of the observed differences recorded in a (i) above. (02mks)

(b) (i). Pin the specimen on a dissecting board. Dissect to release the dorsal cuticle and pin this cuticle to the left of the specimen. Remove all the fat to display the digestive tract. Draw and label the structures of the tract without adjusting the position of any structure. (12mks)

(ii) Proceed to remove the whole digestive tract (from oesophagus to the rectum) and dispose it. Clear off any unnecessary tissue to display the internal structures associated with the cuticles. Draw and label the structures displayed. (17mks)

16. You are provided with a freshly killed specimen labeled **K** (rat).

(a). Observe the ventral view of the head.

(i). Draw and label the ventral side of the head to show the structures for Sensitivity. (7mks)

(ii). How are the structures labeled in (a) (i) adapted for their functions? (06mks)

.....

.....

.....

.....

(b). Dissect the specimen to expose the alimentary canal. Deflect the alimentary canal to the right side of the animal to display the blood vessels supplying the alimentary canal and its associated organs. Draw and label. (21mks)

(c). Remove the alimentary canal, dissect the pelvic girdle and display the major blood vessel that drain the hind limbs and urinogenital system.
Draw and label. (10mks).

17. You are provided with specimen **P** which is freshly killed (rat).

(a). Examine the ventral side of the right fore and right hind feet.
(i). State two observable differences between the fore foot and hind foot. (02mks)

Fore foot	Hind foot

(ii). Draw and label the ventral side of a hind foot. (06mks)

(ii). State the importance of the features labeled on the foot. (005mks)

.....

.....

.....

.....

(b). Place the animal ventral side upper most, examine it and identify its sex giving a reason. (02mks)

Sex.....

Reason.....

.....

(c). Dissect the specimen to expose the muscles of the thorax and fore limbs up to the elbows. Draw and label. (07mks)

18. You are provided with specimen Q (cockroach). Lay the specimen on its dorsal side with its ventral side upper most.

(a). Without labeling, draw the anterior view of the head. (06mks)

(b). lay the specimen on its ventral side with its dorsal side upper most after cutting off the wings and limbs. Open the thoracic and the five adjacent abdominal segments along the right line. Carefully separate the cuticles and pin the dorsal cuticle on the other side. Carefully stretch and display the organs of alimentary canal without breaking on its right. Draw and label the exposed features of the dissection. (23mks)

(c). By using the forceps, pluck off the salivary glands and make a slide, view the slide under medium power.

(i). without labeling, examine and draw the salivary glands. (03mks)

(ii). describe how the salivary glands are adapted to its functions. (03mks)

PHYSIOLOGY

These are practicals on metabolic reactions of organisms. Physiology question is set from a theory, it's therefore important to interpret the theory behind the physiology. Not the following for higher score in a physiology practical.

a. Pick out the key / guiding instructions, materials and chemical reagents within the instructions.
b. Seek to understand unfamiliar words and phrases.
c. Analyze questions below the table of results before you fill the table.
d. Always be concise and precise in your observations and deduction.
e. Observation determines the deduction. Therefore write accurate observation.
f. Always use accurate amounts of reagents in the tests.

When writing a chemical test, follow the following principles;

State the quantity of the solution used in the test, the correct reagent for the test, the correct quantity of the reagent, the correct state of the reagent and the condition of the test e.g. boiling for the Benedict's test

Use this Benedict's test on the food substance labeled P to understand the procedure of writing a correct chemical test by following the principle of the chemical test listed above.

To **$2cm^3$** of substance P add **$2cm^3$** of **Benedict's solution** and **boil.**

If some of the principles are not stated e.g. the condition for the test and the correct reagent, marks for observation and for the conclusion are lost whether were correct or not.

- State exact colour of the solution, always the last colour determines the nature of the conclusion.
- Whenever the test involves incubation, suspect enzyme controlled reaction. Then carefully look out for the property of the enzyme being tested.
- When writing the observations avoid the 'ish' prefix like bluish, reddish, greenish blue. Always state the original colour of the test solution and the colour changes during the test till the final colour.
- Record the observation in the present tens e.g. the solution changes from blue to green solution or in the past tens e.g. the solution changed from blue to green solution.

The major food substances tested for are Starch, reducing sugar, non reducing sugar, proteins, vitamin C (ascorbic acid), and lipids.

The table below contains standard chemical tests, expected observations and conclusion for food substances.

Food substance	Chemical test	Observation	conclusion
Starch	To $2cm^3$ of food substance add 2 drops of iodine	The colorless solution turned brown	Starch absent
		The turbid white solution turns to pale black	Little starch present
		The turbid white solution changed to intense back	Much starch present
Reducing sugars	To $2cm^3$ of food substance add $2cm^3$ of Benedict's solution and boil	The colourless solution turned blue and remained blue on boiling	Reducing sugars absent
		The colourless solution turned blue and to green solution on boiling	Little reducing sugars present
		The colourless solution turned blue, then to green, to yellow precipitate on boiling	Moderate amount of reducing sugars present
		The colourless solution turned blue, then to green, yellow, to orange precipitate on boiling	Much reducing sugars present
Proteins	To $2cm^3$ 0f food solution add $1cm^3$ of $NaOH_{(aq)}$ followed by 2 drops of $CuSO4_{(aq)}$.	The turbid solution turned to blue precipitate	Proteins absent
		The turbid solution turned to blue precipitate then to pale purple solution	Little proteins present
		The turbid solution turned blue precipitate then to deep purple solution	Much proteins present
Non reducing sugars	To $2cm^3$ of food substance add $1cm^3$ 0f $HCl_{(aq)}$ then boil then cool then add $1cm^3$ of $NaOH_{(aq)}$ then $2cm^3$ of Benedict's solution and boil	The colourless solution turned blue solution and remains blue solution	Non reducing sugars absent
		The colourless solution turned blue solution, to green solution	Little non reducing sugars present
		The colourless solution turned blue solution, to yellow precipitate	Moderate non reducing sugars present
		colorless solution turned green solution, yellow precipitate, to orange precipitate	Much non reducing sugars present
Lipids	To $2cm^3$ of food solution add 5 drops of ethanol	The colourless solution remains clear	Lipids absent
		The colourless solution becomes turbid	Lipids present
Vitamin C	To $1cm^3$ of DCPIP add food solution drop wise till excess	DCPIP remains blue	Vitamin c is absent
		DCPIP is decolourised	Vitamin C is present

Note

- Amount of vitamin c in the solution is indicated by how fast the solution decolourises the DCPIP. The faster the solution it decolourises the reagent the higher the concentration of vitamin c. If a given solution requires fewer drops to decolourise the same amount of DCPIP, then it has a higher concentration of vitamin c.
- Boiling of the vit. C solution lowers its concentration and thus it requires more drops to decolourise the same amount of DCPIP. This is due to evaporation and break down of vit. C. the more the boiling of the solution, the more vit. C is lost through evaporation and broken down and hence the less the concentration of the vit. C in the solution. If the locules/ segments of orange or plant tissues are boiled in the water, the concentration of vit. C in the juice lowers because most of the vit. C diffuses into water as the membranes of the locules become more permeable with the boiling. Further still as the locules boil water diffuses into the Locule and dilutes the concentration of the vit. C. The more the boiling of the locules, the more water enters the locules and hence the lower the concentration of the vit. C in the juice.

- The only way to know that vit. C in the locules is decreasing in concentration is to test for it with DCPIP. The juice of the locules that are boiled for long will require more drops to decolourise the same amount of DCPIP. The water within which the locules are boiled tests positive for vit. C. This confirms the diffusion of the vit. C into the water from the locules.
- The knowledge of break down of the vit. C by heat helps the scientist to maintain high concentration of it in the fruits by; avoiding over boiling of fruits and vegetables, slightly boil the fruits in little water, store the fruits in cold places or where possible eat row fruits.
- If DCPIP is added to food solution, it turns to pink when vitamin c is present. But when vitamin c is absent, the solution instantly turns blue. The concentration of vitamin c is indicated by the number of DCPIP required to turn the solution pink. The more the number of DCPIP required turning the solution pink, the higher the concentration of vitamin c present in the concentration.
- In the chemical test, the word drops implies solution because droppers are only used on the solutions.

Enzymes and enzyme activity

Introduction:

Enzymes are organic catalysts of high molecular weight, with complex structure. They occur in the protoplasm of living cells. Because they are proteins, their properties are properties of proteins. The essential role of an enzyme is to lower the amount of activation energy required to initiate a particular reaction.

Enzymes are specific in their action in that a single enzyme will only catalyse a single chemical reaction. An enzyme operates by becoming temporarily interlocked with the substrate molecule (template or lock-and-key theory) and its ability to catalyse the reaction depends on the closeness of this theory.

Their activity is affected by environmental factors like temperature and pH. They are named by adding the suffix "-ase" to the name of the substrate on which the enzyme acts, e.g. starch enzymes are amylases, protein enzymes are **proteases,** urea enzymes **ureases,** maltose enzymes maltases. However, other enzymes do not fall into this normal type of nomenclature, e.g. the amylase of saliva called "ptyalin, that extracted from barley, **"diastase".**"

Classification of enzymes

Hydrolytic enzymes These are enzymes that catalyse the break down of / hydrolyse the food substances in presence of water a process called hydrolysis.

(a) Those enzymes that catalyse break down of some carbohydrates are;

(i) **Diastase / amylase** that catalyses break down **starch** into reducing sugars under suitable conditions like alkaline medium and favorable temperature.

(ii) **Sucrase or invertase** catalyses breaks down **sucrose** into reducing sugars under alkaline medium and favorable temperature.

(b) **Proteolytic enzymes** these are enzymes that break down proteins e.g. Pepsin and Trypsin break down insoluble large molécules of proteins into soluble molécules. Proteins area large molecules which form turbid solution when dissolved in water. But when à turbid solution is incubated with à protease enzyme, it clears due to the break down of proteins into soluble smoller molecules.

(c) Those catalyse the break down of lipids (Fats) is Lipase.

Oxidising – reducing enzymes:

(d) Catalase It decomposes or breaks down H_2O_2 to water and O_2. It does not hydrolyse hydrogen peroxide because its break down does not involve water. Evolution of oxygen causes bubbling or effervescence or froth when a solution of catalase enzyme is mixed with hydrogen peroxide. Effervescence is a result of enzyme activity (break down of H_2O_2). The rate of bubbling thus relates directly with the rate of enzyme activity. The higher the rate of effervescence the higher the rate of enzyme activity. Too much effervescence leads to formation of the froth which directly relates to amount of oxygen evolved. The growth of the froth for a given time corresponds with the rate of reaction. Froth growth is measured by mixing the substrate (H_2O_2) with the enzyme in the measuring cylinder.

When writing observation of the catalase reaction, the focus should be put on the rate of bubbling. Indicating whether it is slow / little / few, moderate (fast) or very fast effervescence.

Then conclusion must relate to the rate of effervescence by stating whether the rate of enzyme activity is low, high or highest.

The rate of enzyme activity depends on many factors like;

- Surface area of the tissue containing the enzyme molecules or the concentration of the enzyme molecules. The higher the concentration of the enzyme molecules, the higher the activity of the enzyme or the higher the chances of collision of the enzyme molecules with the substrate and hence the faster the rate of reaction.
- Concentration of the substrate (H_2O_2). Its concentration is directly related to the rate of reaction. The higher the concentration of the substrate molecules, the higher the collision of the substrate with the enzyme molecules at a time leading to higher rate of reaction
- Medium of the solution. Catalase is more active in the neutral solution, followed by alkaline solution. It is not active in acidic solution.

The rate of reaction of enzyme catalase can be measured by;

- Counting the number of bubbles or the amount of froth formed at a given time. The more the bubbles or froth the faster the rate of reaction.

- Noting the time taken for bubbling or the reaction to stop. The time of the reaction depends of many factors like concentration of the substrate or of the enzyme and the temperature of the medium.

(e) **Zymase** – is a complex of enzymes usually extracted from yeast cells. It breaks down glucose into ethanol.

Cheap sources of enzymes

1. Zymase, sucrase (optimum p_H5) from yeast cells.
2. Proteolytic enzymes from fruits juices e.g. pineapples.
3. Urease from extract of Soya bean seedlings with radicles 2 – 3 cm long
4. Pepsin from extracts of stomach lining.
5. Diastase from barley.
6. Catalase from extracts of living tissues like liver muscle, leaf, potato, apple, pawpaw etc.

Physiology of germinating seeds

Seeds are storage organs of seed bearing plants. They mostly store carbohydrates in form of starch for example maize, sorghum and Soya peas. Some store mostly proteins e.g. beans and Soya beans. While others store lipids e.g. ground nuts and cotton seeds.

During germination the stored food is broken down or hydrolysed by seed enzymes into simple soluble molecules which are used for development of the seedling. The soluble molecules are translocated from the storage regions to area of development, from endosperm to the cytoplasm.

Hydrolysis of stored food increases with germination. This causes a decrease in the complex stored food molecules and an increase in simple food molecules. Further increases in the period of germination leads to the decrease in both complex and simple molecules since are being used for germination.

- Starch is hydrolysed or broken down by amylase enzyme into reducing sugars leading to a decrease in starch and an increase in reducing sugars with germination. But after a week (07 days), the amount of reducing sugars in the seed also decreases because it is being respired for energy.
- Proteins are broken down into simple molecules by protease enzymes which are used for structural purposes. Thus protein amounts decreases with the progress of germination.
- Lipids are broken down by lipase enzyme leading to its decrease with germination.

WATER RELATIONS OF PLANT TISSUES

The cells of plants are osmotic systems and some of these in the root are especially concerned with the process of absorption from the exterior. An appreciation of the role of osmotic systems in water uptake and movement can be gained by studying the Osmotic pressure, osmotic potential or water potential of plant tissues under different conditions

The important terms used:-

Osmotic pressure

This is the ability of the plant tissue or the solution to take in water molecules. It is always positive. The higher the osmotic pressure the more the water molecules is taken up by the plant tissue. A highly concentrated solution has a higher osmotic pressure.

Osmotic potential

Its definition is similar to that of osmotic pressure. Osmotic potential is always negative. A solution with a more negative osmotic potential is more concentrated and hence has a lower value of osmotic potential. Such a solution of a lower osmotic potential has a higher ability to

take in water and a lower ability to lose water. A dilute solution has a higher osmotic potential (a less negative value) and hence a lower ability to gain water but a higher ability to lose water.

In case of the plant tissues (cylinders) of the same tuber, when placed in solutions of similar concentration the most turgid cylinder that has absorbed more water is the most dilute and hence has the highest osmotic potential. The softest cylinder has lost the most amount of water and hence is the most concentrated cylinder with the lowest osmotic potential.

Solute potential

It is similar to the osmotic potential. A tissue /solution with a more negative solute potential (the lowest solute potential) is highly concentrated and it hence easily takes in water. A tissue / solution with a less negative solute potential (highest solute potential) is the most dilute with the highest solute potential. A solution with the highest solute potential has the lowest ability to gain water but with highest ability to lose water. A solution with the lowest solute potential has a highest ability to gain water but with lowest ability to lose water.

Water potential

This is the ability of a plant tissue to lose water. It is always negative. A solution with a less negative water potential has a higher water potential or is more dilute and hence it easily loses water. A solution with the lowest water potential has a lower ability to lose water.

Hypotonic solution

This is a solution which is more dilute and can easily lose water to a concentrated plant tissue.

Isotonic solution

This is the solution which has a concentration similar to that of the plant tissue or to the other solution.

Hypertonic solution

This is a highly concentrated solution which can easily gain water from the dilute solution or dilute plant tissue.

Experiments used to determine the water potential of plant tissue

Water potential of plant tissues can be determined by using the following experiment

Change in length of the potato cylinders

Cylinders of same length and diameter are immersed in solutions of different concentration and left to stand for 45 -60 minutes. After 60 minutes, remove the cylinders and accurately measure and record the final length and diameter. Then obtain the difference in the length and diameter.

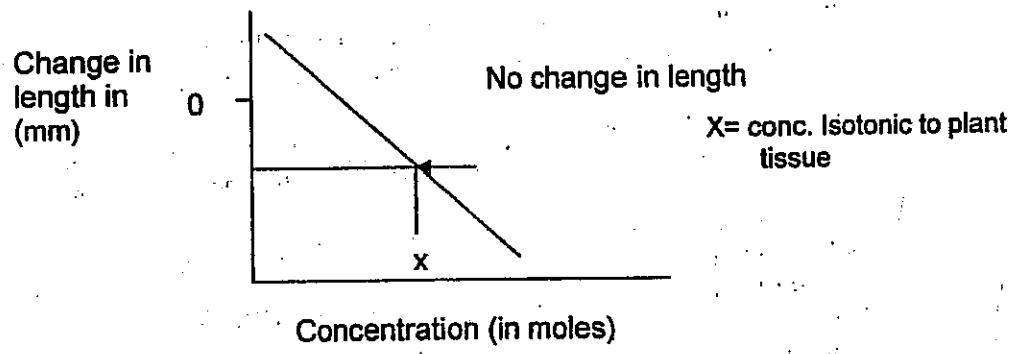
The solution, in which the change in the length and diameter is almost zero, is isotonic to the plant tissue.

The cylinders placed in hypotonic solution absorb water by osmosis and increase in length and diameter. Thus the change in the length and diameter is positive.

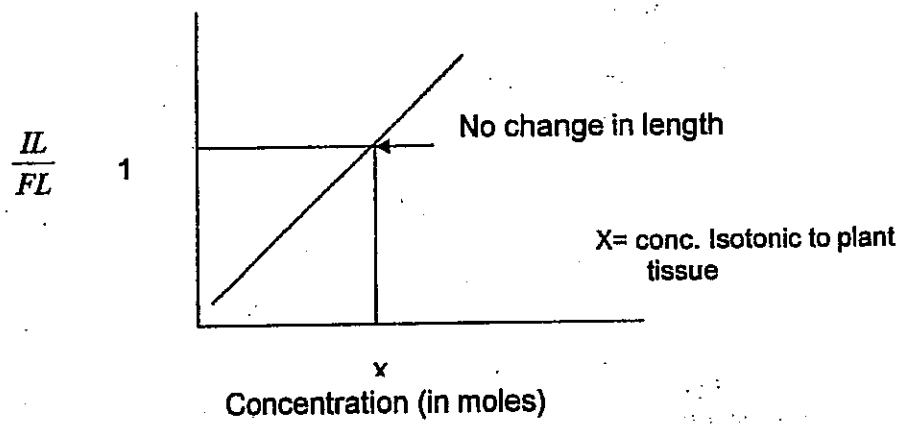
The change in the length and diameter is negative when the cylinders lose water by osmosis to a hypertonic solution.

If a change in length is plotted on a graph against varying concentration, a linear graph is obtained. The vertical axis must have negative and positive figures.

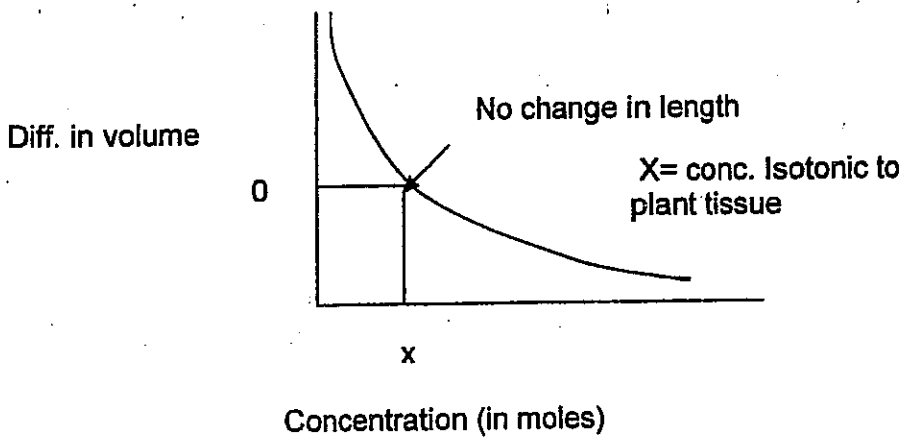
Study the illustration below.



When the ratio of the initial length (IL) to the final length (FL) ie ($\frac{IL}{FL}$) is plotted against concentration a linear graph is obtained. Study the illustration below.



When difference in the volume of the cylinders is plotted against the concentration a curve is obtained. The difference in the volume is inversely proportional to the concentration. To obtain a difference in the volume, subtract initial volume from the final volume (FV-IV). Study the graph below.



Rising and sinking of the drop

Two sets of the solution are made. One of which is dyed to become coloured. Then dip the cylinders of same size in coloured solution for 45 minutes. Remove the cylinders. With the dropper suck the coloured solution and dip the dropper mid way into the corresponding clear solution and then release a drop. Do the same to other solutions.

The drop floats within / spreads (does not sink or rise) in the isotonic solution to the plant tissue.

The drop rises in the denser solution i.e. when the coloured solution is less dense than clear solution.

The drop sinks in less dense solution i.e. when the coloured solution is denser than the clear solution.

The density of the solution is directly proportional to the concentration of the solution ie as the concentration increases the density also increases.

The rate, at which the drop rises, increases with decreasing density of the coloured solution.

The rate of sinking of the drop increases with increase in the density of the coloured solution.

When the drop spreads, there was no net gain or loss of water by the cylinders in the coloured solution. Then the concentration of the coloured and the clear solutions remain the same.

When the drop sinks, the hypertonic cylinders osmotically absorbed water from the coloured solution making it more concentrated than the corresponding clear one. The drop sinks faster when the cylinder has osmotically absorbed more water from the coloured solution making it more concentrated compared to the corresponding one.

When the drop rises, the hypotonic cylinder osmotically lost water to the hypertonic coloured solution making it less concentrated than the corresponding clear solution. The drop rises faster when the cylinder has lost more water to the hypertonic coloured solution making it more less dense (less concentrated) compared to corresponding clear solution.

Change in the volume of the solutions

Solutions of varying concentration are set. Cylinders of same size are made at least 1cm diameter and 6cm length. Immerse one cylinder in each solution. Let the experiment stand for 60 minutes. Remove the cylinders without losing any drop of the solution. Then measure and record the final volume of the solutions.

The solution whose volume remains the same or closest to the original volume, has a concentration similar to that of the potato cylinder. Such solution also gives a ratio of initial volume to final volume of 1:1 or nearest to that.

The solution which increased in the volume osmotically gained water from the hypotonic potato cylinder. Thus the solution was more concentrated or has lower water potential or has higher osmotic pressure or lower osmotic potential than the cylinder.

The solution which reduced in the volume osmotically lost water to the hypertonic cylinder. Thus the solution is less concentrated or has a higher water potential or a lower osmotic pressure or a higher osmotic potential than the potato cylinder.

When arranging solutions in decreasing water potential or osmotic potential, start with more dilute solution and end wit more concentrated solution. This is because a more dilute solution has higher osmotic potential or water potential.

The cylinders in the solution with higher osmotic potential are characterized by being hard or turgid or rigid or stiff, longer, swollen or bigger and with a rough texture.

The cylinders in the solution the lowest osmotic potential are characterized by being soft or flabby, shrunken, shorter and with a smooth texture.

The importance of the above characteristics of the cylinders in different concentrations are;

- The herbaceous plant takes in water by osmosis to become turgid and gain support.
- Turgidity enables plant to store water.
- Flabby nature leads to wilting of plant leaves to reduce water loss.

Percentage plasmolysis of plant cells

The epidermal strips are immersed in the solutions varying concentration for 20 minutes. Count the number of plasmolysed cells in every 20 cells. Calculate the percentage plasmolysis of the cells in each solution. Then plot a graph of percentage against concentration.

NB Some times a standard solution (a solution of a known concentration) is provided. This can be used to prepare many solutions of varying concentration but of same volume. This is done by using dilution method. Ie a certain volume of the standard solution is obtained which is then diluted to prepare the required solution.

Follow the formula below.

$M_1V_1 = M_2V_2$

Where M_1 = concentration of standard solution
V_1 = Volume of a standard solution to be diluted
M_2 = Concentration of the new solution
V_2 = Volume of the new solution.

Bending of the plant strips

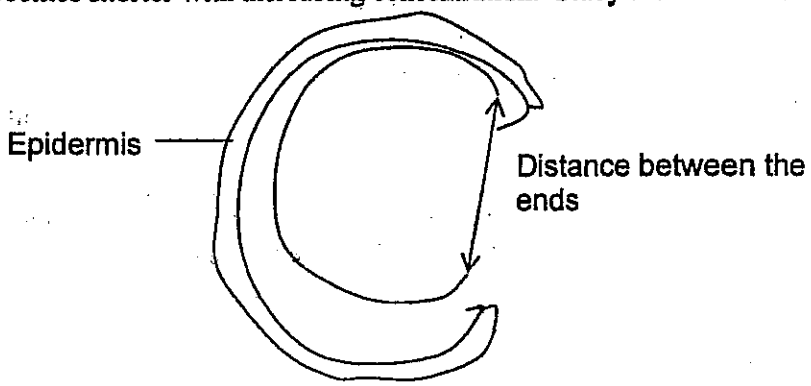
Obtain a piece of plant. Slice it longitudinally using a sharp razor blade into equal sized strips. Immerse one strip into each of the various solutions with different concentration. Leave the experiment to stand for 20 minutes. After 20 minutes record and account for appearance of the strips. Measure the distance between the two bent ends and study how the distance between the two ends varies with varying concentration.

The strip bends in wards when its inner fleshy cells loss water osmotically to a hypertonic solution. Due to loss of more water by fleshy inner cells than the epidermal cells, the fleshy cells shrink making the whole strip to bend in wards.

The strip in the solution with the same concentration it remains straight without bending. This is due to no net osmotic gain or loss of water by the strip.

The strip in the hypotonic solution bends out wards with its epidermal layer in wards. This is a result of osmotic gaining of more water by the fleshy layer than the epidermal layer. As the fleshy layer gains more water, it expands more leading to out ward bending.

When the strips are immersed into solutions of different concentration their degree of curvature increases with increase concentration ie the distance between the two ends becomes shorter with increasing concentration. Study the illustration of the curved strip.



If the distance between the two ends is plotted against the concentration of the solutions, a graph showing an inverse proportionality between the distance of the two ends and the concentration of the solutions.

Guiding questions about physiology

1. Select 30 healthy seedlings from those provided **(04 day soya bean seedling)**. Grind them in a mortar and pestle, breaking down the tissues thoroughly.

Add 100ml of water and continue grinding gently for about one minute. Leave the mixture to stand for about 15 minutes and decant the clear extract into a beaker.

Take 6 conical flasks and label them 1 to 6. Starting from flask 1 to 6 transfer the following quantities of urea solution to the flask; 1.0ml, 15.0ml, 20ml, 30ml, 40.0ml, and 50ml. Make up the solutions in each flask to 50ml by adding water.

Beginning with flask No. 6 and working down to flask No. 1, add 5 ml of the seedling extract to each flask and shake to homogenize. Start timing the experiment and allow it to run for 1:30 hours.

Meanwhile prepare to titrate by filling the burette with dilute acetic acid. (N.B if you are not familiar with titrations, the teacher can show you how the acid is released from the burette a little at a time by manipulating the clip or bread.)

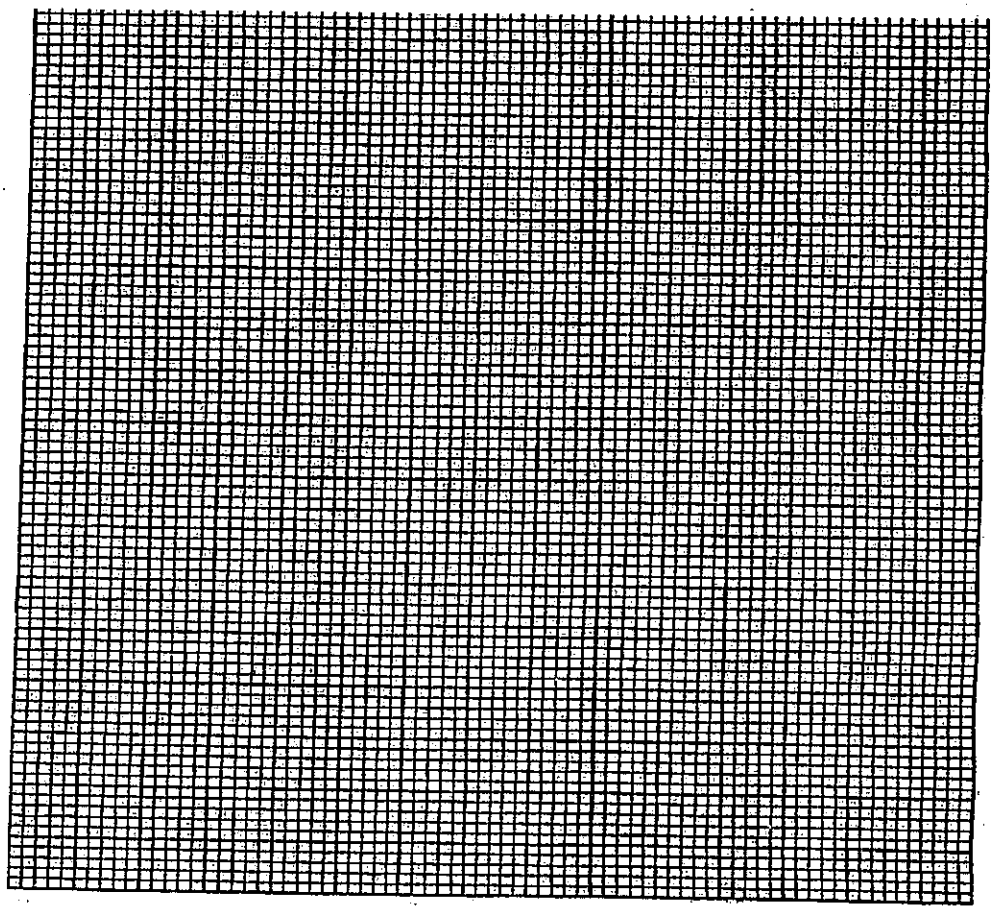
After 1 ½ hours start titrating with flask No. 6 as follows:

Add 3 ml of litmus solution and shake to mix. The mixture in the flask will turn light blue. Note the level of the acid in the burette. By manipulating the clip or bread, titrate, shaking the flask each time the acid is added until the colour of the mixture turns pink and note the amount of acid added to the mixture in flask No. 6.

Repeat the procedure with flasks 5 to 1.

(a). Tabulate your results.

(b). Draw a graph putting amount of urea used on horizontal axis and the acid used on the vertical axis.



Given that urea is broken down to carbon dioxide and ammonia with the help of an enzyme in the seedling extract.
Explain the colour changes in the flasks when litmus liquids and acid are added.

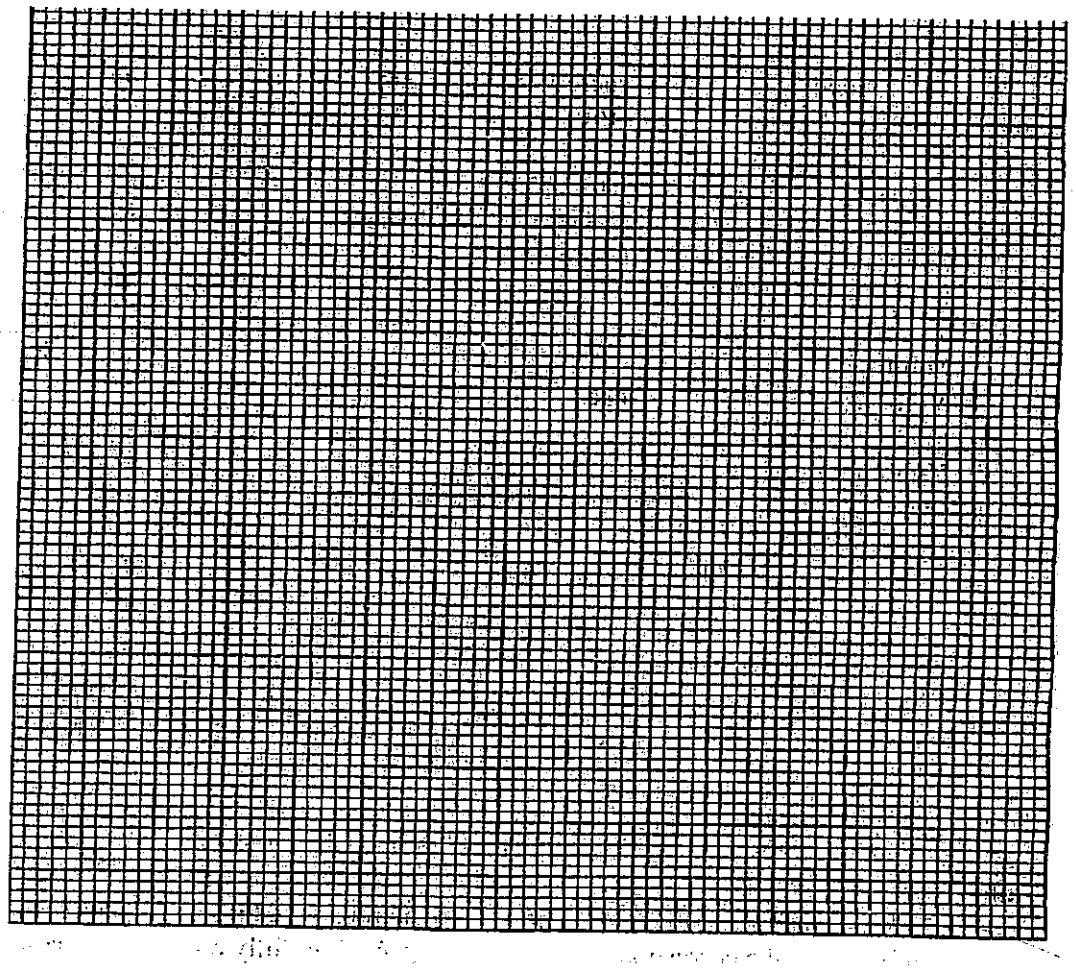
(C). What is the name of the enzyme?

(d). Interpret the graph in terms of enzyme – substrate relationships and rate of reaction.

2.(a) You are provided with an Irish tube, distilled water, sucrose solutions of different molarities. Using a borer, produce **5** cylinders of tissue from the potato tuber provided. Cut the cylinders to uniform length of 40mm each. Place one cylinder of tissue in each beaker of distilled water and sucrose solutions of **0.0M, 0.1M, 0.2M, 0.4M, 0.6M, and 0.8M.** Leave for at least **45** minutes. Remove the tissue cylinders and blot gently with blotting paper to remove excess solution. Measure them to the nearest millimeter.

(i) Record your results in an appropriate table and calculate the ratio of initial length of the cylinder to their final length.

(ii) Plot a graph of $\frac{\text{Initial length}}{\text{Final length}}$ (IL) against the sucrose concentration. (FL)



(iii) At which molarity is the ratio $\frac{IL}{FL} = 1.0$?

(iv). what deduction can you make about the plant tissue?

(v). Feel the potato cylinders in distilled water and the different sucrose solutions between your fingers and record your observations.

(vi). What is the significance of your observation about the role of water in plant tissues?

3.You are provided with coloured sucrose solutions each measuring $10cm^3$ and each with a concentration as shown. A (0.0M), B (0.1M), C (0.25M), D (0.4M), E (0.75M), and F (1.0M).

(a). using the clear sucrose of **1.0M** and distilled water, prepare $10cm_3$ each of solution A_1-F_1 with concentrations corresponding to that of solutions **A-F** above.
(i). Record the amount of the clear solution and distilled water used in the table below; (06mks)

Table 1

Solutions	A_1	B_1	C_1	D_1	E_1	F_1
Volume of clear solution used (cm^3)						
Volume of distilled water used (cm3)						

(ii). State the formula used to determined the amount of clear solution used in preparation of solution A_1-F_1

Using a cork borer, cut six plant tissues of length **6cm** from specimen **q**, transfer one plant tissue to each of the coloured solutions and leave to stand for **1hour.**
After 1hr;

1. Suck a little of the coloured solution A into a dropper and insert the tip of the dropper halfway into the corresponding clear solution A_1. Carefully release **one drop** of the coloured solution and withdraw the dropper.

2. Observe and record the movement of the coloured drop in the table below.
3. Repeat procedure 1 and 2 using a drop from the remaining solutions (B-F)

Table II

Solutions	Observed movement of the colored drop
A	
B	
C	
D	
E	
F	

(c). Explain the observed behavior of a drop of coloured solution from.

(i). solution **C** (3mks)

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(ii). Solution **B** (3mks)

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(iii). Solution **E** (3mks)

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(iv). Suggest how you would experimentally verify the explanations given in c (i), (ii) and (iii). (3mks)

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D (i). Compare the physical conditions of the plant tissues immersed in solution **B** and **F**.
Table III

From solution B	From solution F
1	
2	
3	

(ii). Explain how the physical conditions of the plant materials from the two solutions **(B and F)** may be used to establish their osmotic potentials. (4mks)

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(iii). Suggest one advantage of the observed physical condition of the plant from solution **B** has over that from solution **F** in non woody plants. (3mks)

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4. You are provided with coloured sucrose solutions each measuring $10cm^3$ and concentrations as shown;
A (0.0M), B (0,1M), C (0.25M), D (0.4M), E (0.75M) and F (1.0M)
(a). using the clear sucrose solution **(1.0M)** and distilled water, prepare $10cm^3$ each of solutions A_1-F_1 with concentrations to that of solutions **A-F** above.
(i). record the amount of the clear solution and distilled water used in the table below. (6mks)

Solutions	A_1	B_1	C_1	D_1	E_1	F_1
Volume of clear solution (cm^3)						
Volume of distilled water used (cm^3)						

(b). using a corkborer, cut six plant tissues of length 6cm each from specimen **Q**.
Transfer one plant tissue into each of the coloured solutions and leave to stand for 1hr.
After 1hr;

1. suck a little of the coloured solution A into a dropper and insert the tip of the dropper halfway into the corresponding clear solution A1. Carefully release one drop of the coloured solution and withdraw the dropper.
2. Observe the movement of the coloured drop and note the time taken for the drop to either rise to the top of the clear solution or sink to the bottom.
3. Repeat procedure 1 and 2 using a drop from the remaining solutions **(B-F)**.

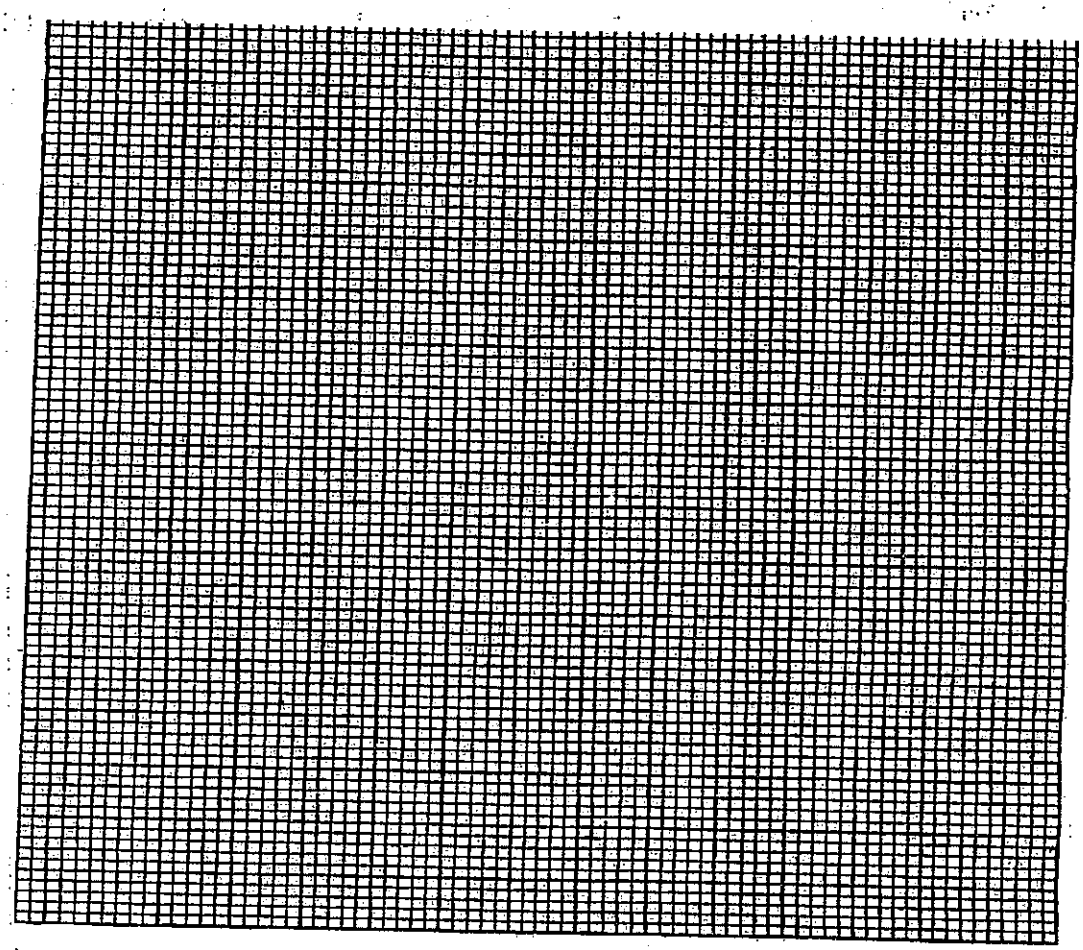
(i). record your results as follows: (6mks)

- -ve values for time taken if drop sinks

- +ve values if drop rises.
- Zero if drop spreads out or remains stationary where it was released.

Drop from solution	A	B	C	D	E	F
Time taken (seconds)						

(ii). Plot a graph to show the relationship between time taken and the original molarities of solutions **A-F.** (11mks)



(ii). Explain the shape of the graph (9mks)

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5. You are provided with six coloured sucrose solution of varying concentrations. Each of the coloured solution has a corresponding clear solution of the same concentration.
Obtain twelve test tubes, label six of the **A-F**. Label the remaining test tubes A_1-F_1.
With $10cm^3$ measuring cylinder, measure $10cm^3$ of each of the coloured solutions and pour each into the corresponding test tube. Repeat the same measurements for the clear solutions.
With a corkborer of 0.5cm diameter, cut 12 potato cylinders of 5cm long. Drop two cylinders into each of the coloured solutions. Let them stand for 40 minutes.

After 40 minutes, with a dropper sucker little solution of **A**. insert the dropper into the corresponding clear solution (A_1) and carefully release one drop the coloured solution at the middle way of the clear solution. Immediately start the stop clock.
(a). observe and record the movement of the coloured drop and the time taken for the drop to either sink to the bottom or rise to the surface in the table of results below.
Repeat the procedure for the remaining solutions B-F
Record the time as **–ve** for sinking and **+ve** for rising

Table of results (12mks)

Solution	**Movement of the drop**	**Time taken in minutes**
A_1		
B_1		
C_1		
D_1		
E_1		
F_1		

(b). explain the time recorded for movement of the drop in;
(i). E_1 (03mks)

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(ii). D_1 (03mks)

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(iii). B_1 (03mks)

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(iv). A_1 (03mks)

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(c). (i). Measure and record the volume of **F** and **D** at the end of the experiment. (02mks)

Volume of **F**.....cm^3

D.....cm^3

(ii). Explain the change in volume of solution **F** (02mks)

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(iii). Suggest one coloured solution with concentration closest to the potato cylinder (01mk)

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(d). examine the cylinder of solutions **E, D** and **A**

(i). with reasons arrange the cylinder in their increasing osmotic potential. (5mks)

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(ii). State the three physical differences between cylinders **E** and **A** (03mks)

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(iii). Give the significances of the differences given in (d) (ii) above to plants.(3mks)

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6.You are provided with specimen **P** and sugar solutions of varying concentrations labeled **A, B, C, D, E,** and **F.**

(a). measure 8.0cm3 of each solution and transfer the solutions into test tubes labeled correspondingly. Using a cork borer, obtain six equal sized cylinders of at least1cm diameter, from specimen **P** and trim the cylinders to uniform length of 6.0cm. Immerse a cylinder into each of the solutions in the test tubes and leave for 1:30minutes.

(i). After 1:30minutes, transfer solution A into a measuring cylinder and record the final volume in table below.

Repeat the procedure for the remaining solutions. (06mks)

Solutions	**A**	**B**	**C**	**D**	**E**	**F**
Final volume						
Initial volume:final volume ratio						

(ii). Calculate the initial volume to final volume ratio, of the solution, in the spaces provided in the table above. (06mks)

(b). suggest the solution with the concentration nearest to that of the cell sap of specimen P. explain your answer. (06mks)

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(ii). Arrange solutions **A** to **F** in order of decreasing osmotic potential.
Explain your answer. (06mks)

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c). explain the results obtained in test tubes A, D and E. (09mks)

Test tube **A**

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Test tube **D**

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Test tube **E**

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7. You are provided with plant materials labeled **P1 and P2,** sucrose solution **A – F** of concentrations – **0.0M, 0.2M, 0.3M, 0.4M** and **0.5M, 0.8M** respectively.

(a). Carry out the procedure below:

Measure and cut 5.0cm length of Specimen P1. Then from each piece obtain four equal sized strips by slicing P1 longitudinally using a sharp razor blade.

Repeat this procedure using specimen P2. Observe the strips from P1 and P2. Record and account for the appearance and physical nature of the strips from the specimens. (06 mks)

Strip from P1 –

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Strip from P2 -

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b. Transfer 30mls of Sucrose solution into Petri dishes **A – F.**

Choose the best strips and immerse one strip from P1 into each solution plus one from P2 into solution A only. Leave the set up to stay for 20 minutes before examining the strips. Record and account for the appearance and physical nature of the strip placed in solution A after 20 minutes. (08 mks)

Strip from P1

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Strip from P2

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c. Explain the curvature of the strips P1 placed in the following sucrose solution:

A –

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D –

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F –

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d. Establish the extent of curvature of strips from P1 by measuring the difference between the ends of the strips.

(i) Tabulate your results below: (07 mks).

8. You are provided with solution **A**, **B** and **C**. You are required to carry out the following tests to identify the nature of solution **C**, and then find out the action of solutions **A** and **B** on **C**.

(a) Carry out tests in Table 1 on solution **C** to identify its nature. Record your tests, observation and deductions in Table 1 below (9 mks)

Table 1

Test	Observation	Conclusion
Starch		
Proteins		
Reducing sugars		

(b) Carry out tests described in Table 2, and record your observations and deductions in the table. (4 mks)

Table 2

Test	Observations	Deductions
(i) To 1cm3 of **A** in a test tube, add 1cm^3 of dilute sodium hydroxide solution mix well, then add 1cm^3 of **C** and incubate at $(35-40)^{0C}$ for 20 minutes.		
(ii) Repeat test (b) (i), using solution **B** instead of solution **A**.		

(c) Repeat the procedure in (b) using dilute hydrochloric acid instead of Sodium hydroxide. Record your observations and deductions in Table 3 below. (4mks)

Tests	Observation	Deduction
(i). To 1cm3 of **A** add 1cm3 of dilute NaOH then add 1cm3 of **C**, incubate at 35-400c for 20 minutes.		
(ii). Repeat the test above using solution **B** instead of **A**		

(d) Repeat the procedure in (b) but without using hydrochloric acid or sodium hydroxide. Record your observations and deductions in Table 4 below. (4 marks)

Tests	Observations	Deductions
(i) To 1cm3 of **C** in a test tube add 1cm3 of **A** mix well and incubate at $(35-40)^{0}C$ for 20 minutes.		
(ii) Repeat test (d) (i) using solution **B** instead of solution **A**.		

(e) (i) Comment on the effects of solutions **A** and **B** on solution **C**. (2 mks)

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(i) From your results, what are the characteristics of:

Solution **A** (3 mks)

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Solution **B** (3 mks)

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(iii) Suggest where in a mammalian body, substances similar to solutions **A** and **B** are likely to be found. Explain your answer. (4 mks)

(iv) What was the purpose of the tests in Table 4? (1 mark)

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9. You are provided with solution **X** and **Y**.

(a). Identify the food substances in the solutions **X** and **Y** using iodine solution, Benedict's solution and million's reagent only. Record your tests, observations and deduction in the table below.

Test	Observation	Deduction

(b). Cut a piece of the stomach from the dissection in question 1 (toad), measuring $1cm^2$. Wash and grind it in a mortar. Add 4 cm^3 of distilled water, leave to settle then decant. Label the extract, **S**.

Label four test tubes 1, 2, 3 and 4 and add contents to each test tube as shown in the table below.

Test tube 1	2cm of X and 1cm^3 of dilute hydrochloric acid solution.
Test tube 2	2cm^3 of X and 1cm^3 of dilute sodium hydroxide solution.
Test tube 3	2cm^3 of Y and 1cm^3 of dilute hydrochloric acid.
Test tube 4	2cm^3 of Y and 1cm^3 of dilute sodium hydroxide solution.

Divide extract S into four equal portions and add a portion to each of test tube 1, 2, 3 and 4 above.
Incubate the test tubes at 40^{0}C for 20 minutes.
After 20 minutes,

(i) Observe test tubes 1 and 2 and record your observations and deductions in the table below.

	Observation	Deductions
Test tube 1		
Test tube 2		

(ii) Identify the food substances in test tube 3 and 4 using the reagents provided. Record your tests, observations and deductions in the table below.\

Test tube	Tests	Observation	Deduction
3			
4			

(12 mks)

(iii) From your results, state two properties of the active substance in solution S.

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10. You are provided with solutions **A, B, C** and **D** which are extracts from seedlings of same type of seed at different stages of germination.

(a).Carry out an iodine test on each solution. Record your tests, observations and deductions in Table 1 below.

Solution	Iodine	Observations	Deduction
A			
B			
C			
D			

(b).Carry out a Benedict's test on each of the solutions **A, B, C** and **D.** Record your tests, observations and deductions in Table 2 below.

Solution	Benedict's test	Observation	Deduction
A			
B			
C			
D			

(c).Solutions **E** and **F** are extracts of seedlings of same type of seed, but different from seed types from which extracts **A, B. C** and **D** were obtained. Solution **E** is from seedlings of the same age as those from which extract **A** was obtained, while extract **F** is from seedlings of same age as of those from which extract **C** was obtained.
Carry out the following tests on solutions **A, C, E** and **F.**

Record your tests, observations and deductions in table 3 below.

Solution	Biuret Test	Observations	Deductions
A			
B			
C			
D			
E			
F			

(d).(i) From your results in **Table 1** and **Table 2,** arrange the solutions **A, B, C** and **D** in order, starting with solution from the youngest seedlings and ending with that from the oldest seedlings. (01 mks)

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(ii) Give reasons for your answer in (d) (i) (04 mks)

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(e).(i) From your results in Table 3 compare the contents in solution **A** and **E** and contents in solution **C** and **F**. (02 mks)

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11. You are provided with solution **Z** which is a plant extract and solution **V**. Label six test tubes as **A, B, C, D, E** and **F** and put into each test tube **3** cm^3 of solution **V**.

(a).(i) To test tube **A** add 1cm^3 of solution **Z** at once. Record the observations and the time taken for the reaction to stop.

(ii) Repeat the procedure in (a) (i) with test tubes **B, C** and **D** in water bath of temperatures 30^{0}C, 40^{0}C and 50^{0}C respectively and enter all the results in Table 1.

Test tube	**Temp. (^{0}C)**	**Observations**	**Time taken for the reaction to stop. (sec)**
A	Room temperature		
B			
C			
D			

(b).Solutions **W** and **X** are common laboratory reagents.
Add 5 drops of solution W into test tube E and 5 drops of solution **X** into tube **F**. Then add 1cm^3 of solution **Z** to each of the test tubes E and F simultaneously. Record your observation in Table 2 below. (02 mks)

Test tube	Contents	Observations
E		
F		

(c).The concentrations of solution **V** have varied to give solutions V_1, V_2 and V_3. Add $1cm^3$ of solution **Z** into each of the test tubes containing solution V_1, V_2 and V_3. Record your observations in Table 3. (03 mks)

Contents of test tube	Observations

(d).Explain the observation you have made in test tubes

(i) A, B, C and D in (a):

Test tube A

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Test tube B

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Test tube C

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test tube D

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(ii) E and F in (b):

Test tube E:

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Test tube F:

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(e).In part (c) where the concentration of V has been varied, arrange the solutions in order of increasing reactivity, starting with the least reactive.

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(f).Giving two reasons, suggest the active substance in solution Z. (03 mks)

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(g). What properties of the active substance have been demonstrated? (03 mks)

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12. You are provided with suspension **X** and carbohydrate solution **P** and **Q**. You are required to determine the nature of solution **P** and **Q** and action of suspension **X** on them.

(a).Carry out the following tests and records your observations and deductions in Table 1

Tests	Observation	Deduction
(i) Take 1cm^3 of **P** add 1cm3 of Benedict's solution an boil		
(ii) Take 1cm^3 of **Q** and add 1cm^3 of Benedict's solution and boil		

(b).Take 4cm^3 of suspension **X** in a test tube and place it in a water bath of boiling water for 10 minutes. Remove the test tube from the water bath and allow cooling. Label it boiled **X.**

Label six test tubes 1 to 6. In each test tube, add contents as shown in Table II and leave to incubate at the respective temperatures for 25 minutes.

Table II

Test tube	Contents	Temperature of incubation
1	Put $2cm^3$ of **P** in $1cm^3$ of unboiled X	Room temperature
2	Put $2cm^3$ of **Q** and $1cm^3$ of unboiled X	Room temperature
3	Put $2cm^3$ of **P** and $1cm^3$ of unboiled X	40^0C
4	Put $2cm^3$ of **Q** and $1cm^3$ of unboiled X	40^0C
5	Put 2 cm^3 of **P** and $1cm^3$ of boiled X	40^0C
6	Put $2cm^3$ of **Q** an $1cm^3$ of boiled X	40^0C

After incubation, carry out the Benedict's test on the contents of each of the six test tubes using 1cm3 of the test tube solution and 1cm3 of Benedict's solution in each case. Record your observations and conclusions in Table III.

Table III

Test tube	Observations	Conclusion
1.		
2.		
3.		
4.		
5.		
6.		

a. Explain your observations in test tubes:
(i) 1, 3 and 5.

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(ii) 2, 4 and 6

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(c).(i) What conclusions can you draw about the identity of carbohydrates **P** and **Q**?

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(ii) Suggest a further test you would carry out to confirm the identity of **P** and **Q.**

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13. You are provided with suspensions **A** and **B.**

(a). using the lab chemicals provided, carry out experiments to determine the composition of the two suspensions. In the final experiment, to $2cm^3$ of each suspension add solution **C** dropwise.

Record your experiments and observations in the space below. NB: do not carry out Benedict's test at this stage. (15mks)

	A	
	B	
	A	
	B	
	A	
	B	

	A
	B

(b). giving two reasons for your observations, name the suspension with;

(i). a complex composition (03mks)

Suspension.....

Reasons

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.....

(ii). an active substance only (03mks)

Suspension.....

Reasons

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c). suggest the purpose of the experiment where solution **C** was used. (02mks)

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(d). to $2cm^3$ of the suspension named in (b) (i) above add $2cm^3$ of solution **D**. Transfer the contents of the tube into material **V** provided. Tie the open ends of material **V** tightly using thread.

Suspend the material and its contents into a small beaker containing $30cm^3$ of warm water (temperature 40^0c).

Carry out Benedict's test on the warm water after 2 minutes, 10 minutes, and 30 minutes

Record your test, observations and deduction (08mks)

Test	**Observation**	**deductions**
	1 minutes	
	10 minutes	
	30 minutes	

(i). giving evidence from your observations in (a) and (b), comment on the nature of solution **D** and material **V**.

Solution **D** (03mks)

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Material **V** (03mks)

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(ii). relate the results obtained in d above to similar physiological activity in humans. (08mks)

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14.You are provided with solution **X** and specimen **W**.

(a). cut specimen **W** into four uniform sized smaller cubes. Label the cubes **A, B, C** and **D**. Treat cubes **A, B,** and **C** as follows;

A-Biol in water for 1 minute, remove and cool

B-cut into four small pieces and boil in water for 1 minute, remove and cool

C-chop into small pieces and crush into fine paste, boil in 3cm3 of water for 1 minute and cool

Then crush materials **A, B,** and **D** separately into fine paste and add 3cm3 of water to each to make extract

(i). carry out the tests in the table below and record your observations and time taken for the reaction to cease in the table below. (13mks)

Experiments	**Observations**	**Time taken in seconds**
(1). To $2cm^3$ of solution **X** add $2cm^3$ of extract **A**		
(2). To $2cm^3$ of solution **X** add $2cm^3$ of extract **B**		
(3). To $2cm^3$ of solution **X** add $2cm^3$ of extract **C**		
(4).To $2cm^3$ of solution **X** add $2cm^3$ of extract **D**		
(5). To $2cm^3$ of solution **X** add 10 drops of HCl, followed by 2cm3 of extract **D**		

(ii).giving one reason, suggest the nature of solution **X** (02mks)

Nature of solution **X**.....

Reason

.....

.....

(ii). explain your observation in tubes **1, 2, and 5** (08mks)

Tube 1

.....

.....

.....

Tube 2

.....

.....

.....

Tube 5

.....

.....

(iv). From your observations in table 1, state two properties of the active substance investigated in the experiments.

.....

.....

(b).(i). Extract **W** was prepared from specimen **W**. using the chemicals and reagents provided carry out tests to determine the composition of extract **W** and solution **E** .record your tests, observations and conclusions in table below. (10mks)

Tests	Observations	conclusion
	E	
	W	
	E	
	W	

(ii). To 2cm3 of E add 2cm3 of extract W and incubate at temperature 35-400c for 50 minutes. Then repeat the tests in (b) (i) above. Record in the table below.(5mks)

Name of the test	Observation	conclusion
1		
2		

(iii). Explain the result in table above (03mks)

.....

.....

.....

(iv). From your observations in (a) and (b) comment on the biological role(s) of specimen W. (02mks0

.....

.....

.....

15. You are provided with specimen **B**.

(a) Using a scalpel, peel the specimen then cut out two cubes from it. Cube **B1** measuring, **1cm x 1cm x 1cm** and cube **B2** measuring, **2cm x 2cm x 2cm.**

(i) Calculate the surface area, the volume and the surface area to volume ratio of each tube in Table I. Show your working. (03mks)

Table I

	Surface area	Volume	Surface : Volume ratio
B1			
B2			

(ii) Immerse each cube completely in a beaker containing potassium permanganate solution and leave for 15 minutes. After 15 minutes remove the cubes from the solution and wipe them using a blotting paper.

Using a razor blade, cut each cube into two halves. Using one half of each cube, measure the distance in mm, across the uncoloured portion as indicated in fig. 1

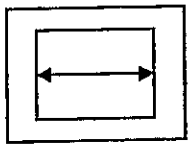


Fig. 1

Record your results

B1 .....mm

B2 .....mm (02 mks)

(iii) What physiological process in observed in (ii) (01 mk)

.....

(iv) How do the results in (ii) relate to the physiological process named in (c) (i), in living organisms? (04 mks)

.....

.....

.....

(d).Cut a very thin slice of specimen **B** using a sharp razor blade. Place the slice on a slide in a drop of water irrigate with iodine solution. Observe the slice under the medium power of a microscope.

(i) Draw and label the three adjacent cells observed. (06 mks)

(ii) Giving a reason, suggest the name of the tissue observed. (02 mks)

.....

.....

(iii) From your observation, state the function of the tissue observed. (02 mks)

.....

.....

(d).Using a mortar and pestle, crush the remaining piece of specimen **B**. Add 10cm^3 of water to it, stir then decant the liquid part into a test tube.
(i) Carry out tests for proteins, starch and reducing sugar on the solution, using the reagent provided. Record your tests, observations and conclusions in Table II.

Table II

	Test	Observation	Conclusion
Proteins			
Starch			
Reducing sugars			

(10 mks)

(ii) To 5cm^3 of solution **B**, add 2cm^3 of solution **Y** provided. Incubate in a water bath at 35 – 40^{0}C for 5 minutes. Repeat the tests in Table II above using the incubated mixture. Record your observations and conclusions in Table below. (06mks)

Test for;	Observation.	Conclusion.
Proteins		
Starch.		
Reducing sugars		

(iii) From the results in (c) (ii) suggest the nature of solution **Y** (02 mks)

.....

.....

(iv). State one property of solution **Y** shown by the results in (c) (ii).

.....

16. Solutions P_1, P_2, and P_3 are extracts of different plant organs. Carry out the following tests in tables **1, 2, 3, and 4** to determine the nutrient content of each solution. Record your tests and observations in the tables.

(i) Benedict's test

Table 1

Test	**Observation**
	P_1
	P_2
	P_3

(iii) Biuret test

Table 2

Test	**Observation**
	P_1
	P_2
	P_3

(iv) Iodine test

Table 3

Test	Observation
	P_1
	P_2
	P_3

(v) DCPIP test

Table 4

Test	Observation
	P_1
	P_2
	P_3

(b). From your results suggest the plant parts that the solutions were obtained. Explain your answer.

.....

.....

(c). Dissect the two specimens of Q, remove the alimentary canal and cut out the foregut and midguts. Put both the midgut and foregut in s mortar, grind into a fine paste and add $3cm^3$ of water. Stir, leave to settle and decant to obtain extract C. Divide the extract equally into three test tubes labeled as P_1, P_2, and P_3.

To test tube P_1 add $3cm^3$ of solution P_1, to test tube P_2 add $3cm^3$ of solution P_2 and to test tube P_3 add $3cm^3$ of solution P_3. Incubate the test tubes at 35-400c for 20 minutes. After incubation, carry out the tests in Table 5 on the contents of each test tube to establish the effect of extract C on solutions P_1, P_2, and P_3.

(I). Record your observations in the table.

Table 5

Contents	Observations after 20 minutes		
	Biuret test	Iodine test	DCPIP test
Of test tube P_1			
Of test tube P_2			
Of test tube P_3			

(ii). Explain your results of the tests with the contents of

test tube P_1.

.....

Test tube P_2

.....

.....

Test tube P_3

.....

.....

(iii). From your results in (c) (i) ,state **two** properties of the active substances in extract **C.**

.....

.....

.....

.....

17. You are provided with specimen **S** (ripe orange). You are required to carry out tests on the specimen using the procedure provided, then answer the questions that follow.

Procedure

- Label five test tubes as **A, B, C, D** and **E.**
- Peel specimen **S,** choose five large locular segments and separate them individually.
- Squeeze the juice from one segment into a test tube labeled **A.**
- Place the remaining four segments in a beaker containing water and ensure that the segments are covered. Heat the water in the beaker and when it starts boiling, start a stop clock.
- Remove the segments from the boiling water one at a time, after 1 minute, 4 minutes, 6 minutes and 10 minutes, and place them in a petridish. (*take care to note which segment has been boiled for how long)*
- After the segments have cooled, squeeze the juice from each of them into labeled test tubes as indicated in a table below.

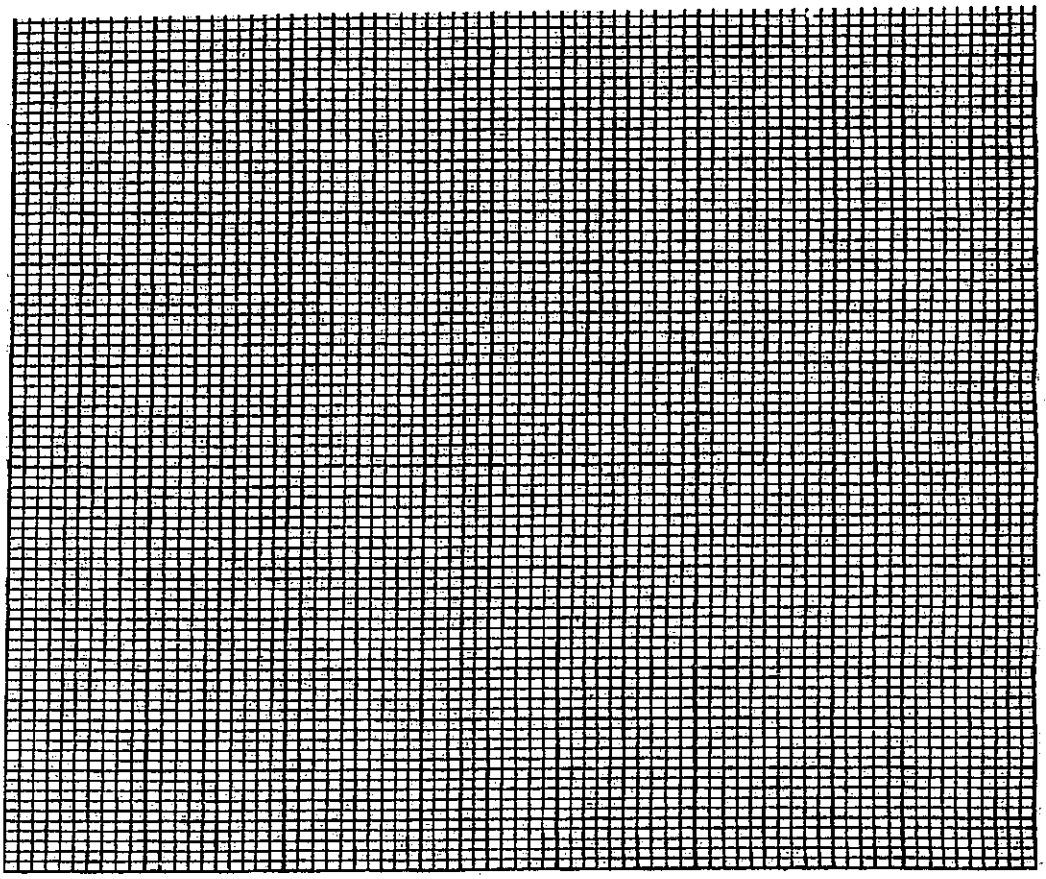
Duration the segment has been boiled (minutes)	Test tube into which juice is squeezed
1	**B**
4	**C**
6	**D**
10	**E**

(a). Carry out the following tests using the juices prepared.

To 1cm3 of DCPIP in the test tube add the juice from test tube A, drop by drop using a dropper, and record the number of drops required to decolourise the DCPIP, a table below. (05mks)

Test tube containing juice	Duration the segment was boiled (minutes)	Number of drops of juice needed to decolourise DCPIP
A	0	
B	1	
C	4	
D	6	
E	10	

(b). Represent your result on a graph, in the space below. (11mks)



(c). (i). State the conclusion drawn from these results (1mks)

.....

(ii). State two explanations for your results (05mks)

.....

.....

.....

(iii). Suggest how one of the suggestions in (c) (ii) can be verified. (02mks)

.....

.....

(d). What is the significance of your results from the tests? (01mks)

.....

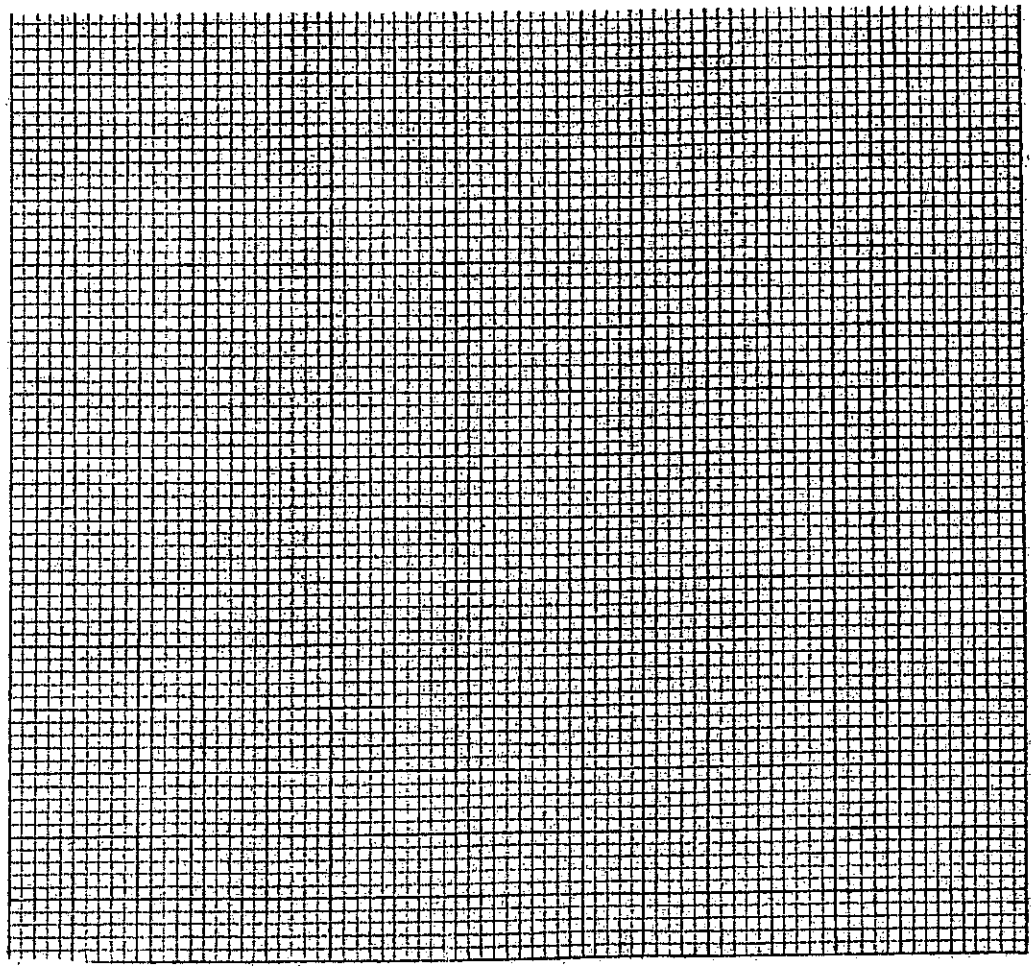
.....

18. you are provide with solutions **X, y,** and **Z** which are extracts of a plant tissue, at different concentrations and solution **Q**. you are to carry out tests using the solutions and answer the questions that follow.

(a). in a 10ml measuring cylinder, add 3 cm^3 of **X** followed by 2 cm^3 of **Q** and start the stop clock. Observe the reaction and record the volume of the contents including the froth, every 20 seconds for 60 minutes, in table below. Repeat the procedure with solutions **Y** and **Z** and record the results in the table. (06mks)

Time (s)	Volume of mixture of (X+Q) cm^3	Volume of the mixture of (Y+Q) cm^3	Volume of mixture of (Z+Q) cm^3
0			
20			
40			
60			

(b). (i). Using, same axes represent your results in a graphical form in the space provided below. (12mks)



(ii). Using, the graphs in (b) (i), calculate the rate of reaction for each mixture. Show your working. (03mks)

X+Q.....

.....

Y+Q.....

.....

Z+Q.....

.....

c). (i). State what is being investigated in the tests (01mk)

.....

(ii). explain the results of your tests (03mks)

.....

.....

.....

.....

.....

Plants and their structures

Determination of magnification of a microscopic drawing

View the specimen using a given objective lens (magnification power) like medium power. View and draw the specimen. Remove the specimen and place a transparent meter rule to measure the field of view. Record the size of the field of view in millimeter (mm). The size of the field of view is equivalent to the actual size of the specimen. Convert the size of the field of view into micrometer (μm), (1mm = 1000 μm). Measure the size of the drawing in millimeter and convert it into micrometer.

The magnification of the drawing = $\frac{\text{size of the drawing (μm)}}{\text{Actual size of the specimen (μm)}}$

If a part of the drawing is drawn, calculate the actual size of the part drawn (it can be one cell) and record it in micrometer. Then work out the magnification of the drawn part as shown for the whole specimen above.

For example, if 10 cells are viewed in a field of view of 2mm, the actual size (length) of the one cell drawn is

$$\frac{2mm}{10 \text{ cells}} = 0.2mm$$

Thus the actual size (length) of the one cell is $0.2mm \times 1000 = 200\ \mu m$

Suppose the length of one cell drawn is 4mm, the length of the drawn cell in micrometer is $4 \times 1000 = 4000\ \mu m$

Thus the magnification of the drawing $= \frac{\text{the length of the drawing } (\mu m)}{\text{Actual length of a cell } (\mu m)}$

$$= \frac{4000\ \mu m}{200\ \mu m} = 40$$

The common specimens used under this section are;

- Plant organisms e.g. Rhizopus (bread moulds), Algae (spirogyra), Bryophytes (moss) and other plants.
- Plant structures like leaves, stems, roots, flowers and seeds. When studying plant structures, consider the external and internal features.

Rhizopus (bread mould)

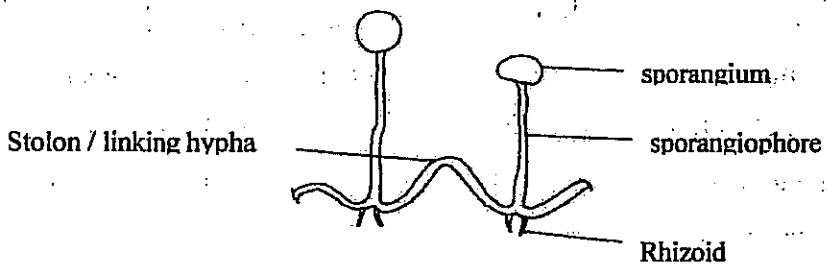
Classification of Rhizopus species

Kingdom Fungi

Phylum Zygomycota

Class Zygomycetes

Diagram of Rhizopus



Structural features of Rhizopus

It consists of mycelium, sporangiophpre, and sporangium.

Mycelium

It consists of stolon or linking hyphae and rhizoids. Stolon is long, slender, and thin net work of hyphae called mycelium. Mycelium has a large surface area for support.

Rhizoids are numerous, thin, and slender. They are;

- Thin to easily penetrate the substratum.

- Many or numerous to increase surface area for absorbing nutrients.
- To easily absorb nutrients easily by reducing diffusion distance.

Sporangium (spore capsule)

It is ball shaped or bulbous or spherical, swollen, and dull coloured or black.

Rhizopus is found in moist places to avoid desiccation. It is smooth, thus it can easily lose water leading to desiccation if exposed to high temperatures.

The nutrition of Rhizopus is heterotrophic due to lack of chlorophyll.

Adaptations of Rhizopus to survive in its environment

- It produces numerous spores for easy multiplication or for easy colonization of new areas.
- It has numerous rhizoids to increase surface area for easy absorption of nutrients.
- It has a net work of hyphae (mycelium) for support.
- It has long sporangiophpre to easily disperse spores.
- It has thin rhizoids for fast absorption of nutrients.

Spirogyra

Classification of spirogyra

Kingdom Protoctista

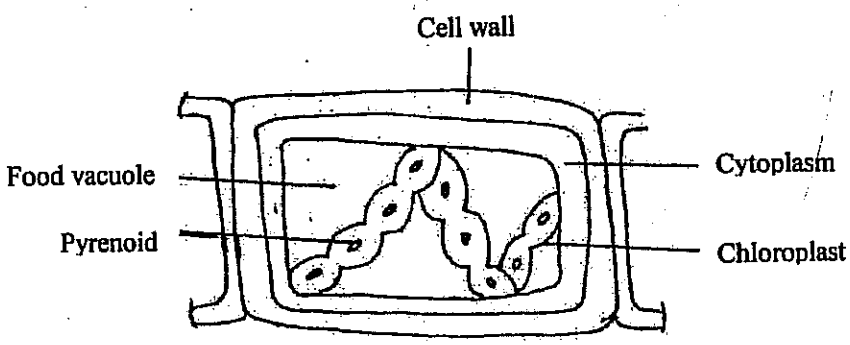
Phylum Chlorophyta

Class Chlorophyceae

Structural characteristics of spirogyra

- It is log, unbranched and filamentous.
- Its filaments are septate lengthwise.
- It has spiral shaped chloroplast.
- It has numerous pyrenoids.
- It has a large vacuole.
- It has thick cell wall.
- It has thin cytoplasm.

A drawing of the spirogyra



Adaptations of spirogyra to survive in its environment

- It has long filament to increase to increase its surface area for absorbing light and for gaseous exchange.
- It has septate for fragmentation or asexual reproduction and for flexibility.
- It has spiral chloroplast to increase surface area for photosynthesis.
- It is filamentous for floating on water.
- It has numerous pyrenoids to store more food.
- It has thick cell wall for protection.

It has an autotrophic nutrition due to possession of green chloroplast.

It is smooth, thus its habitat is aquatic to avoid desiccation.

Spermatophytes (higher plants)

These are seed bearing plant in the phylum spermatophyta. They include gymnosperm (coniferous plant) which bears no flowers and angiosperms wich bear flower.

Angiosperms

It is divided into monocotyledonous and dicotyledonous plants.

Monocotyledonous plants are characterized by having;

- Parallel veined leaves
- Leaf sheath
- Fibrous root system
- Vascular bundles distributed randomly distributed in the stem.
- Narrow and elongated leaves

Dicotyledonous plants are characterized by having;

- Net work veined leaves
- Leaf petiole or leaf stalk
- Tap root system
- Vascular bundles radially arranged on the ring of the cambium
- A central pith
- A clear cortex

For description of plant leaves refer to O' level practical book of the same author.

Plant tissues

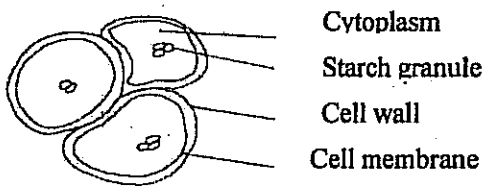
These include;

- Parenchyma tissue
- Sclerenchyma tissue
- Collenchyma tissue
- Epidermal tissue

Parenchyma tissue is characterized by having the following features.

- It is made of spherical or round cells
- Its cells have thin cytoplasm
- Its cells have a large food vacuole
- Its cells area closely packed
- Its cells have starch granules
- Its cell have thin cell wall

A drawing of parenchyma cells



Functions of parenchyma cell

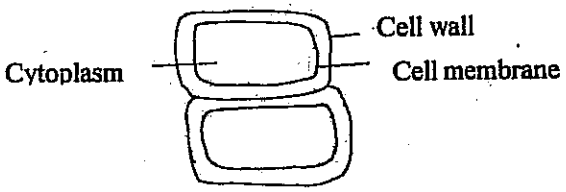
- It is used for storage of food due to possession of starch granules and large food vacuole.
- It is used for support when turgid due to being closely packed.

Collenchyma tissue

It is characterized by having;

- Cell with thick cell wall
- Polygonal (rectangular) cells
- Closely packed cells

A diagram of Collenchyma tissue



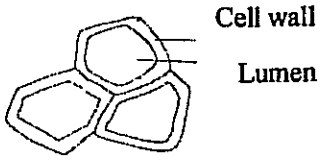
Collenchyma tissue is used for support due to its closely packed cells with a thick cell wall.

Sclerenchyma tissue

This tissue is characterized by having;

- Thick walled cells
- Hollow cells
- Cells with no cytoplasm
- Cells with narrow lumen
- Lignified cell wall
- Polygonal cell tissue

A drawing of Sclerenchyma tissue



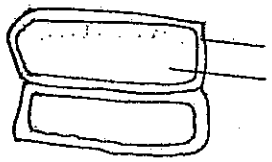
Functions of Sclerenchyma tissue

- It is used for support due to possession of a very thick lignified cell wall
- Its cells are hollow for easy flow of materials
- Its cells have a narrow lumen to facilitate capillarity

Epidermal cells

- Its cells are polygonal or rectangular
- It is thin and thus transparent
- Its cells are closely packed

A drawing of epidermal tissue



Functions of epidermal tissue

- They are closely packed to protect inner tissue from physical injuries
- It is transparent to allow light penetration

NB

- When a cross section of an angiosperm stem is stained with an acidified pyloroglucinol, lignin in the tissues of Sclerenchyma and xylem stains red or pink.
- When asked to draw a tissue plan of a section observed under a microscope, only draw tissue lay out without showing details. Ie tissue plan of the description of the dicotyledonous stem.

For the description of floral structures and drawing of the floral sections refer to O' level practical book of the same author.

THE FLOWERS

Floral formula

This is a conventional formula showing the number of floral structure and nature of the flower and its structure.

The following symbols are used in a floral formula.

⊕ = Actinomorphic or regular flower

% = Zygomorphic or irregular flower

♂ =Staminate flower

♀ =Pistilate flower

⚥ =Bisexual flower

K = Calyx, C=Corolla, A= Androecium, G=Gynoecium. **Ie K C A G**

If one part is attached (z) to the other (y), they represented in a floral formula as

Z⌒Y

The number of each floral part is represented by numeral subscript to the symbol.

NB P represents perianth (petal and sepal are indistinguishable)

A hibiscus flower is used as a case study

Its floral formula is written as, $\oplus\ \delta\ K_{(5)}\, C_5\, A_{(\infty)}\, G_{(5)}$

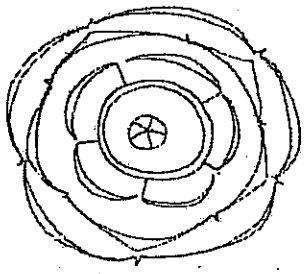
Ie $K_{(5)}$ = Five fused sepals or calyx

C = Five free petals or corolla

A ∞ = Numerous stamens

$G_{(5)}$ = Superior ovary with five fused carpals

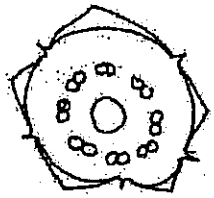
The floral diagram of a hibiscus



Floral formula of bougainvillea flower

$\oplus\ \delta\ P_{(5)}\ A_8\ G$

Its floral diagram



INFLORESCENCES:

This refers to the growth of many flowers on the same stalk. The stalk that bears the flowers is called peduncle or main axis. It may be divided into branches of different length or not divided. Each flower on the peduncle is called a floret. A floret may be free or they be closed in the set of bracts.

A case study of some inflorescence

Maize inflorescence

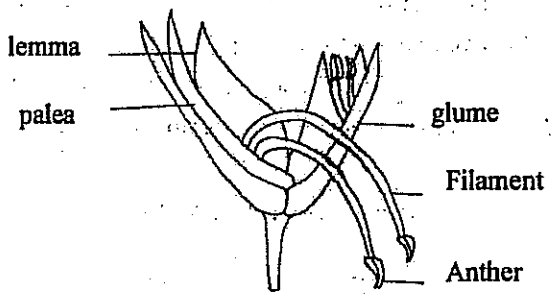
It consists of a main axis called peduncle which branches into many branches that are alternately attached to the peduncle to expose the florets for easy pollination. Each branch bears numerous and paired spikelets which are also alternately attached to the branches. The spikelets in the pair, one is stalked and the other is sessile.

The spikelets (florets) are alternately attached to the peduncle and irregular. Each spikelet bears two florets which are covered by bracts. The outer bracts are called glume and are hairy, hard, tough and curved or boat shaped. The inner bracts are membranous or thin, smooth curved in wards and occur in pairs. Both inner and outer bracts are parallel veined and dark coloured.

The florets are staminate, consisting of thin, long, flexible, and slender filaments each bearing large, grooved or dangling, bilobed anthers. The advantage of alternate arrangement of florets is to expose

the florets for easy pollination. The disadvantage of the floral arrangement of florets or spikelets is that it makes the inflorescence large or conspicuous to the herbivores for easy predation.
The large anthers produce numerous pollen grains that make pollination easy. The lose attachment of anthers to the filament makes pollination easy. The long nature of the filaments exposes the anthers hence making pollination easy.

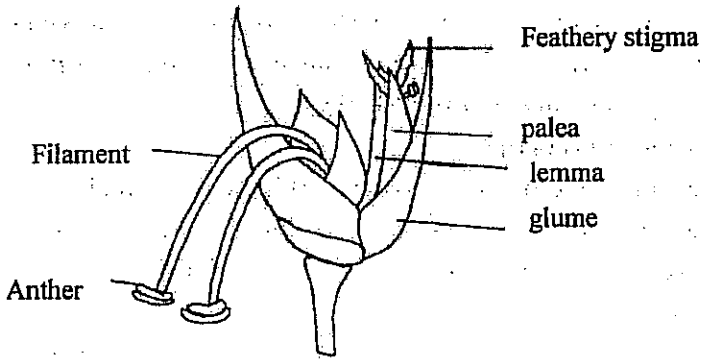
The drawing of the maize spikelet



Panicum maximum inflorescence (guinea grass)

The inflorescence consists of a peduncle branching into numerous branches whose length shortens towards the apex of the peduncle. The branches have a whorl arrangement along the peduncle.
The spikelets occur in groups of two or three, all asessil or having stalks of varying length. The spikelets are numerous and are attached alternately on the peduncle and lateral branches which have terminal spikelet.
Each spikelet has two florets which are enclosed by bracts, the glume and inner bracts called palea and lemma. The palea and lemma occur in pairs. Both the inner and outer bracts are smooth, parallel veined, dark coloured and curved in wards. The outer bracts are tough, thick and hard. The inner bracts are thin (membranous or papery). The florets are bisexual, bearing long, thin and slender filaments with large bilobed anthers which are loosely attached. The florets have superior ovary which bears two/ forked feathery stigmas. Such stigma provides a large surface area for easy trapping of pollen grains in air making pollination easy. The bisexual nature of the florets makes self pollination easy. The spikelets (florets) have zygomorphic symmetry or are irregular.

A drawing of the panicum floret

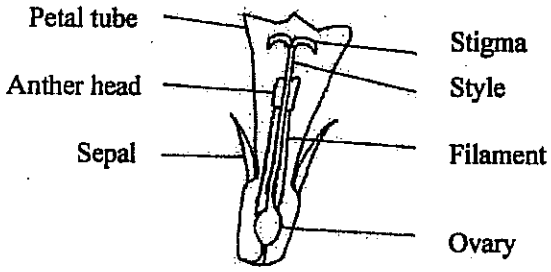


Biden pilosa inflorescence

It has numerous sessile florets which are attached onto a flattened (cup shaped) and expanded apex of the peduncle. The inner florets called the disc or tubular florets are arranged in the

circular pattern around the center. The outer florets are called ligulate which are covered by numerous overlapping and dull coloured bracts making the involucre.
The ray (ligulate) florets are Zygomorphic and found at the peripheral of the expanded apex of the peduncle. It consists of white fused petals which are fused at the base and open towards the apex. It has few corolla projections. The disc florets are bisexual, Actinomorphic and consist of five yellow petals which are fused to form a tube hence the name tubular floret. Its petals have many corolla projections. It has five stamens with fused, bilobed, and elongated anthers and short filaments. Its stigma is bilobed.
Both ray and disc florets have inferior ovary and free spiny sepals called pappus and are sessile.

A drawing of the tubular floret



Inflorescence of *Lantana camara*

It consists of numerous sessile florets which are radially arranged on a clubbed apex of peduncle.
Florets are bisexual, Actinomorphic and their petals are brightly coloured and fused to form a tube hence are tubular. Florets have free stamens and superior ovary. All florets are enclosed by dull coloured bracts. The outer florets are older than inner ones.

Inflorescence of commelina species

It has one or few florets on the peduncle which are asessile (stalked).
Each floret has a single, curved, hairy, dull coloured and parallel veined spathe (petal like bract). Florets are bisexual, have free brightly coloured petals and are Zygomorphic.
Florets have superior ovary and free stamen consisting of brightly coloured anthers that are supported by long, thin, and flexible filament.

Inflorescence of Banana

It consists numerous, bisexual, Zygomorphic, sessile and clustered florets which are arranged in rows and attached at the base of inner surface of the dull coloured, prominently parallel veined, large, thick (fleshy) and in ward curved spathe.
Each floret has two perianth which are curved (boat shaped), dull coloured and attached to the ovary. One of the perianth is large and long while the other is short and small. The pistil of the floret consists of inferior, elongated and posteriory tapering ovary, elongated grooved style, and brightly coloured trilobed stigma (three fused stigmatic surfaces.
Its stamen consists of long and slender filaments supporting flattened, elongated, grooved, bilobed, brightly coloured and curved (shovel) anthers.

Inflorescence of the cassia

It consists of numerous, bisexual, and zygomorphic florets attached to a clubbed end of the peduncle. Florets have long stalks (pedicel).

Florets have curved, free (polypetalous), brightly coloured, large, prominently veined and papery (thin).

Florets have numerous stamens with filaments of varying filaments which bear bilobed, elongated, thick, and curved anthers with variable size.

Florets have a pistil with elongated, dull coloured, curved and superior ovary, short style and flattened stigma surface.

Inflorescence of Bougainvillea

It consists of three asessile, bisexual, and zygomorphic florets all attached at the end of the peduncle. Each floret is attached on inner upper surface along the midrib of the bract. The pedicel of the floret is fused with the midrib of the bract which is bright coloured, large and veined.

Each floret has perianth which is dull coloured and fused into a funnel tube.

Florets have a pistil with a superior and cone shaped ovary, short and flexible style, and spear shaped, elongated, hairy stigma.

Florets have eight, long, and slender filaments, and rounded anther.

Inflorescence of *Gynandropsis gynandra*

This is a common inflorescence with many florets which are alternately / spirally and individually attached by long pedicel along one main peduncle. The mature or lower florets have longer pedicel than younger or upper florets making all the florets attain the same level.

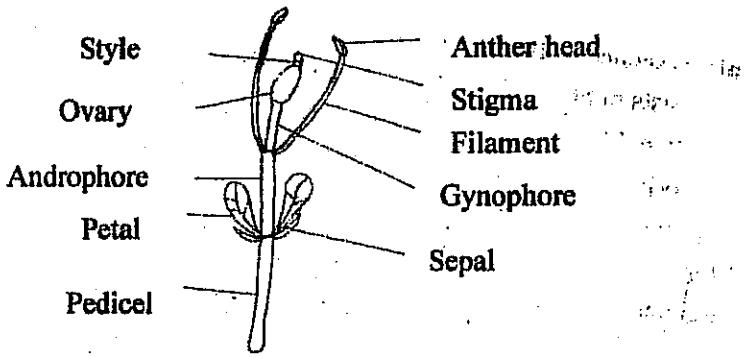
Each floret has;

- no bract
- five, green, veined, hairy, free, anterior tapering calyx /sepals.
- five, free, smooth, veined, bright coloured corolla / petals with a narrow base and broad apex.
- Long, smooth and bright coloured pedicel
- Stamen with long, slender, free, bright coloured, smooth filament and elongated, bilobed, bright coloured anthers. The elongated anthers produce large amounts of pollen grains to enhance cross pollination. The stamens are exposed to ease dispersing of pollens to enhance cross pollination.
- Pistil with superior, elongated, hairy, green ovary and short style, and bilobed, flat, brightly coloured stgma. The flat stigma provides a large surface area for landing of the insects during pollination.

Note. The bright coloured strucrural features of this flower attract pollinators leading to cross pollination by insects.

The receptacle of each floret has distinct internodes and nodes to which floral structures are attached. Its stamens are attached to long internode called androphore and the ovary is attached to internode called gynophore. This arrangement exposes the essential structures of the flower for easy pollination leading to ensured higher chances of fertilization.

The drawing of the external features of *Gynandropsis gynandra*



NOTE.

- The inflorescence that is pollinated by wind has pollen grain which is small, round/ circular and smooth. Being small reduces its weight so that it can easily be blown by wind. The smoothness reduces air resistance and hence blown by air easily.
- The inflorescence pollinated by insects is large, circular and spiky. The spiky surface easily attach on to the insect or stigma to easy pollination. The large size of the pollen provides a large surface area for attachment to the insect.

NB. The florets considered above are aimed at acquainting the students and the teachers with the necessary information that can be used to analyze any other flowers and inflorescence.

Fruits

These are mature fertilized ovary. Some fruits have dry pericarp (fruit wall) while others have fleshy pericarp. The one with dry pericarp are referred to as dry fruits and the ones with fleshy pericarp are called succulent fruits.

Most of the fruits are covered in the biology practical for ordinally level by the same author. However in this book some fleshy and a few dry seed fruits are considered.

Tomato fruit

Characteristics of tomato a fruit

Pericarp distinctively divided into three layers ie epicarp, mesocarp and endocarp. The epicarp is membranous, mesocarp is fleshy and endocarp is juicy. The endocarp is divided into many locules by septa.

It has many small seeds which are covered by a jelly coat. Seeds have a short funicle and are attached around the central placenta

Avocado / Mango fruit

Its pericarp is distinctively divided into three layers ie the hard epicarp, thick and fleshy mesocarp and the hard and fibrous endocarp.

It has one, enlarged seed found at the centre with elongated funicle attached to the placenta found at the base or at the apex.

It has one Locule.

Been pod

The pond is long, curved and large. It consists of a dry and fibrous pericarp which is not distinctively divided into layers (epicarp is fused with mesocarp, but the endocarp is papery). The pericarp has two sutures (lines of weakness).

It has many enlarged seeds which are attached along the side (margin) on one side of the pod. Its placenta is papery and is found along the margin on one side of the pod. The seeds have short funicle and are found in one Locule which is partially divided by the septa.

Orange fruit

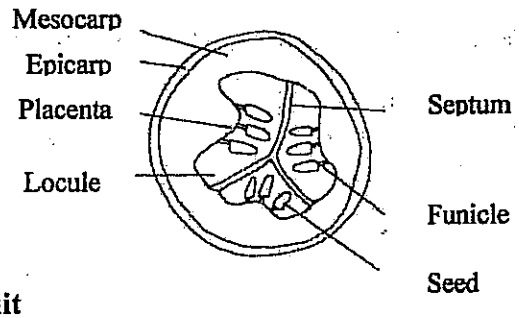
Its pericarp is distinctively divided into epicarp, mesocarp and endocarp. The epicarp is hard, thick and bears acid glands. The mesocarp is spongy and thin. The endocarp is juicy, divided into several locules by septa and consists of juicy, swollen and both ends tapering hairs.

Its seeds are hard, many and with short funicle seeds are radially arranged around the central spongy placenta.

Cucumber fruit

Its epicarp is divided into thin hard epicarp, fleshy mesocarp and endocarp. Endocarp is divided into three locules. Placenta is found at three points at the peripheral of inner lining of the endocarp. Seeds are many, oval shaped and are radially and regularly attached at three points by elongated funicles. The seeds are attached to the peripheral wall of the endocarp and projecting inwards.

A drawing of the cross section of a cucumber



Green paper fruit

Its pericarp is divided into thin epicarp, spongy, fleshy mesocarp and endocarp. Its Locule is partially divided by septa. It has a free central and thick placenta arising from the base. It has many, flattened, and hard seeds which are clustered on the placenta.

Pawpaw fruit

Its pericarp is divided into mesocarp and endocarp. Mesocarp is fleshy and thick. The placenta is thin and found at the peripheral. It has many rough clustered seeds which are radially and regularly attached to the peripheral wall by short funicle. The fruit has one Locule.

Constructions of Identification Key

Before an identification key for the given specimens is constructed, a critical study of observable features should be made. Then, the specimens which have obviously similar features are grouped together. In each group, special features are identified which distinguish a particular specimen from the rest in that group.

The Dichotomous Classification is one way in which the specimens are split into successive pairs. See the example below.

Example: Identifying 4 specimens in a table below.

Table of characteristics:

Character	M	O	A	N
Sex	Male	Male	Female	Female
Eye colour	Brown	Blue	Blue	Blue
Body colour	Brown	Brown	Brown	Black

The Dichotomous key:

1 Students male ----- ----------2
Students female ----------3
2 Eyes brown ---------- M
Eyes blue---------- O
3 Body brown ---------- A
Body black ---------- N

In the above Dichotomous key, the following should be noted:

(a) The number on the right hand side (e.g. -----2) tells you the number of the pair of character on the left you should move to next.

(b) Such character like body colour does not help you to identify the two male students nor does eye colour help to identify the two girls, since the former character is common to the two boys and the latter, to the two girls. Such characters can therefore be ignored in this key construction (see the key again) and also size is not used in a dichotomous key.

Guiding questions about plants and animals

1. You are provided with specimens **C (cockroach), D (bee), E (house fly), F (wasp)** and **G. (termite)**

(a). Classify specimen **C** under the following taxa.

(i) Kingdom:

(ii) Phylum:

(iii) Class:

(iv) Order:

(v) Family

(b). Carefully examine specimen **C.** Give three characteristics, which make it to be classified in the class (iii) above.

(c). With the use of a sharp blade and a microscope, carefully cut off the labium of specimen **C** and make a clear well labeled diagram.

(d). State four external structural observable characteristics of specimens C, D, E, F and G.

Specimen	Characteristics
C	
D	
E	
F	
G	

(e) Construct a dichotomous key to identify the specimens.

2. Specimens **A (Hibiscus), B (Morning glory), C (Crotalaria), D (Tubular floret of bidden)** and **E (jacaranda)** are flowers
(a). Examine **A, B, C D** and **E** and write their floral formulae.

(b). Draw floral diagram of **A, B, C and D**

(c). (i) In a suitable table, use the ovary, sepals, petals, symmetry sex, and others to write down the characteristics of **A, B, C, D and E.**

(ii) Using the characteristics above construct a dichotomous key to identify **A, B, C, D and E.**

3. Examine specimens $L_1 - L_5$ provided (L_1-**Mango,** L_2-**lantana camara,** L_3-**coach grass,** L_4-**sweet Potato,** L_5-**amaranthus**) Leaves.

(a).(i) State two observable features to show that these are the same plant organs:-

Feature 1 –

Feature 2 –

(ii) For each specimen, mention one way in which it is structurally unique from the others.

L_1 –

L_2 –

L_3 –

L_4 –

L_5 –

(b).For specimens L_2 and L_3 only, give two:

(i) descriptive similarities

1-

2 –

(ii) Ecological advantages specimen L_3 has over L_2

1-

2 –

(c).In the space below, draw an outline of the lamina of specimen L_2 and L_3 at magnitude **x 0.5**

(i) From the outlines work out the actual area of the lamina for each specimen.

L_2 –

L_3 –

(ii) Express the size of the lamina as a ratio i.e. L_3: L_2 –

(iii) Comment on the ecological significance of this ratio to the plants from which specimens L_2 and L_3 were obtained.

(d).By limiting yourself to the characteristic features of the lamina.
Construct a dichotomous key which can be used to identify the specimens in the given order i.e. starting with L_1 and ending with L_5

4. Specimen **P(passion).Q (bean pod).R (orange) .S (tomato)**and **T (mango)** are fruits.
(a).(i) Cut specimen **R** – transversely in to two halves:
Draw a labeled diagram of one half

(ii) Observe the placenta of specimen R suggest two roles of placenta in the fruit.
1 –

2 –

(b).Cut open the remaining specimens into two halves and examine them.
(i) Tabulate differences in the placentas of specimen R and Q.

(ii). Describe the placentation in the specimen:

P:

Q:

R:

S:

T:

(C).Construct a dichotomous key to identify the specimens in the given order (start with P and end with T)

5. Specimen **B1 (commelina leaf from shade)** and **B2 (water lily leaf)** are plants collected from different habitats. Peel off a thin epidermal layer from the upper and lower surfaces of each leaf. Mount the peel in a drop of water on a slide. Apply a cover slip and examine with a microscope using medium power. Compare the number of stomata per field of view of the surfaces of both leaves.

Enter your results in the table below.

Surface	B_1	B_2
Upper		
Lower		

(a) (i) Comment on the results in the table.

(ii) Make a simple labeled plan diagram of the tissues as seen in the section under low / medium power of a microscope.

(iii) Name one anatomical structure seen in (ii) above which enabled organ to carry out its functions.

(b) What do your results suggest about the habitat of the plants from which the leaves were collected?

6. .Specimens **Q (maize), R (panicum maximum), S (lantana camara), T (commelina)** and **U (Bidden pilosa)** are reproductive parts (inflorescence) of different plants.

(a) Remove one of the outer most flowers and one flower from the middle part of specimen **U.** Using a hand lens examine the two flowers and state two differences between them. (02 mks)

(i) .....

.....

(ii) .....

.....

(b) (i) Using a hand lens examine a flower from each of specimens **Q** and **R.** Describe the structure of each flower.

Flower from **Q.** (04 mks)

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.....

Flower from **R.**

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.....

(ii) State one advantage of specimen **R** over specimen **Q** in reproduction. (02

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.....

(iii) How is specimen **R** adapted for pollination? (04 mks)

.....

.....

.....

.....

(c) Open up one flower from each of specimens **Q** and **R**. Draw and label each flower in the space provided.

Flower from **Q.** (02 mks)

Flower from **R.** (03 mks)

(d) Construct a dichotomous key to identify specimens ***Q, R, S, T*** and **U.** (08 mks)

.....

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7. You are provided with specimens; **P (mango), Q (bean pod), R (orange), S cucumber), T (green pepper)** and **U (pawpaw).** Open specimen **Q** longitudinally and cut the rest transversally.

(a).Looking at the sections, describe seed arrangement in each of the following specimens:

(i).P

.....

.....

.....

.....

(ii) Q

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.....

.....

.....

(iii) R

.....

.....

.....

.....

(iv) S

.....

.....

.....

.....

(b).(i) Give two internal features common to both specimens T and U.

(02 mks)

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.....

(ii) State one difference in the internal structure of specimen T and U.

(01 mks)

.....

.....

.....

(c).Draw and label a transverse section of specimen S and one half of specimen Q which is containing the seeds.

Specimen Q

Specimen S

(d).Limiting yourself to the internal features of the specimen, construct a dichotomous key to identify them. (10 mks)

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8. You are provided with specimen **C (beans), D (cassia), E (maize)** and **F (bougainvillea)** which are inflorescences.

(a).Observe each specimen and describe the pattern of arrangement of florets. (04 mks)

C:

D:

E:

F:

(b).Remove a single floret from specimens **C, D** and **E.**

Examine the florets using a hand lens where necessary.

(i). Give two descriptive features on each of the following floral parts of each floret.

Floral part	Floret of specimen C	Floret of Specimen D	Floret of Specimen E
Pistil			
Anthers			

Petals			
Bracts			

(ii) With reference to the information in the table in b (i), state how the florets from specimens D and E are adapted to their modes of pollination. (02 mks)

Floret from D .....

.....

florets from E: .....

.....

.....

(c).Remove one floret from specimen **F.** Cut it symmetrically into two halves. Observe the internal structures using a hand lens.
Draw one half of the floret and label only the essential reproductive floral structures.

8. You are provided with specimen **B(water lily leaf), C1 (sunny commelina), C2 (shade commelina), D1 (dicotyledonous root system),** and **D2 (monocotyledonous root system).**
C1 and **C2** are whole plants while **B, D1** and **D2** are plants parts.
Specimens **B1, C1** and **C2** are each from a different habitat.
(a).State three observable differences between specimen **C1** and **C2.**

.....

.....

.....

.....

(b).Obtain a small piece of the epidermis from the upper surface and lower surface of specimen B. Mount each epidermis in a drop of water, one at a time. View under low power of a microscope, count and record the number of stomata in a field of view, for each surface, in the table below.
Repeat the procedure with leaves of specimens **C1** and **C2.**

Specimen	Surface	No. of stomata
B	Upper	
	Lower	
C_1	Upper	
	Lower	
C_2	Upper	
	Lower	

(c).(i) suggest a suitable habitat for which each specimen was obtained

B .....

C1 .....

C2 .....

(ii) State adaptations of each specimen to its habitat stated in (c) (i).

B

.....

.....

.....

.....

.....

Petals			
Bracts			

(ii) With reference to the information in the table in b (i), state how the florets from specimens D and E are adapted to their modes of pollination. (02 mks)

Floret from D .....

.....

florets from E: .....

.....

.....

(c).Remove one floret from specimen **F.** Cut it symmetrically into two halves. Observe the internal structures using a hand lens.
Draw one half of the floret and label only the essential reproductive floral structures.

8. You are provided with specimen **B(water lily leaf), C1 (sunny commelina), C2 (shade commelina), D1 (dicotyledonous root system),** and **D2 (monocotyledonous root system).**
C1 and **C2** are whole plants while **B, D1** and **D2** are plants parts.
Specimens **B1, C1** and **C2** are each from a different habitat.
(a).State three observable differences between specimen **C1** and **C2.**

.....

.....

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.....

(b).Obtain a small piece of the epidermis from the upper surface and lower surface of specimen **B**. Mount each epidermis in a drop of water, one at a time. View under low power of a microscope, count and record the number of stomata in a field of view, for each surface, in the table below.
Repeat the procedure with leaves of specimens **C1** and **C2.**

Specimen	Surface	No. of stomata
B	Upper	
	Lower	
C_1	Upper	
	Lower	
C_2	Upper	
	Lower	

(c).(i) suggest a suitable habitat for which each specimen was obtained

B .....

C1 .....

C2 .....

(ii) State adaptations of each specimen to its habitat stated in (c) (i).

B

.....

.....

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.....

.....

C_1:

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.....

.....

.....

.....

C2

.....

.....

.....

.....

(d).Draw and label stomata from specimen **C1.**

(e)(i) State one difference between specimen **D1** and **D2**

.....

.....

(ii) Giving reasons, state two advantages of specimen **D1** over **D2**

.....

9. You are provided with specimens **D (wasp), E (cockroach), F (bee), G (house fly)** and **H (termite).**

(a).State three observable differences between specimens **D** and **G.** (3 mks)

Specimen D	**Specimen G**
(i).....	.....
.....	.....
(ii).....	.....
.....	.....
(iii)	.....
.....	.....

(b).Using a hand lens examine the tarsus of the hind limb of each of specimens **F** and **G.**
(i) Draw and label the tarsus of each limb. (6 mks)

(ii) Give the ecological significance of the structure of each tarsus. (2 mks)
.....
.....
.....
.....

(c).Examine the mouth parts of specimens **G** and **H**, using a hand lens.
(i) Draw and label the mouth parts of specimens **G** and **H.** (7 mks)

(ii) Relate the structure of each mouth part to its function on the specimen.
(2 mks)
.....
.....
.....
.....

(d).Using features of the abdomen only, construct a dichotomous key to identify specimens **D, E, F,** and **H.** (8 mks)
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10. You are provided with specimen **K**

(a). cut it longitudinally and examine it. Describe its internal structure (03mks)

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.....

.....

(b). remove one of the leaves of specimen **K**. Strip off a piece of the inner most layer and place it on a slide with a drop of water and cover with a cover slip. Examine under the medium power of a microscope.

(i). Describe the structure of a cell, clearly seen (02mks)

.....

.....

(ii). Now examine under low power of a microscope, count and record the number of cells in field of view. (02mks)

From left to right.....

From top to bottom.....

(c).(i). Remove the slide from the stage, measure the field of view using a transparent ruler and record your results. (01mks)

Field of view.....mm

(ii). convert the diameter of the field into micrometres (μm). Show your working (2mk

.....

.....

.....

(iii). Calculate the actual length of the one cell in micrometres (μm). Show your working. (03mks)

.....

.....

.....

(d). return the slide having the tissue onto the stage. Draw one cell from the tissue being observed under the medium power of a micrometer. (03mks)

(e). measure the length of your drawing in mm and record it. (01mk)

Length of drawing .....mm

(ii). calculate the magnification of your drawing. Show your working. (03mks)

.....

(f). mount a little piece of specimen L and view under the medium power of a microscope. Draw and label one cell. (05mks)

(g). Explain how the structure of each of the cells from specimen K and L relate to their functions. (04mks)

(i).....

.....

(ii).

.....

11. You are provided with two coins and an adhesive tape. You are required to use them to determine the genotype and phenotype numbers using one trait.

PART. A: Determine number of expected genotypes

How many of each genotype combination are expected in the offspring of a class if both parents are **Rr for** a trait? Use the punnett square below to determine the genotypes. Record the number of each genotype in column A of table 1, punnet square.

	R	R
R		
R		

How many of each genotype combination are expected if there are 100 offspring? Record this number in column B of table 1.

PART B: Determining numbers of observed genotypes:

a. Cover both sides of two coins with adhesive tape. Trim off any excess tape with a razor of blade. Print an **R** on one side of each coin and **r** on the other side of each coin.
b. Place one coin in each hand shake and the toss the coins into your desk. Read and record the letter combination in column C. (Toss Results) of table 1. make a slash (1) in the proper row of column C to indicate the letter combination.
c. Toss the coins a total of 100 times. Record the coin combination for each toss in Table 1. Record in column D the totals for each combination.

PART: C. Determining numbers of expected phenotypes

d. Assume that R represents the dominant gene for normal skin pigment. Assume that r represents a recessive condition called albinism, no skin pigment. From the punnet square, list in column A of table 2 the number of offspring expected to have skin colour and the number of expected albinos.
e. Calculate the number expected to have each tract if there are 100 offsprings. Record the numbers in column B of table 2.

PART: Determine numbers of observed phenotypes.

f. From column D of table 1, total and record a column C of table 2 the number of offspring who will have normal skin pigment and those who will be albino.

Table 1: Expected and observed genotypes.

Gene combination	(A) Expected genotype for 4 offspring	(B) Expected genotype for 100 offspring	(D) observed genotype for 100 offspring
RR			
Rr			
Rr			

Table 2 expected and observed phenotypes

Phonotype possible	(A) Expected pheonotype for 4 offspring	(B) Expected phenotype for 100 offspring	(D) observed phenotype 100 offspring

(a) What is meant by
(i) Expected genotypes?
(ii) Observed genotypes?

(b) What does each coin represent in this investigation?

(c) How does the chance of a coin landing on each side compare to the chance that a gamete cell will receive a particular gene at meiosis?

(d) Why must coins be used to determine the genotypes for the offspring?
(e) Compare:-
(i) The expected genotypes of 100 offspring with the observed genotypes.

(ii) The expected phenotypes for 100 offspring with the observed phenotypes.

Do you agree or disagree? If they disagree how much do they disagree?

(f) Are your results wrong if they do not agree?

Explain

12. Specimen **F_1 (bougainvillea inflorescence)** and **F_2 (banana inflorescence)** are provided. Examine the specimens using hand lens and answer the following questions:
(a) (i) What common features would enable you place specimens **F_1** and **F_2** in the same group? (02 mks)

1.

.....

.....

2

.....

.....

.....

(ii) Describe the arrangement of florets in the Specimens. (05 mks)

F_1

.....

.....

.....

F_2

.....

.....

(b) (i) For any three named floral structures, state two descriptive features (09 mks)

FLORAL STRUCTURE	**DESCRIPTIVE FEATURES**	
	F_1	**F_2**
1.	1	
	2	

2.	1.	
	2.	
3.	1.	
	2.	

(ii) For Specimen F_1 only, relate the descriptive of structure named 1 in the table to the role-played in Specimen F_1. (02 mks)

Descriptive feature 1 –

.....

.....

.....

Descriptive feature 2 –

.....

.....

(c) Give one functional advantage Specimen (04 mks)

(i) F_1 has over F_2 -

.....

.....

.....

(ii) F_2 has over F_1 –

.....

.....

.....

(e) Remove one floret from F_1. Examine using a hand lens.
Make a floral diagram of the specimen and give a suitable key. (05 mks)

13. You are provided with specimen **M (dicotyledonous stem)**. Cut thin transverse section through the root of specimen **M**. Place one of the sections on to a glass slide and add a drop of phloroglucinal followed by a drop of concentrated hydrochloric acid or sulphuric acid. Leave to stand for one minute. Drain excess liquid and place a cover slip. Examine under low power magnification of the microscope. A hand lens may be used.

(a).Draw a plan diagram to show the distribution of the coloured tissues.

(b).What substance in the tissues takes up the colour?

(c).What is the role of the coloured substances to the plant?

(d).Which tissues of the plant is the coloured substance likely to be found in?

14. Specimens **R (panicum maximum inflorescence), S (bidden pilosa inflorescence)** and **T (maize inflorescence)** are inflorescences. Examine the specimens using a hand lens where necessary.

(a) Describe the structure of the inflorescence and flowers of each specimen.

(i)Specimen **R** *(04 marks)*

Structure of the inflorescence

.....

.....

.....

.....

Structure of the flowers

.....

.....

.....

.....

(ii). Specimen **S**

Structure of inflorescence.....

.....

.....

.....

Structure of flowers

.....

.....

.....

.....

.....

(iii). Specimen **T.**

Structure of inflorescence.....

.....

.....

Structure of flowers.....

.....

(c) State one advantage and one disadvantage of the structural arrangement of the flowers of specimens **R** and **T.**

(i). **R** (02 marks)

.....

.....

.....

(ii). T (02 marks)

.....

.....

.....

(c) Using a hand lens ,examine one flower of specimen R displacing some structures where necessary to expose all parts.

Draw and label it.

15. Your are provided with specimens **X** (panicum maximum inflorescemse) and **Y** (hibiscus) which are reproductive parts of flowering plants.

(a). Remove a spikelet from specimen **X** and examine it using a hand lens
(i). Describe the structure of the spikelet (04mks)

.....

.....

(ii). Describe the feature of **X** that promote the propagation of the plant from which it was obtained. (03mks)

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.....

.....

(b). Examine specimen **Y** and state three structural features which are unique to specimen **Y** and not found on **X.** (03mks)

.....

.....

.....

(c). (i). Open up the spikelet of specimen **X** and expose the gynoecium.
Draw and label. (04mks)

(ii). Remove the outer parts and expose the gynoecium of specimen **Y.**
Draw and label. (04mks)

(d). Observe the stigma of specimen **X** and **Y.** how are they adapted to their function? (03mks)
(i). Stigma of **X**

.....

.....

(ii). Stigma of **Y**

.....

.....

(e). (i). Obtain some pollen grains specimen **X** and mount it in a drop of water. View under the medium power of a microscope.
Draw **one** pollen grain that can be seen clearly. Do not label. (02mks)

(ii). Repeat the procedure and view the pollen grains from specimen **Y** under the medium power of a microscope.
Without labeling, draw **one** pollen grain. (02mks)

(iii). what is the significance of the structure of each pollen grain? (06mks)

X.....

.....

.....

.....

Y.....

.....

.....

16. You are with specimens **K** *(Bougainvillea)* and **M** (*Gynandropsis gynandra*) which are inflorescences.
(a). describe the flower arrangement on specimen **M** (01mks)

.....

.....

(b). pick one flower from each inflorescence and examine it using a hand lens. Describe the structure of each flower with respect to the specified parts as indicated in table below (15mks)

Part of flower	Flower from specimen K	Flower from specimen M
Calyx		
Corolla		
Bracts		
Stamens		
Pistil		

(c). What peculiar features of specimen M are not found in a typical flower. (o1mks)

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(d). What is the ecological significance of the features in (c) to the plant from which specimen M was obtained? (01mks)

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(e). Draw and label the external features of a flower from specimen M (13mks)