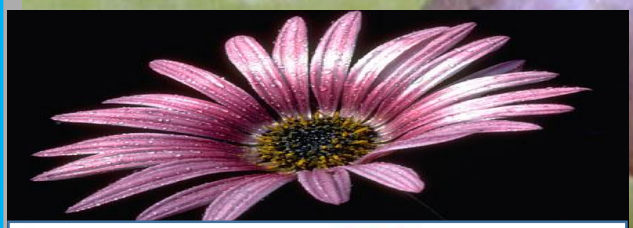
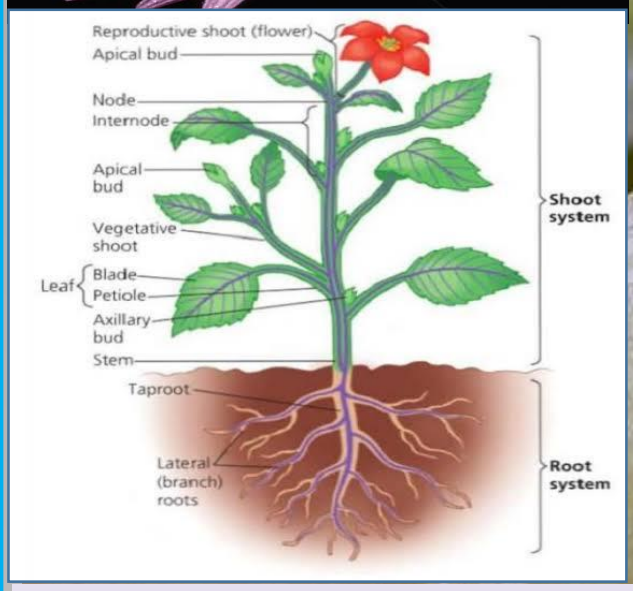
PRECISE APPROACHED TO O' LEVEL BIOLOGY PACTICALS

COMPETENCE-BASED-CURRICULUM

1ST EDITION 2026

BEST FOR S3 AND S4





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PAPER FORMAT (553/2 OR 553/3)

Biology practical paper typically contains two items which may be selected as follows:

Item 1: (Physiology and Physical experiments in biology)

1. Nutrition
   - ✓ Food test
   - ✓ Enzyme activity
2. Transport
   - ✓ Osmosis
   - ✓ Diffusion
3. Soil Science
   - ✓ Capillarity
   - ✓ Retention
   - ✓ Drainage
   - ✓ Soil pH

Item 2: (Anatomy / structure and function in living organisms)

1. Plants and their structures
   - ✓ Leaves
   - ✓ Flowers
   - ✓ Fruits
   - ✓ Stems
   - ✓ Seeds
   - ✓ Roots
2. Animals and their structures
   - ✓ Arthropods are mainly insects such as cockroaches, houseflies, termites, bees etc.
   - ✓ Fish
   - ✓ Teeth
   - ✓ Vertebrae bones
   - ✓ Parasites such as ticks

   Candidates are required to attempt all the two items within a duration of two and a half hours (2½)

Nature of practical items

• Item 1 in the paper may include a scenario or real-life situation on scientific investigation in Biology.

• Item 2 in the paper may include a scenario or real life situation on structure and function in living organisms.

Expected candidate's Report / Response

1. **Scientific investigation in Biology.**

Under scientific investigation in biology, a candidate is expected to write a report, which should include the following.

- ✓ Aim of the investigation
- ✓ Hypothesis
- ✓ Variables
- ✓ List of requirements
- ✓ Procedure
- ✓ Results / observation
- ✓ Data analysis and interpretation
- ✓ Conclusion and advice

a) Aim of the Investigation

The aim explains the purpose of the experiment. It shows what the investigation is trying to find out and the reason(s) for carrying out the experiment. It should be written as a simple statement beginning with **"To…"**

Examples:

• To find out how temperature affects enzyme activity in order to determine the conditions under which enzymes work most efficiently in living organisms.
• To investigate osmosis in Irish potato strips so as to demonstrate how water molecules move across a semi-permeable membrane and its importance in living tissues.
• To compare capillarity in different soil samples so as to understand how soil type influences upward movement of water, this affects plant growth and water retention.

A good aim:

• Is clear, specific, and written in simple scientific language.
• States the factor (variable) being tested in the investigation.
• Mentions the biological process, system, or specimen involved.
• Shows the purpose or reason for carrying out the investigation (the "why").

b) Hypothesis

A hypothesis is a scientific prediction of what you think will happen in the experiment, based on prior knowledge.

It should show:

- ✓ Cause and effect
- ✓ The expected trend or relationship

Examples:

- ✓ Increasing temperature will increase enzyme activity up to an optimum, after which it will decrease.
- ✓ Potato strips placed in concentrated salt solution will lose water and become shorter.
- ✓ Soil with smaller particles will show greater capillarity than sandy soil.
- ✓ Leaves exposed to light will produce more starch than those kept in darkness.

A hypothesis must be:

- ✓ Testable
- ✓ Logical
- ✓ Scientifically based

c) Variables

Variables are factors that can change during the experiment. They must be carefully identified and controlled to ensure a fair test.

1. Independent Variable:

This is the factor that is changed or manipulated by the experimenter.

Examples:

- ✓ Temperature in an enzyme experiment
- ✓ Salt concentration in osmosis
- ✓ Soil type in a capillarity experiment

2. Dependent Variable

This is the factor being measured or observed, and it depends on the independent variable.

Examples:

- ✓ Rate of enzyme reaction
- ✓ Change in length or mass of potato strips
- ✓ Height water rises in soil columns

3. Controlled Variables

These are factors that must be kept constant to ensure a fair test.

Examples:

- ✓ Size and thickness of potato strips
- ✓ Same volume and type of solution
- ✓ Same plant species
- ✓ Same duration of experiment
- ❖ Failing to control variables leads to unreliable results.

d) Results / Observations

Results are what you see, measure, or record during the experiment.

They may be presented as:

- ✓ Tables
- ✓ Drawings
- ✓ Graphs
- ✓ Written observations

Example Table (Osmosis)

Solution	Initial length(cm)	Final length(cm)	Change in length(cm)
Distilled water	4.0	4.5	+0.5
10% salt	4.0	3.2	-0.8

Observation Statements

- ✓ Potato in distilled water became firm and swollen
- ✓ Potato in salt solution became soft and shrunk

Observations must be objective (what you see), not opinions.

Being able to take accurate measurements is an essential skill for all Biology students. As part of the UCE course you will be expected to be able to take accurate measurements using a variety of different apparatus. When using measuring cylinders, you will need to look for the meniscus, which is the bottom of the curve formed by the liquid.

Thermometers are a very common tool for measuring temperature in Biology experiments so you will need to be able to take readings reliably. Not all of the points of the scale on a thermometer will be marked but you will still need to be able to determine the temperature. To do this you will need to work out the value of each graduation. In the diagram below there are four marks between 95 and 100. Each of these marks indicates $1^{o}C$.

Graph work

CHAPTER ONE

Nutrition

01. FOOD TESTS

These are tests that can be used to determine whether specific food substances are present or absent in a given food samples either in solution or in solid state.

The major foods eaten by animals are of two forms. These include: - organic compounds and inorganic compounds. The main organic compounds are: - **carbohydrates, proteins, lipids and vitamins.**

a) **Carbohydrates:**

These are divided into the following;

i Monosaccharide for example glucose, fructose and galactose.

ii Disaccharides for example lactose, maltose and sucrose.

iii Polysaccharides for example starch, cellulose in plants and glycogen in animals, chitin in exoskeleton of arthropods.

Point to note; All monosaccharaides (simple sugars) and disaccharides (complex sugars) except sucrose are called reducing sugars because they have got an active reducing group. Sucrose is called non-reducing sugar

The food substance tested during food tests include:

(i) Starch

(ii) Reducing sugars

(iii) Non-reducing sugars

(iv) Proteins

(v) Lipid (fats and oils)

(vi) Vitamin C (Ascorbic acid)

When carrying out food test on any food substance it is very important to note the following: -

- The test reagent (i.e. type of food substance it tests, its nature and color).
- The test procedure i.e. proportionality, order of addition and conditions like heating, cooling and shaking.
- The color change expected
- The color of the original/test solution before adding the reagent i.e. turbid, colorless, milky, cloudy etc.
- The nature of the test and resultant substance i.e. solution or precipitate.

THE TABLE BELOW SHOWS THE TEST REAGENTS AND THEIR COLOR

REAGENT	ORIGINAL COLOR
Iodine solution	Brown
Benedict's/Fehling's solution	Blue
Millon's reagent	Colorless
Copper (ii) sulphate	Blue
Dilute hydrochloric acid	Colorless
Sodium hydroxide	Colorless
Ethanol	Colorless
Distilled water	Colorless
DCPIP solution	Blue

THE TABLE BELOW SHOWS THE FOOD TYPE AND THE TEST REAGENT USED

FOOD TYPE	TEST REAGENT
Starch	Iodine solution
Reducing Sugar	Benedict's/Fehling's solution
Non-reducing sugar	Benedict's/Fehling's solution, Dilute hydrochloric acid and sodium hydroxide
Proteins	Millon's reagent
	Copper (ii) sulphate solution and sodium hydroxide solution (biuret's reagent)
Lipids	Ethanol and water
Vitamin C	DCPIP(Dichlorophenolindolphenol) solution

TEST FOR:

1) **REDUCING SUGARS e.g. glucose, fructose (Benedict's test/ Fehling's Test)**

Test	Observation	Deduction
To 1cm^3 of the test solution, add 1cm^3 of Benedict's solution and boil.	A colorless solution changes to blue solution, then to green solution, yellow precipitate, orange precipitate and finally brown precipitate on boiling.	Reducing sugar present.
	Colorless solution turns blue solution which persists/ remains on boiling.	Reducing sugar absent.

Note: During the above test, the final color indicates the quantity of reducing sugars present in a given food sample or solution i.e.

- Blue shows that no reducing sugars are present.
- Green shows that little reducing sugars are present.
- Yellow shows that moderate reducing sugars are present.
- Orange and brown/red shows that much reducing sugars are present.

2) NON-REDUCING SUGARS e.g. sucrose

Test	Observation	Deduction
To 1cm^3 of the test solution, add 1cm^3 of dilute hydrochloric acid and boil for 1 minute. Cool under tap water and then add 1cm^3 of sodium hydroxide solution followed by 1cm^3 of Benedict's solution and boil again.	A colorless solution changes to blue solution, then to green solution, yellow precipitate, orange precipitate and finally brown precipitate on boiling.	Non-reducing sugar present.
	Colorless solution turns blue solution which persists/ remains on boiling.	Non-Reducing sugar absent.

Note:

In testing for non-reducing sugars;

- Dilute hydrochloric acid is added to hydrolyze the non-reducing sugars to reducing sugars.
- The mixture is boiled to increase the rate of hydrolysis reaction and is cooled to stop the hydrolysis reaction.

- Sodium hydroxide or sodium hydrogen carbonate solution is added to neutralize the excess acid added because Benedict's / Fehling's solution does not work in acidic conditions.

3) STARCH (Iodine test)

Test	Observation	Deduction
To $1cm^3$ of test solution in a test tube add 2-3 drops of iodine solution.	Turbid/Milky/ cloudy solution turns to a blue black/black/blue solution.	Starch present.
	Milky/cloudy solution turns to brown solution.	Starch absent.

4) LIPIDS

(i) *Translucent mark test*

Test	Observation	Deduction
Rub the substance on a piece of paper (if provided as solid) or add 2 drops of test solution on a piece of paper. Allow to dry, hold the paper against light and observe.	Translucent spot or patch or mark is left on the paper.	Lipids present.
	No translucent mark is observed.	Lipids absent

(ii) *Sudan iii test*

Test	Observation	Deduction
To $1cm^3$ of test solution add $2cm^3$ of distilled water followed by 2-3 drops of Sudan III and shake.	Red droplets are seen in the mixture.	Lipids present.
	Solution remains with the original color.	Lipids absent

(iii) *Emulsion/ethanol test*

Test	Observation	Deduction
To 1cm^3 of the test solution add 5cm^3 of ethanol and shake vigorously followed by 2cm^3 of distilled water.	Cloudy/ creamy/ milky emulsion/suspension is formed.	Lipids present.
	Mixture remains colorless	Lipids absent

5) PROTEINS

(i) *Millon's test*

Test	Observation	Deduction
To 1cm^3 of test solution add 4 drops of Millon's reagent and boil for 2 minutes.	A pink or red coagulated mass forms.	Proteins present.
	Colorless solution remains colorless solution	Proteins absent

(ii) *Biuret's test*

Test	Observation	Deduction
To 1cm^3 of the test solution add 1cm^3 of Sodium hydroxide solution followed 2 drops of copper II sulphate solution and shake slightly.	Turbid/milky solution turns to purple solution.	Proteins present.
	Turbid/milky solution turns into colorless solution turns then to blue precipitate.	Proteins absent.

6) VITAMIN C

Test	Observation	Deduction
To 1cm^3 of DCPIP Solution in a test tube, add the test solution drop wise until in excess.	The blue color of DCPIP solution is decolorized/ discharged i.e. The blue solution turns to colorless solution.	Vitamin C present
	The blue color of DCPIP solution remains/persists	Vitamin C absent

Worked examples

Example 1

In a boarding school, the school nurse has noticed that some students in lower classes are becoming weak, losing body weight and experiencing frequent illness during the term. The students report that they mainly survive on meals served in the school dining hall.

The school management believes that the meals are "nutritious and filling" but nurse suspects that although the students are not starving, their meals may lack some essential nutrients needed for body-building and protection.

Two foods commonly served to students were sampled from the school kitchen, labeled sample A and sample B, and taken to the science laboratory for nutrient investigation.

Task:

Design and carry out a scientific investigation on the food sample A and B to explain the students' health problems and advise the school on how to improve the diet.

- *You are provided with the following by your teacher:*
  25 cm³ of Sample A (prepared by boiling 125 g of white rice, mashing it while warm, adding 500 ml of distilled water, mixing thoroughly into slurry, allowing solids to settle, decanting the liquid, and diluting the decanted solution to 1000 ml using distilled water).
- *25 cm³ of Sample B (prepared by soaking 125 g of dry beans in water for 24 hours, boiling until soft, pounding into paste, mixing with 500 ml of distilled water, decanting the solution, and diluting the filtrate to 1000 ml using distilled water).*

  Access to:
- *Iodine solution*
- *Benedict's solution*
- *Dilute hydrochloric acid*
- *Dilute sodium hydroxide*
- *Copper(II) sulphate solution*
- *DCPIP*
- *Ethanol + water (for fats test)*
- *6 test tubes, beakers, droppers*
- *Test tube rack and holder*
- *Source of heat and thermometer*

a) Aim:

To investigate the nutrients, present in food samples A and B and advise the school on the adequacy of the pupils' diet.

b) Hypothesis:

The frequent sickness of the pupils may be due to absence of essential nutrients (proteins, vitamins, fats) in food samples A and B.

c) Variables:

− Independent variable: Food sample (A or B)
− Dependent variable: Type of nutrient present (starch, protein, fats, vitamin C)
− Controlled variables: Volume of sample used, amount of reagent, temperature,

Materials used:

− Sample A
− Sample B
− Iodine solution

– Benedict's solution
– Dilute hydrochloric acid
– Dilute sodium hydroxide
– Copper (II) sulphate solution

Data presentation (procedure and observation)

Procedure	Test sample	Observations	Deductions
To 1cm3 of food sample add 2 drops of iodine solution	A	Cloudy/turbid/milky solution turns black/blue-black	Starch present
	B	Cloudy/turbid/milky solution turns black/blue-black	Starch present
To 1cm3 of food sample add 1cm3 of benedict's solution and boil	A	Cloudy/turbid/milky solution turns blue and colour persisted	Reducing sugars absent
	B	Cloudy/turbid/milky solution turns blue and colour persisted	Reducing sugars absent

Option 2: *(Vitamin C absent in Sample A):*
The pupils' diet lacks vitamin C, which may reduce immunity and cause frequent sickness. Advise the school to include vitamin C-rich foods such as oranges, mangoes, guavas, and pawpaw to improve the pupils' health.

Student Work:

01. A school science laboratory is investigating how the food stored in seeds changes when the seeds begin to germinate. The teacher explains that during germination, the stored starch in seeds is gradually hydrolyzed into reducing sugars to provide energy for growth and seeds that have germinated for a longer time are expected to contain more reducing sugars and less starch than those at the earlier stage.

To help leaners study this change, the teacher prepared four liquid extracts from seeds at different stages of germination, labeled solution A, B, C and D. the number of days of germination for each solution was not disclose to the students.

Task

Design and carry out a scientific investigation to identify the food substances present in solutions A, B, C and D, compare their sugar content, and arrange the solutions in the order of increasing days of germination based on your results.

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02. You went back to your village during the Christmas holidays and your grandmother tells you about your neighbor's child who almost died a few weeks ago. She adds that the child was so small, and had failed to grow; she had scanty hair and a scaly skin. However, at the hospital, they started feeding her on some food formula and she became well within three weeks without taking any medicine. Her skin started getting better and she was continuously gaining weight and looking better. As a student of biology, this intrigues you and you want to find out more about what was in the food formula that made the child get better without medication. You acquire some of the food formula and you ask the village government school's permission to use their lab for which you are allowed. However, the headteacher of the school demands a report of the activities you will carry out in his Lab. You were provided with food sample A and B

Task:

Design an experiment you will carry out to find the food substances present in the food formula and record your results in a report to present to the headteacher. Your experiment planning should include the following aspects.

(a) (i) Aim of the experiment, Hypothesis, Materials and apparatus used, Procedure, Presentation of results and Conclusion.

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(iii) Procedure and your results of the experiment

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More Examination Type Questions

01. Siza is a university student preparing for his final examinations, which are three months away. He feeds on one type of snack which he buys from the University Canteen. Recently he started suffering from frequent infections and easily becomes tired after reading for only 30 minutes. To overcome his health challenges and increase the amount of time he could spend reading, Siza's friends advised him to change his diet. Now, he is wondering which food nutrients should be included in his diet. You are provided with food samples P and Q which have been prepared from food substances sold at the University Canteen.

Task:

Designing and carry out a scientific investigation on samples P and Q. Use your results to identify a food sample that you would recommend to be part of Siza's diet and explain your recommendation. Your design and investigation should include the following:

(a) Aim, hypothesis, variables and apparatus/requirements.

(b) Procedure and results of the investigation.

(c) (i) Identify the food sample you would recommend to be part of Siza's diet.

(ii) Explain why you have recommended the sample in (c)(i) above to be part of Siza's diet.

02. Anita's 5-year-old baby frequently falls sick and has to visit the hospital regularly. The doctor told her that the frequent sickness is as a result of feeding. Anita feeds her baby on food nutrients; A and B plus food supplement containing mineral salts, fats and roughages. Anita is wondering what could be missing in her baby's food.

Task:

Design and carry out an investigation on the food samples A and B and use your findings to advise Anita accordingly. Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

(a) Aim, hypothesis, variables and materials used

(b) Procedures and results of your experiment

(c) (i) Identify the food sample you would recommend to be part of Anita's diet.

(ii) Explain why you have recommended the sample in (c)(i) above to be part of Anita's diet.

03. A secondary school athletics team is preparing for an inter-school sports competition. The coach wants to provide the athletes with food that can give them more energy during training and competitions. Two food samples eaten regularly by students are labeled Food E and Food F. The school laboratory technician wants students to help determine which food provides more energy-giving nutrients.

Task:

Design and carry out an investigation on the food samples E and F and use your findings to advise the coach on the best food for energy supply.

Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

(a) Aim, hypothesis, variables and materials

(a) Procedures and results of your experiment

04. A biscuit company in Kampala is developing a new type of nutritious biscuit for school children. The nutrition team wants to ensure that the ingredients used in the biscuits can supply the right nutrients needed for growth and energy. Two of the main ingredients used in the biscuit mixture are provided as Solution M and Solution N. The company wants to know the types of food nutrients present in each of these ingredients so that they can decide how best to use them in biscuit production.

Task:

Design and carry out an investigation on Solution M and Solution N to identify the food nutrients present in each ingredient and use your findings to advise the biscuit company on how each solution contributes to nutrition. Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

(a) Aim, hypothesis, variables and materials

(b) Procedures and results of your experiment

ENZYME ACTION

Enzymes are biological catalysts, proteins in nature that speeds up rate of chemical reactions. Enzymes act on substances known substrates.

1.9.1 Characteristics of enzymes:

- They work on specific substrates.
- They work at specific pH i.e. they are affected by pH changes.
- They work best at an optimum temperature (35^oC-40^oC). They are denatured by excess heat.

The Water Bath

The water bath is an alternative method of heating in food tests or food related experiments like those involving the investigation of the action of enzymes on food substances. It should be noted that in all enzyme controlled reactions, the temperature of water bath should be kept at least between 35-40^0C for the whole length of the experiment.

The following are the factors that affect the rate of enzyme action

(a) ***Temperature.***

Enzyme action increases with temperature up the optimum, beyond which enzymes are denatured.

(b) ***pH.***

Enzymes have specific optimum pH. Any change in pH will affect enzyme action. pH can be acidic, alkaline or neutral.

(c) ***Concentration of substrate.***

Enzyme activity increases with increase in substrate concentration.

(d) ***Concentration of enzymes.***

Enzyme activity increases with increase in its concentration.

(ii) ***Co-factor/ co-enzyme***

(iii) ***Inhibitors***

These reduce enzyme activity.

Sources of enzymes

- Human saliva (salivary amylase)
- Pancreas (pancreatic amylase
- Germinating seeds

1.9.4 HYDROLYSIS OF STARCH USING SALIVARY AMYLASE:

Starch is hydrolyzed by salivary amylase to maltose (reducing sugar) in a suitable pH medium i.e. neutral or alkaline medium. In acidic medium starch is not hydrolyzed.

Test	Observation	Deduction
To $1cm^3$ of starch solution, in a test tube, add $1cm^3$ of diluted saliva. Warm in a water bath at 30-35^{0}C for 10 minutes. Add a few drops of iodine solution.	The brown color of iodine solution persists/remains	Starch was hydrolyzed to reducing sugars
To $1cm^3$ of starch solution, in a test tube, add $1cm^3$ of diluted saliva followed by 10 drops of dilute HCl. Warm in a water bath at 30-35^{0}C for 10 minutes. Add a few drops of iodine solution.	the milky/cloudy turns to blue-black solution	Starch was not hydrolyzed to reducing sugars
To $1cm^3$ of starch solution, in a test tube, add $1cm^3$ of diluted saliva followed by 10 drops of sodium hydroxide solution. Warm in a water bath at 30-35^{0}C for 10 minutes. Add a few drops of iodine solution.	The brown color of iodine solution persists/remains	Starch was hydrolyzed to reducing sugars

1.9.4 HYDROLYSIS OF STARCH BY OTHER ENZYMES (not salivary amylase):

These enzymes can be amylase in maize, diastase in barley. These enzymes are extracted from seeds by soaking different sets of seeds for example maize, for different times that is to say two days, seven days and ten days. They are then ground and water is added into them, to get fine extracts.

A control is set up by using an extract prepared from unsoaked seeds.

These are then tested with Benedict's solution for reducing sugars.

In each of the extracts a sample is tested for reducing sugar using benedict's solution. The test will be positive soaked in water for a longer time and were germinating. This is because germination involves mobilizing the food reserves by the enzyme activity to soluble usable forms i.e. breaking down starch to maltose.

In unsoaked seeds, the Benedict's test will be negative i.e. starch is not broken down.

1.9.5 HYDROLYSIS OF SUCROSE BY INVERTASE

Invertase is the enzyme found in yeast and it brings about the conversion of sucrose to glucose and fructose which are reducing sugars.

Test	Observation	Deduction
To $1cm^3$ of sucrose solution add $1cm^3$ of yeast suspension and incubate the mixture in a water bath maintained at temperature of 35^oC to 40^0C for 15-20 minutes and then add $1cm^3$ Benedict's solution and boil.	A colorless solution changes to blue solution, then to green solution, yellow precipitate, orange precipitate and finally brown precipitate on boiling.	Non-reducing sugars (sucrose) was hydrolyzed to reducing sugars

ALCOHOLIC FERMENTATION USING ENZYMES IN YEAST

Procedure

Mix glucose and yeast in a test tube and pour a layer of oil over it, this ensures anaerobic conditions. Fit it with a delivery tube fitted to another test tube containing lime water or indicator solution to test carbon dioxide evolved.

For positive results (in presence of carbon dioxide) if lime water is used

Observation

Solutions changes milky or cloudy

If indicators are used like bromomethyl blue- changes color from blue to yellow

Cresol red -changes color from red to yellow.

HYDROLYSIS OF PROTEINS BY THE ENZYME PEPSIN

Proteins are hydrolyzed to amino acids by pepsin in acidic solution. However, they can also be hydrolyzed by Trypsin but an alkaline medium.

Test	Observation	Deduction
To $1cm^3$ of protein solution add $1cm^3$ of pepsin solution followed by 2-3 drops of dilute HCl and incubate the mixture in a water bath maintained at temperature of 35^oC to 40^0C for 15-20 minutes.	The turbid/milky/cloudy solution turns to colorless Solution i.e. the turbidity/ milkness/cloudiness disappeared.	Proteins were hydrolyzed.

HYDROLYSIS OF HYDROGEN PEROXIDE BY THE ENZYME CATALASE

H_2O_2 is a toxic (poisonous) substance produced as a result of metabolic activity in the cells of both plant and animal tissues. These tissues contain an enzyme catalase which is capable of decomposing hydrogen peroxide (H_2O_2) into water and oxygen which are non-toxic.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

Highly active tissues like liver cells show a very fast reaction compared to low active ones, and generally animal tissues show greater activity than plant tissues.

When a piece of potato tuber or liver is dropped in a solution of hydrogen peroxide, gas bubbles will be seen coming out of the potato or liver surface. This gas can be collected and will relight a glowing splint indicating that it is oxygen.
This reaction does not occur in dead tissues e.g. boiled tissues. If boiled potato tuber or liver tissue instead of unboiled, no gas bubbles are given out. This is because boiling denatures enzymes in the potato or liver tissue.
If the potato tuber or liver tissue is cut into small pieces or crushed and dropped in the hydrogen peroxide solution, the reaction will be much faster as shown with faster evolution of gas bubbles. This is because crushed or small pieces of potato tuber or liver tissues have large surface area for enzyme reaction.
The reaction is fastest when pH is neutral, is moderate in alkaline and very slow or stops in acidic medium.

Worked examples

Example 1

In a rural daycare, the caretaker observed that some children complained of feeling hungry soon after meals, while others occasionally experienced low energy. The nutrition assistant suspects that although the meals are filling, some food components may not be easily digested.
To investigate this, the assistant has provided two types of solution to the pupils: solution P, which is a liquid extract from a food, and solution Q, R and S, while the enzyme solutions is suspected to act on solution P at different concentrations.

Task:

Design and carry out scientific investigation to determine the food substances present in solution P and the effect of different concentration of the enzyme solution on solution P.

You are provided with the following by your teacher:
– 10 cm³ of Solution P (prepared by crushing 125 g of peeled cassava into paste, adding 500 ml

distilled water, mixing thoroughly, decanting the liquid, and diluting the filtrate to 1000 ml with distilled water)
− 5 cm³ of 0.5% amylase solution, labelled Q
− 5 cm³ of 1.0% amylase solution, labelled R
− 5 cm³ of 5% amylase solution, labelled S
− 6 test tubes, hand lens, labels
− Access to: source of heat, iodine solution, Benedict's solution, dilute NaOH, $CuSO_4$, ethanol + water (for fats test)

(i) **Aim (01 score)**

To investigate the food substances, present in Solution P and determine the effect of different concentrations of enzyme solutions (Q, R, S) on Solution P.

(ii) **Hypothesis (01 scores)**

The food substances in Solution P can be hydrolyzed by enzyme solutions, and higher enzyme concentrations will result in more breakdown of the food substance.

(iii) Variables (03 scores)

− Independent variable: Concentration of the enzyme solutions (Q, R, S)
− Dependent variable: Amount of reducing sugar formed (extent of hydrolysis of Solution P)
− Controlled variables: Volume of solutions used, incubation temperature (37–40°C), incubation time (15 minutes), volume of Benedict's solution, and source of heat.

(iv) Materials used (03 score)

− 10 cm³ of Solution P (cassava extract)
− 5 cm³ of 0.5% amylase solution (Q)
− 5 cm³ of 1.0% amylase solution (R)
− 5 cm³ of 5% amylase solution (S)
− 6 test tubes, hand lens, labels
− Iodine solution
− Benedict's solution
− Dilute NaOH
− $CuSO_4$ solution
− Ethanol + water (for fats test)
− Source of heat

(v) **Data presentation (08 scores)**

Procedures	Test sample	Observation	Deduction
To $1cm^3$ of solution P add 2 drops of iodine solution	P	Turbid solution turns blue-black	Starch present
To $1cm^3$ of solution P add $1cm^3$ of dilute NaOH solution followed by 3 drops of $CuSO_4$ solution	P	Turbid solution turns blue	Protein absent
To $1cm^3$ of solution P add $1cm^3$ of benedict's solution and boil	P	Turbid solution turns blue	Reducing sugars absent

Procedure	Observation	Deduction
Add 5cm3 of solution Q to 5cm3 of solution P	Low and less bubbles produced	Low decomposition of solution P

(vi) Comment on the activity of the enzyme at different concentration on to the solution P (03scores)

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(vii) Analyzed, recommend and give advice to the children in relation to the scenario. (05 scores)

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02. A food-processing company is developing a process in which an active substance reacts with Liquid S during production. However, the reaction is slow and delays the process. The company
believes that the reaction may proceed faster when the liquid is placed in a suitable medium. Three different solutions, P, Q and R are available on the market, but it is not known which one provides the most suitable medium for the reaction. The medium that allows the reaction to occur faster and more effectively is considered the best.

Task:

Design and carry out a scientific investigation to determine which solution P, Q or R provides the most suitable medium for the reaction between Liquid S and the active substance. Provide an appropriate recommendation to the company.
Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.
(a) Aim, hypothesis, variables and materials
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CHAPTER THREE

DIFFUSION AND OSMOSIS

Diffusion is the movement of molecules from of a region high concentration to a region of low concentration.

Osmosis is the movement of solvent (water) molecules from a solution of low solute concentration to the solution of high solute concentration across a semi-permeable membrane.

A student in this case will be provided with solutions of different concentrations and a specimen (majorly plant material/tissue). Experiments here may involve placing cut plant tissues e.g. stems, potato cylinders, pawpaw strips, and etc. in solutions of different concentrations and measurements taken may be curvature of plant tissues, change in length of plant tissues.

CURVATURE OF PLANT TISSUE

Cut a plant stem for example ***Commelina*** or flower stalk of *Cana* lily, into 4 equal strips and place one in each solutions of different concentrations of sucrose, and leave to stand for some time. After this time, a student may be asked to observe the cut strips and feel them using his or her fingers.

In such an experiment, the stems curve and the degree of curvature is used to determine the extent of osmosis.

- Solutions whose concentration is near similar to that of the cell sap (**isotonic solutions**) have pieces of stem in them remaining strong and straight.
- Solutions whose concentrations are higher than those of the cell sap (**hypertonic solutions**) have strips in them curving inwards i.e. with epidermis outermost. They are also weak or softer due to flaccidity of their cells resulting from the movement of water from them by osmosis.
- Solutions whose concentrations are lower than those of the cell sap (**hypotonic solutions**) have strips in them curving outwards i.e. with epidermis inner most. Such strips are also found to be strong due to uptake of water by osmosis, which has cause the cell in them to be turgid.

2.2 CHANGES IN LENGTH METHOD

Plant tissues e.g. potato cylinders of the same length and diameter (same volume) are placed in solutions of different concentrations e.g. sucrose and allowed to stand for some time like 1 hour.

Then their lengths are measured and their nature recorded.
Results can be recorded as change in length (final length-initial length**) Or**
Recorded as percentage (%) change in length
Percentage (%) change in length = $\frac{new\ length - original\ length}{original\ length}\ x\ 100\%$

Results can be also being recorded in terms of ratios as initial length**:** final length.
The student may be asked to plot a graph of sucrose concentration against changes in length or percentage change in length.

EFFECT OF DILUTE SOLUTIONS (HYPOTONIC SOLUTIONS) ON PLANT TISSUES (CYLINDERS)

Observation

(i) Texture: plant tissues are hard and brittle
(ii) Size: plant tissues are longer than their original length

Explanation

Plant tissues (cylinders) placed in solutions more dilute than their sap take in water by osmosis and their cells become turgid.

EFFECT OF MORE CONCENTRATED SOLUTIONS (HYPERTONIC SOLUTIONS) ON PLANT TISSUES (CYLINDERS)

Observation

(i) Texture: tissues appear soft and flabby
(ii) Size: they are shorter than their length.

Explanation

Plant tissues place in stronger (more concentrated) solutions than their cell sap loses water by osmosis and their cells become flaccid.

EFFECT OF ISOTONIC SOLUTIONS ON PLANT TISSUES (CYLINDERS)

Observation

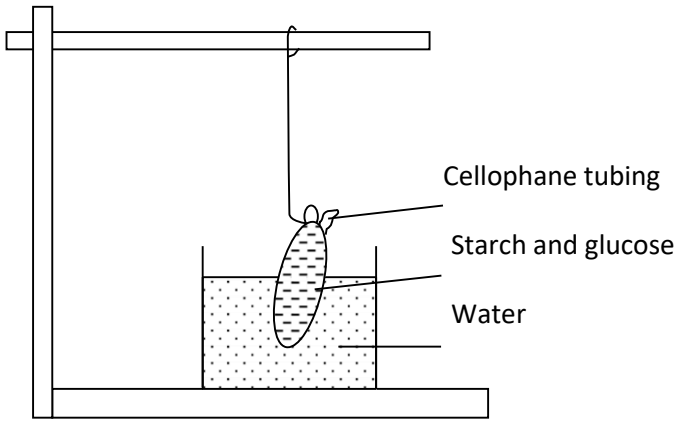
There is no change in length

Explanation

Plants tissues placed in solutions with the same concentration as that of their cell sap there is no net gain or loss of water by osmosis.

OSMOSIS VIA A SEMI-PERMEABLE MEMBRANE

Arrangement of apparatus



A mixture of starch and glucose is placed inside a cellophane tubing/bag and tied very tightly. Then lowered into a beaker of distilled water and the experiment is allowed to stand for some time.

After this time water is tested for the presence of a reducing sugar using Benedict's solution, and for starch using iodine solution.

It is found that only glucose has diffused through (because it is made up of smaller molecules than starch) and the cellophane tubing acts as a semi permeable membrane.

Possible questions to be asked from such an experiment

a) What is the nature/structure of the cellophane bag/tubing?

It is a semi permeable/ selectively permeable membrane

b) Which physiological or biological process is involved?

It is osmosis

c) What is the function of this process?

- It is for absorption and movement of water across the root
- For maintenance of turgidity and hence the support of stems of herbaceous plants.
- It helps in the opening and closure of stomata and flowers.

EXPERIMENTS

EXPERIMENT 18

You are provided with specimen **F** and seven sucrose solutions of 0.0M, 0.1M, 0.3M, 0.4M, 0.5M, and 0.6M.

Place 12cm^3 of each solution into separate test tubes and label them accordingly.

Using a sharp Knife/scalpel cut slices about 5mm thick. From the largest slices cut out a total of seven potato strips each about 5mm wide.

Trim all of them to a length of 50mm wide.

Immerse one potato strip in each solution and leave for at least 45 min. At the end of this period remeasure their lengths to the nearest millimeter.

(a) (i) Calculate the change in length and from this work out the percentage change in length. Record your results in a suitable table.

Sucrose concentration/M	Initial length/mm	Final Length/mm	Change in length/mm	Percentage change in length
0.0				
0.1				
0.2				
0.3				
0.4				
0.5				
0.6				

(ii) Plot a graph of percentage change in length against sucrose concentration

- TO BE PLOTTED ON A GRAPH PAPER

01) Mr. Matovu grows vegetables in containers around his home. During dry seasons, he waters these vegetables to supply them with enough water. One day, he was at work and told his son to water them. The son unfortunately poured a solution onto the vegetables that made all the leaves of the vegetables droop (wilt) and eventually dried. One of the solutions A or B is wrong, which led to the drying of the vegetables.

Task

(a) Carry out a scientific investigation-using specimen T, to identify which solution was poured on the vegetables.

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Explain to Mr. Matovu why the solution used by his son led to the drying of the vegetables.

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(b) Advise Mr. Matovu on how he can prevent his vegetables from drying.

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01. In a vegetable storage Centre, workers observed that fresh produce stored in a warm room loses firmness faster than the produce stored in a cool room. The quality control officer suspects that differences in water movement across plant cell membranes may be influenced by temperature, affecting the firmness of the vegetables. To understand this, she brings samples of a plant tissue labeled T to the school laboratory. She wants students to investigate how temperature affects water movement into or out of the tissue when placed in the same solution.

Task:

Design and carry out a scientific investigation to determine the effect of temperature on the movement of water across the cells of tissue T when placed in the same solution. Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

(a) Aim, hypothesis, variables and materials

CHAPTER FOUR

ANATOMY / STRUCTURE AND FUNCTION IN LIVING ORGANISMS

A candidate is expected to:

- ✓ Identify the specimen(s)
- ✓ State adaptations of the specimen (s) for survival or for their functions
- ✓ Compare and classify specimens
- ✓ Write observations and conclusions
- ✓ Draw accurate biological drawings and label

1) Identification of the Specimen(s)

When identifying a specimen, always follow a systematic approach:

(a) Observe General Features First

- Size and shape
- Color and texture
- Body covering (cuticle, scales, hair, exoskeleton, bark, etc.)
- Number and arrangement of parts (legs, segments, leaves, petals, antennae, etc.)

(b) Observe Detailed / Diagnostic Features:

- Type of symmetry (bilateral / radial / asymmetrical)
- Presence of segmentation
- Type of skeleton (exoskeleton, endoskeleton, hydrostatic)
- Specialized structures (proboscis, claws, wings, root hairs, flowers, spiracles)

(c) Use Biological Terms:

Avoid common words like “legs like a stick”. Use proper terms such as:

- Jointed appendages
- Compound eyes
- Tap root system
- Parallel venation

- Thorax, abdomen, cephalothorax

(d) State the Likely Name

Give:

1. Common name
2. Where possible, the biological group

Example:

The specimen is a cockroach, an arthropod (Class Insecta)

ANATOMY OF PLANTS AND ANIMALS:

Anatomy is the bodily structure of organisms. A number from this section may be on topics such as insects, modified roots, stems, leaves, fruits, seeds and germination, flowers and inflorescence, birds, fish, feathers (birds) and bones (teeth). A number of specimens may be provided and a student asked questions to identify each, classify, give similarities and differences, their habitats or habits, adaptations, draw the structure asked for, label it, stating the magnification and even describing it. All answers to such questions should be based on use of external and observable features on these specimens whose details can be viewed using a hand lens.

DRAWING AND LABELING.

- ✓ Always use a sharp HB pencil or clutch pencil or sketch pencil.
- ✓ Draw what you see but not what you imagine.
- ✓ Draw large diagrams.
- ✓ Don't shade or color your diagram.
- ✓ All drawings must be proportional to the whole diagram.
- ✓ Always make sure that you include the magnification, preferably at the bottom right corner.
- ✓ Labeling must always to the right hand side unless otherwise.
- ✓ The magnification of a drawing is the ratio of the size of the drawing to the size of the specimen.

$$\text{Magnification} = \frac{size\ of\ drawing}{size\ of\ the\ specimen}$$

It can be written as X2 or X3 or X4 or X0.5 etc. Parameters of size can be obtained using measurements of length or width of the specimen and drawing respectively. Each drawing must be given a title. All drawings should preferably be in an upright posture and labeled (Unless when not requested to do so). Label lines must touch actual part of the diagram being labeled. Straight label lines must be used, preferably horizontal lines on the right and left sides of the drawing. Do not use arrow heads or dotted lines. Label lines must not cross each other. Diagrams drawn must be drawn in the central area of the space provided and space for labeling should be put into special consideration. Avoid labeling in plural when labeling a single point or when only one line is used. Do not leave any gaps between the diagram and its individual component parts/ lines. Take special note of spellings when labeling. Some words have similar pronunciation but have different meanings such as a bud and bad, west and waste, axillary and auxiliary.

1.0 PLANT ANATOMY

3.3 PLANT PARTS AND STRUCTURE

Plants are members of kingdom Plantae, which is divided into two divisions equivalent to phyla. These are spermatophyta and pteridophyta.

Flowering plants:

Flowering plants belong to division spermatophyte and class Angiospermae, which is divided into monocotyledonous and dicotyledonous plants.

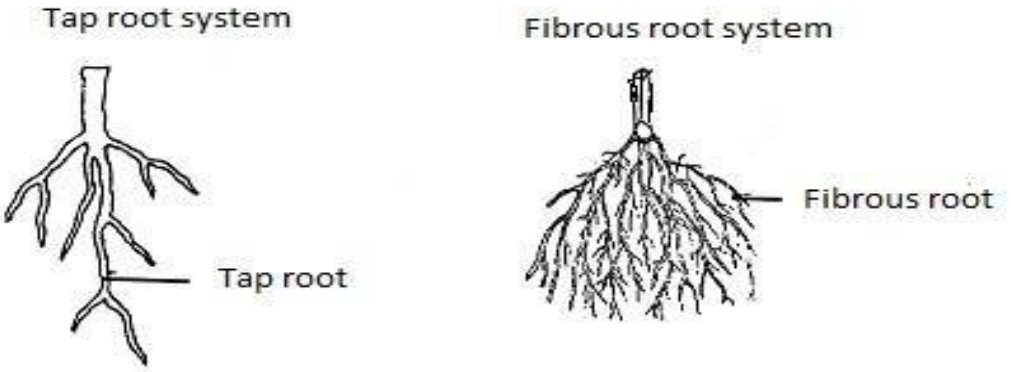
Flowering plants are divided into two main systems/parts:

(a) Shoot system: This is the part found normally above the ground. It consists of the following parts; stems, leaves, and flowers/buds.

(b) Root system: This is the descending part of the axis of the plant. There are main types of root system namely:

i) <u>Tap root system</u>: The main root of this system is called tap root and grows downwards into the soil from which other roots (lateral roots) branch from. This characteristic of dicotyledonous plants e.g. beans, peas, soya beans and ground nuts.

<u>ii) Fibrous root system</u>: This is a root system without a main root and all roots arise from the same point at the base of the stem. This characteristic of monocotyledonous plants e.g. millet, maize, sorghum, rice, wheat etc.



***<u>1.2</u>* <u>Modified roots:</u>**

These are subdivided into modified tap roots and modified adventitious roots.

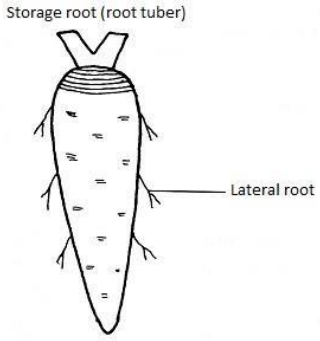
(a) Modified tap roots:

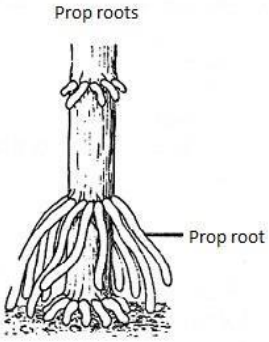
- ✓ Storage roots: These are thick fleshy and succulent roots, also called root tubers. They for modified for storage of food. They include cassava roots and carrots.

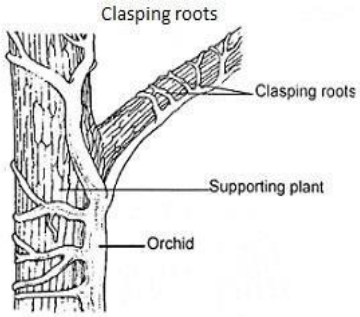
(b) Modified adventitious roots:

- ✓ Storage roots: These are modified adventitious that grow from the nodes of creeping plants. These roots are also known as root tubers. They are modified for food storage. Examples include; sweet potato roots.
- ✓ Prop roots: These roots develop from nodes of a stem close to the soil surface. They provide extra support to the plant. They are found in maize, sugar cane, sorghum etc.
- ✓ Clasping roots: These are roots growing from the nodes of climbing stems of some plants. They provide extra support to the plant.

- ✓ Sucking roots: These are roots found growing on certain parasitic plants, for example, dodder plants. They absorb water, mineral salts and organic food compounds from the







1. STEMS:

A stem is the ascending portion of the plant axis that develops from the plumule of an embryo. They bear leaves, buds and flowers. Points on the stem were leaves or buds arise are called nodes and the regions between successive nodes are called internodes. Most stems are found above the ground; however, there are some stems that are found under the ground and these are referred to as underground stems.

Stems generally conduct materials like water, mineral salts, manufactured food and some manufacture and store food.

Modified stems:

Stems that are considered normal, are located above the ground are grow upright above the ground. Stems that are different from the normal ones are called modified stems and most of them are found under the ground. Modified stems have additional functions.

Modified stems include;

a) Rhizome:

This is a horizontal thick underground stem having adventitious roots growing from the lower side of the nodes. It has terminal buds which develop into aerial shoots and it bears buds in axils of scale leaves. They store food for the plant and also act as organs for vegetative propagation or reproduction. For example, ginger, couch grass, spear grass etc.

b) Stem tuber:

This is a short fleshy underground stem swollen to enable food storage. It has scale leaves and axillary buds which form the eyes. For example, iris potatoes. They store food for the plant and also act as organs for vegetative propagation or reproduction.

c) Bulb:

This is a short conical shaped underground stem comprising of thick fleshy leaves arranged in concentric circles. Fleshy leaves store food for the plant and are protected by scale leaves. Bulbs also contain buds used for vegetative propagation e.g. Onions and garlic

d) Corm:

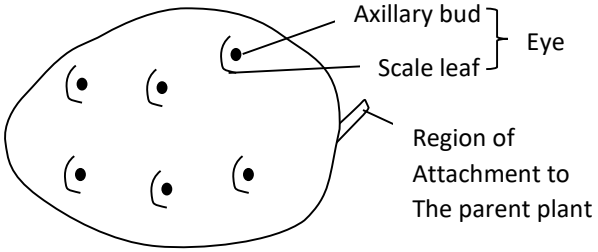
A corm is a swollen fleshy underground stem that grows in a vertical direction. It has a terminal bud lying at the top of the stem and has scale leaves arising from the nodes e.g. Cocoyam They store food for the plant and also acts as organs for vegetative propagation or reproduction.

Other stems

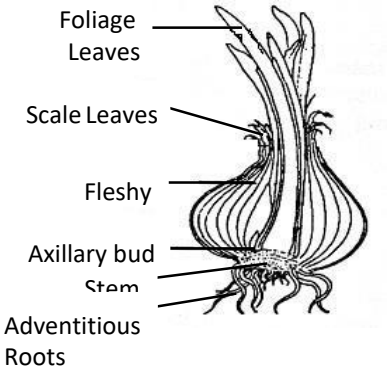
- Climbing stems: These are stems that grow clinging to a support by means of tendrils e.g. in Passion fruits.
- Twinner / Twining stems: These are stems that grow ascending spirally around the support e.g. in bean plant, yams (Balugu).
- Stolons: These are horizontally growing stems that have roots at the nodes and develop buds that grow into new plants. e.g. Straw belly
- Runners: these are slender trailing stems lying flat on the ground with long internodes, and adventitious roots e.g. Commelina sp (wondering jaw) and oxalis.
- Suckers: A sucker is a creeping stem that grows obliquely upwards, directly giving rise to a leafy shoot. E.g. Banana, pineapple, sisal plant etc.

N.B: Runners, stolons, suckers are collectively called creepers or creeping stems

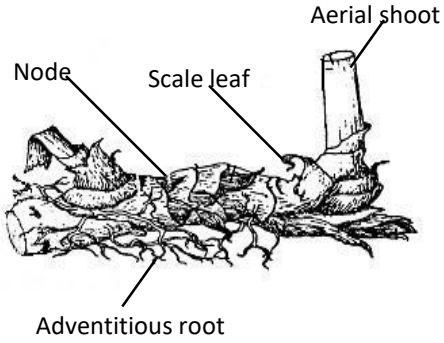
Stem tuber



Bulb



Rhizome



2. LEAVES

This is a thin flattened structure which grows laterally from the node of the stem. It is where photosynthesis takes place.

A typical leaf is made up of three main parts namely

a) Leaf base: This is the part that attaches the leaf to the stem.
b) Leaf stalk (petiole): This connects the leaf base to the leaf blade.
c) Leaf blade (lamina): This is the expanded and flattened portion of leaf.

External structure of a leaf

Leaf venation

This is the arrangement of veins in the lamina of a leaf. There are two types of venation namely;
(i) Reticulate venation (network venation): Here the veins in the lamina branch while intersecting to form a net. These are found in dicotyledonous leaves.
(ii) Parallel venation: In this venation, the veins run side by side without branching. These are found in monocotyledonous leaves.

Leaf margin:

There are several types of leaf margins. These include;
(i) Entire margin: This is a margin without indentations of any kind e.g. mango leaves, orange leave.
(ii) Serrated margin: This is a margin with indentations pointing toward the apex. e.g. Hibiscus and lack jack leaves.
(iii) Crenate margin: This is a margin with round indentation e.g. Bryophylum.
(iv) Wavy margin: This is a margin with wavy blunt curves e.g. Solanum incanum
(v) Lobed margin: This is a margin in which the lamina is deeply divided but does not separated completely e.g. Cassava, sweet potato, passion pawpaw, etc.

Types of leaves

There are two major types of leave. These include simple leaves and compound leaves.

Simple leaves:

Simple leaves are leaves with a single lamina which is not completely divided up into leaflets e.g. mango, Jack fruit, orange etc. Pawpaw and cassava have simple digitate/palmate leaves.

Compound leaves:

Compound leaves are leaves with a single lamina which is completely divided up into leaflets.
Types of compound leaves include

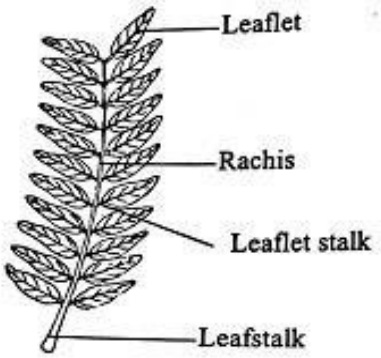
i) **Compound pinnate**: Here leaflets are arranged in two rows opposite one another along the midrib (rachis) e.g. cassia leaf.

ii) **Compound bipinnate:** Here leaflets are arranged opposite each other on the rachis and each leaflet further divides into smaller units called pinnules e.g. Jacaranda leaf.

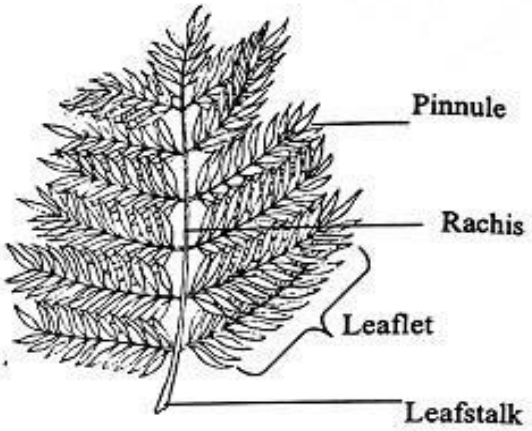
iii) **Compound trifoliate** these are compound leaves with only three leaflets e.g. Soya bean, beans, oxalis, straw berry, peas etc.

iv) **Compound digitate** or palmate: These are compound leaves with leaflets radiating out from the end of petiole like fingers of the hand e.g. Silk cotton and gynandropsis.

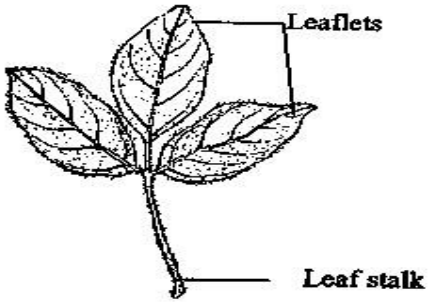
Compound pinnate



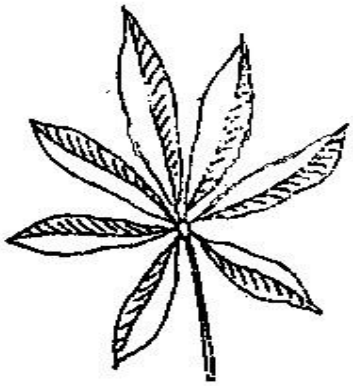
Compound Bi pinnate



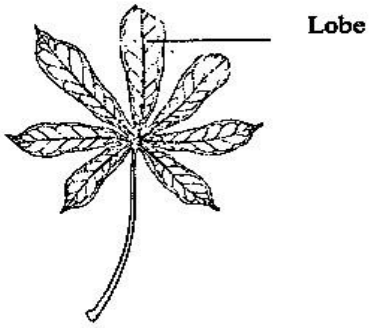
Compound trifoliate



Compound palmate



Simple palmate



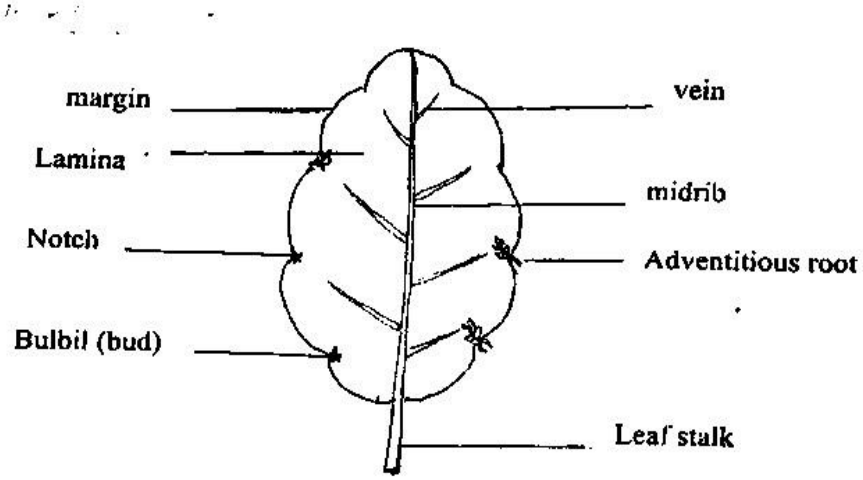
Note:
Lamina may also have the following features;

- ✓ May have hairs to trap moisture hence reducing transpiration.
- ✓ May be thick and succulent to store mainly water and food which is an adaptation for plants leaving in dry areas e.g. Sisal, cactus, and Bryophylum.
- ✓ It may be rough which provides protection.
- ✓ It may have spines for protection against herbivores.

Leaf modifications:
Some leaves have been modified into specialized forms to perform other functions other than the usual photosynthesis, transpiration and gaseous exchange.
Functions of modified leaves include;

a) Some leaves store food and water for the plant. They are thick, succulent and swollen e.g. fleshy leaves of an onion, Bryophylum etc.
b) Some leaves are modified for vegetative propagations/reproduction. These have buds n the margin e.g. Bryophylum.
c) Some leaves are used for support and attachment on other objects. They have leaf tendrils at the apex or between the two leaflets e.g. peas.
d) Some leaves trap and digest insects e.g. Nepenthes. These leaves have leaf blades which arise as an outgrowth of leaf apex.
e) Some leaves provide protection e.g. pineapples, prickly pear, etc. These leaves have spines.

Bryophyllum leaf



3. FLOWERS

A flower is part of a shoot specialized for sexual reproduction. The flower consists of several parts arranged in rings known as whorls. These whorls from outermost to innermost are namely;

a) ***Calyx (sepals):***

This is the outermost whorl of a flower. It is made up of sepals that are normally green in colour. However, in some flowers the sepals maybe brightly coloured, hence referred to as petaloids. Sepals maybe either free (polysepalous) or fused (gamosepalous). Calyx protects the inner whorls of a flower during the bud stage.

b) ***Corolla (petals):***

This is the second whorl of a flower and it is made up of petals which are normally brightly coloured to attract pollinators. The petals can either be free (polypetalous) or fused (gamopetalous). In monocots, petals are small and dull coloured combined with sepals to form a perianth.

c) ***Androecium (stamens):***

This is the third whorl of a flower made up of stamens. Stamens form the male part of the flower and each consists of a filament which supports a head called anther.

d) ***Gynoecium (pistil/carpels):***

This is made up of female reproductive parts called carpels. Each carpel is made up of ovary, style and stigma. A flower with one carpel is referred to as monocarpous, that with several fused carpels is referred to as syncarpous and that with several unfused carpels are referred to as apocarpous.

Other terms used to describe flowers:

(i) Complete flower:

This is a flower having all the four floral whorls.

(ii) Incomplete flower:

This is a flower lacking one or more of the four floral whorls.

(iii) Bisexual flower:

This is a flower with both male and female parts i.e. it has pistil and stamens. These flowers are also called hermaphrodite flowers.

(iv) Unisexual flower:

This is a flower with either male sexual parts or female sexual parts.

(v) Pistillate flower:

This is a female flower i.e. a flower with carpels and no stamens.

(vi) Staminate flower:

This is a male flower i.e. a flower with stamens and no carpels.

(vii) Regular flower:

This is a flower which can be divided symmetrically along more than one plane.

(viii) Irregular flower:

This is a flower which can be divided in two similar halves along only one plane.

(ix) Superior ovary:

This is the ovary that arises above the rest of the floral parts.

(x) Inferior ovary:

This is the ovary that arises below the rest of the floral parts.

Pollination of flowers:

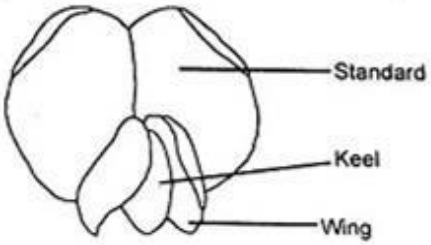
Flowers are generally pollinated by insects (insect pollinated flowers) and wind (wind pollinated flowers).

Characteristics of insect pollinated flowers.

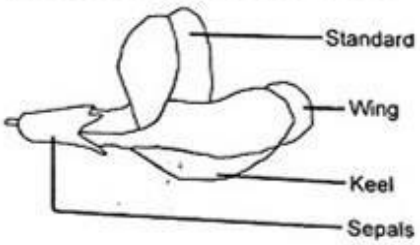
- ✓ They have large and conspicuous petals to provide large landing area and to be easily seen by insects.
- ✓ They have brightly coloured petals to attract insects.
- ✓ They are scented to attract insects.
- ✓ They have sticky stigma on which pollen grains can stick.
- ✓ They produce sticky pollen grains so as to stick on the body of insects.
- ✓ They produce nectar that attracts insects.

Examples of insect pollinated flowers include; crotalaria flower, hibiscus flower, morning glory, cassia flower etc.

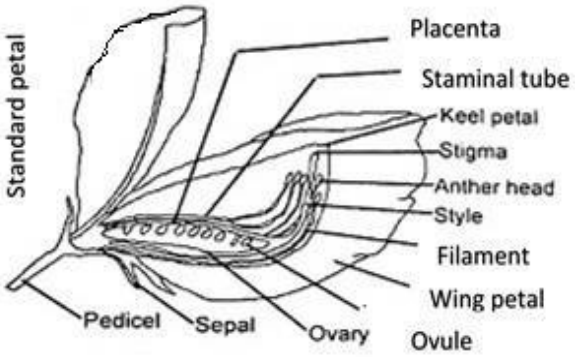
Anterior view of crotalaria flower



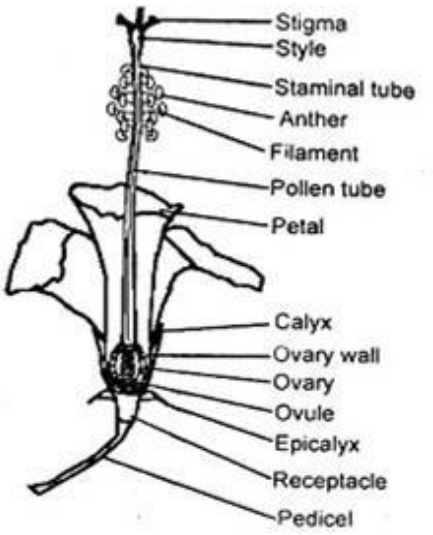
Lateral view of crotalaria flower



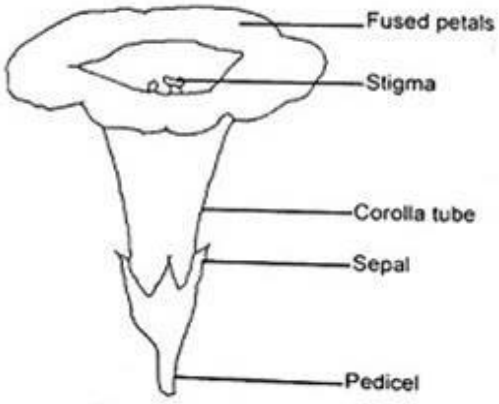
Longitudinal section of crotalaria flower



Longitudinal section of Hibiscus flower



External parts of morning glory flower



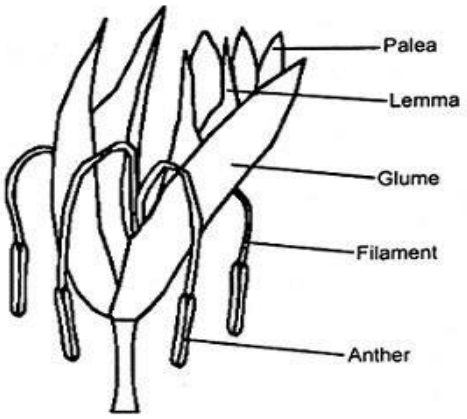
Characteristics of wind pollinated flowers.

- ✓ They have feathery stigma which provide a large surface area for filtering pollen grains from the air.
- ✓ They have long styles for protruding the stigma outside.
- ✓ They have loosely attached anthers.
- ✓ They produce many dusty small pollen grains which are light in weight.

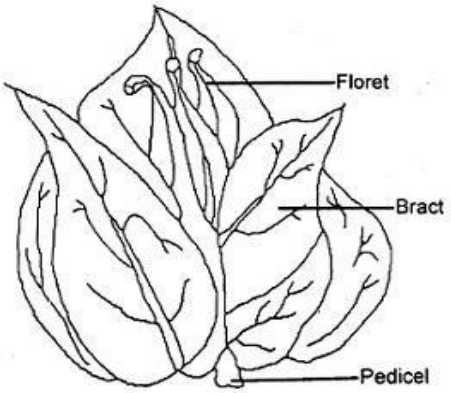
- ✓ They have long thin filaments for holding the anthers outside the flower.
- ✓ They have small dull coloured petals or perianth.

Examples of wind pollinated flowers include; grass flower and maize flower.

Drawing of a maize spikelet



External structure of Bougainvillea flower



4. FRUITS AND SEED

A seed is a fertilized mature ovule. It has one scar (hilium) which is a spot where it was attached to the pod inside the fruit using the funicle.

A fruit is a mature fertilized ovary containing or more seeds. It has a fruit coat known as a pericarp. It has two scars, one where it was attached to the receptacle and the other of the remains of the style or stigma.

CLASSIFICATION OF FRUITS

Fruits are divided into three groups namely;

(i) Simple fruits:

These are fruits which are formed from one flower in which the pistil is either monocarpous or syncarpous.

(ii) Aggregate fruits:

These are fruits formed from one flower with gynoecium having several free carpels (apocarpous).

(iii) Multiple fruits:

These are formed from several flowers and the ovaries become fused after fertilization e.g. Jack fruit, pineapple.

SIMPLE FRUITS

These are the majority of fruits and are divided into dry fruits and succulent fruits. Dry fruits are divided into dry dehiscent and dry indehiscent fruits.

a) Dry indehiscent fruits:

These are single seeded fruits with a pericarp which does not split to set free its seed. These fruits include achene, nut, caryopsis, cypsela and samara.

(i) Achene:

This is a small one seeded dry fruit with a tough leathery pericarp which does not split or dehisce. For example, sun flower.

(ii) Nut:

This is a one seeded fruit with a very hard and tough pericarp e.g. cashew nut. Note: Ground nuts and coconut fruits are not nuts.

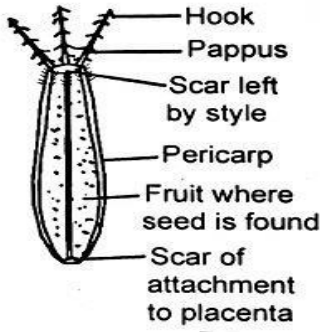
(iii) Caryopsis:

This is achene-like fruit in which the pericarp and testa have become fused together e.g. maize.

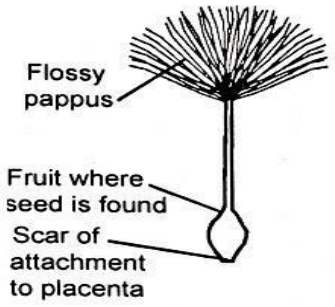
(iv) Cypsela:

This is a small hard one seeded fruit with a persisted calyx above the inferior ovary which forms a parachute of hairs known as pappus that facilitate wind dispersal by increasing the surface area that can be acted on by wind maximally e.g. tridax, black jack, Dandelion etc.

Bidens pilosa (Black jack)



Dandelion



(v) ***Samara:***

This is an achene like fruit in which the pericarp grows flattened to form a wing which facilitates wind dispersal by increasing the surface area that can be acted on by wind maximally e.g. African rose wood.

b) **Dry dehiscent fruits:**

These are fruits where the pericarp on drying splits open (dehisces) to release seed. They split along lines of weakness referred as sutures. These fruits are classified according to the number of splits (sutures) which occur in the pericarp. These include follicle, legume, capsule and schizocarp.

(i) Follicle:

This is a dry many seeded fruit that splits longitudinally along one line of weakness e.g. Sodom apple.

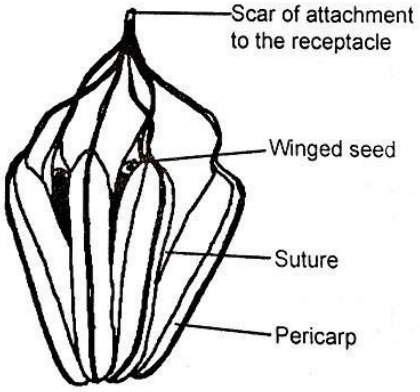
(ii) Legume:

This is a dry many seeded fruit that split longitudinally along two lines of weakness e.g. bean pod, pea pod, cassia pod etc.

(iii)Capsule:

This is a dry many seeded fruit that split longitudinally along more than two lines of weakness e.g. Dutchman's pipe, castor oil, cotton, etc.

Diagram of Dutchman's pipe-Capsule



(iv) Schizocarp:

This is many seeded fruit which on drying breaks up into several parts, each called a mericarp containing only one seed e.g. desmodium. They possess sticking hairs that attach to the body/fur of animals to facilitate animal dispersal.

SUCCULENT FRUITS:

These are fruits which become juicy as they ripen. Part of these fruits is fleshy and edible. The pericarp is divided into three layer i.e. epicarp, mesocarp and endocarp. Succulent fruits include drupe, berry and pome.

a) Drupe:

These are single seeded succulent fruits with a pericarp divided into three layers namely;

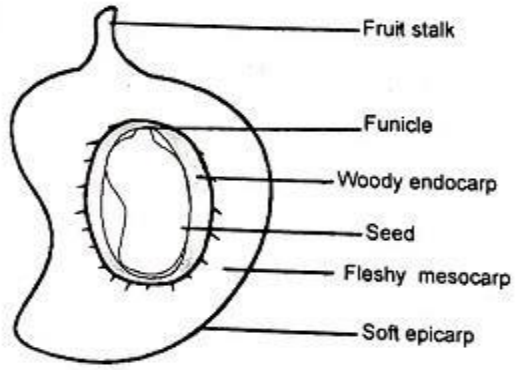
- ✓ Epicarp – an outer thin soft layer.
- ✓ Mesocarp – a middle fleshy edible layer.
- ✓ Endocarp – an inner hard and woody layer which forms the stone.

Example includes avocado, mango fruit, coconut, etc.

Characteristics of drupes

- Has one seed.
- Has fleshy mesocarp.
- The endocarp is hard and fibrous.
- Has only a single chamber (locule) where a seed is located.
- Seed is attached at the base of the fruit i.e. has basal placentation.

Longitudinal Section of a mango fruit:



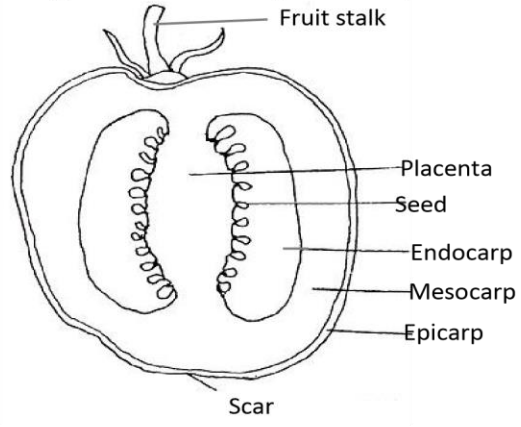
b) Berry:

This is a juicy fruit with many seeds e.g. tomato, orange, etc. The whole of its pericarp is soft.

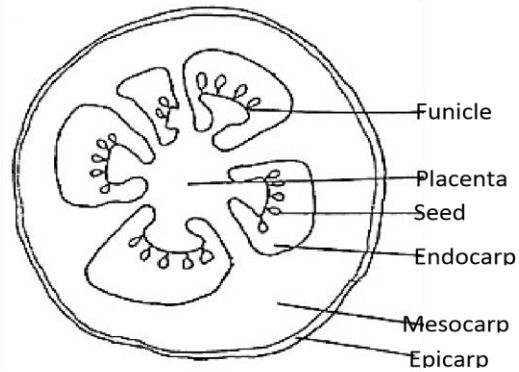
Characteristics of berries:

- Have many small seeds.
- Have a spongy mesocarp.
- Endocarp is juicy, with several juicy hairs or sac in some fruits.
- Have several chambers (locule).
- Seeds are attached around the placenta centrally (axile placentation).

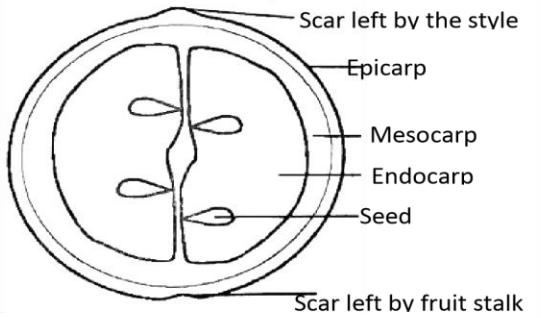
Longitudinal section of a tomato fruit:



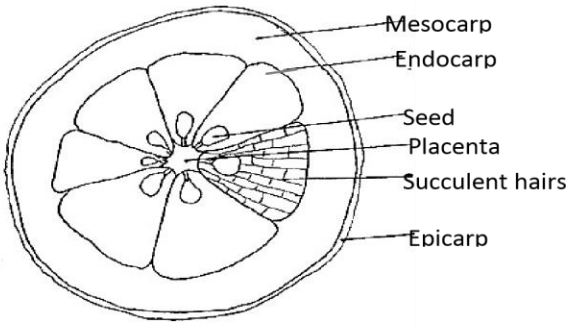
Cross section of a tomato fruit:



Longitudinal section of an orange fruit:



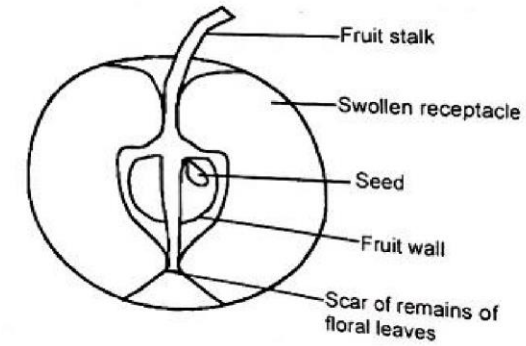
Cross section of an orange fruit:



c) Pome:

This consists of a fleshy pericarp whose receptacle forms part of the fruit e.g. apple.

Longitudinal section of an apple:



PLACENTATION

This is the arrangement of seeds and their attachment on the placenta. There are several types of placentation and these include;

a) Axile placentation:

Seeds arrange themselves radially/centrally around the placenta which is centrally located e.g. oranges, tomatoes, lemon and banana.

b) Marginal placentation:

Seeds are arranged along the placenta located on the margin of the pod of fruits like legumes e.g. bean pod, pea pod, or follicles for example Sodom apple.

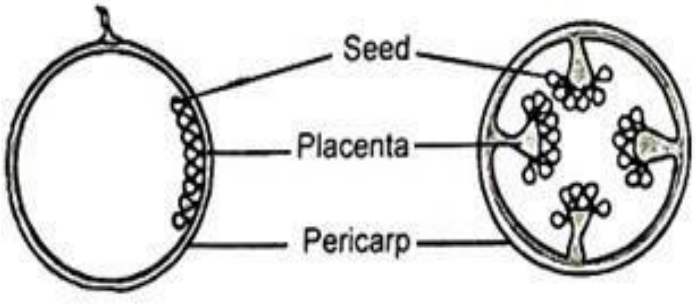
c) Basal placentation:

Here seeds are attached at the base of the pericarp e.g. mango, avocado, etc.

d) Parietal placentation:

There the seed are attached to the inner walls of the pericarp (endocarp) and appear as ridges e.g. pawpaw, passion fruit, cucumber, etc.

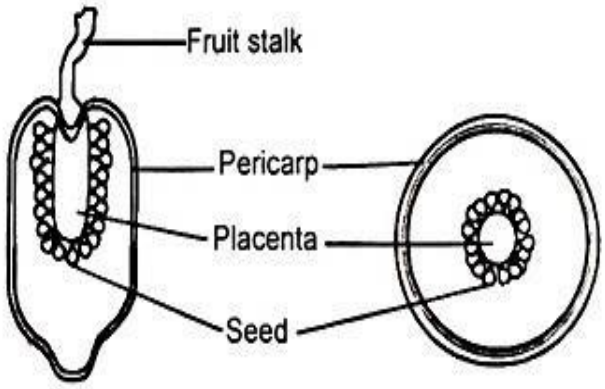
Diagram of Parietal placentation of passion fruit:



e) Free central placentation:

Here the placenta projects freely in the center of the locule (chamber) from where the seeds are attached all around the placenta e.g. green paper.

Diagram of free central placentation of green paper:



SEEDS AND FRUIT DISPERSAL

This is the scattering of fruits and seeds from their parent plants.

Importance of seed and fruit dispersal:

- It reduces overcrowding among plants of the same species.
- It reduces competition for resources.
- It allows colonization of new areas.
- It minimizes the spread of diseases.
- It enhances chances of survival and continuity of plant species

Types / modes of dispersal

There are four types of dispersal namely; animal dispersal, self-dispersal (explosive dispersal), wind dispersal and water dispersal.

(a) **Animal dispersal:**

Fruits dispersed by animals have the following characteristics;

- Some are large and brightly coloured to attract animals.
- Some fruits when are scented to lure animals.

- Some fruits possess hooks on their pericarps to attach on the fur, skin or cloth of animals e.g. Black jack and desmodium.
- Some fruits are succulent i.e. have edible parts.

(b) **Wind dispersal:**

Seeds/fruits dispersed by wind have the following characteristic;

- They are light in weight.
- They have structures like hair or wings that allow the float in air.
- They are loosely attached to allow them be easily shaken off by wind.

(c) **Self-dispersal:**

These fruits are mainly dry dehiscent, that split along lines of weakness ejecting/releasing the seeds e.g. legumes.

(d) **Water dispersal:**

Seeds/fruits dispersed by water have the following characteristics;

- They are usually light and contain air spaces that allow them float on water so that they can be carried by running water.
- Some fruits have fibrous mesocarp to prevent water from penetrating them.
- They normally possess impermeable outer coat.

PRACTICAL EXAMPLES

01. In a school of botanists, science heed teacher observed that certain plants were producing more fruits and seeds than others, while some plants were wilting faster and losing water more quickly. The heed teacher wanted the students to investigate how the structure of different plant parts affects pollination, growth, and water conservation, which ultimately influences plant productivity.

To help the students, the teacher collected different leaves and flowers from the garden.
The teacher explains that leaves may have adaptations that help them retain water. While flowers may have features that help them attract pollinators or facilitate self or cross pollination. By studying the specimens provided, students could identify how these structures contribute to the survival, reproduction and yield of plants in the garden.
You are provided with specimens G, H, F, N and M

Task.

(a) State differences between specimen M and N.

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(b) i) Give the possible agent of pollination for specimen M and N and give reason(s) for your answer.

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ii) Explain how the specimens encourage self or cross pollination

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(c) outline the observable characteristics of leaves G, H, F

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(d) Describe how specimen F minimizes transpiration.

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(e) Construct the dichotomous key to identify G, H, F

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02. In a wetland-bordering school in Mpigi, students established a biodiversity garden to compare how different plants adapt to humid and shaded environments. Over time, they observed that some plants produced many healthy fruits and seeds, while others showed slow growth and frequent fungal infections.

The Biology teacher explained that these differences may result from variations in flower structure and leaf anatomy, which influence pollination success, air exchange, and water-regulation mechanisms.

To deepen understanding, the teacher collected several specimens from the garden. The flowers differed in petal arrangement, colour, and position of reproductive organs, while the leaves showed variations in size, texture, and thickness. Students were required to investigate how these structural differences affect reproduction, survival, and plant productivity in the moist environment.

You are provided with specimens A, B, C, D, and E. Using a hand lens and other laboratory equipment, compare their structures and relate them to pollination efficiency and adaptation to the environment.

Task:

(a) State the differences in structure between specimen D and specimen E.

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(b) (i) Identify the probable pollination agent for specimen D and specimen E, giving a reason in each case.

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ANIMAL ANATOMY

Animal structure and parts

Arthropods

Arthropods belong to the phylum arthropoda and it is the largest invertebrates.

General characteristics of arthropods

- They have jointed limbs.
- They have segmented bodies.
- They possess an exoskeleton.

The general characteristics can also be reasons for grouping under the phylum arthropoda.

Classes of arthropods

Arthropods are divided into five main classes, namely

Phylum:	**class**	**examples**
arthropoda	Insecta	Grasshopper, butterfly, ants. Bees etc.
	Arachnida	spider, mites, scorpion, ticks etc.

	Crustacean	crabs, Cray fish, lobster, water flea etc.
	Diplopoda	millipedes
	Chilopoda	centipedes

Class: arachnida

Examples include;

Spider, mites, scorpion, ticks etc.

Characteristics of class arachnida:

- They have four pairs of legs.
- They have two main body parts.
- They have no antennae.
- They have no compound eyes

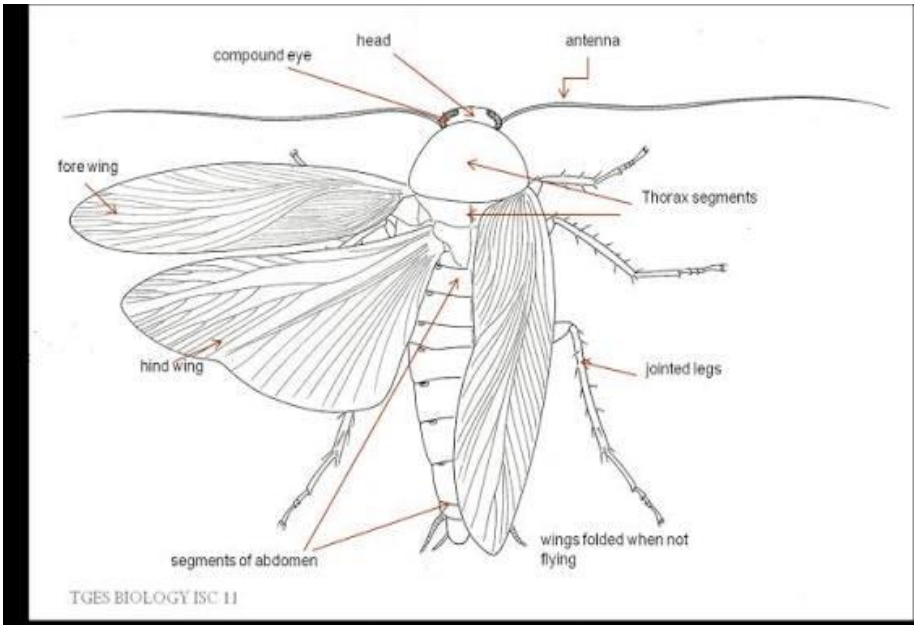
Class: insecta

Characteristics of class insecta

- They have three pairs of jointed legs all found on the thorax.
- They have three main body parts.
- They have a pair of antennae on the head.
- Majority have a pair of compound eyes on the head.
- They have exo-skeleton

Features of some common insects.

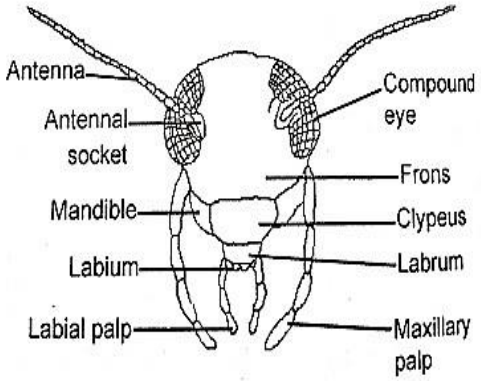
1.0.Cockroach
Order: Dictyoptera
Reason: *Has hard outer wings.*
The body is dorso-ventrally flattened.
Habitat: Dark, dirty and damp warm places.
Structure of a cockroach



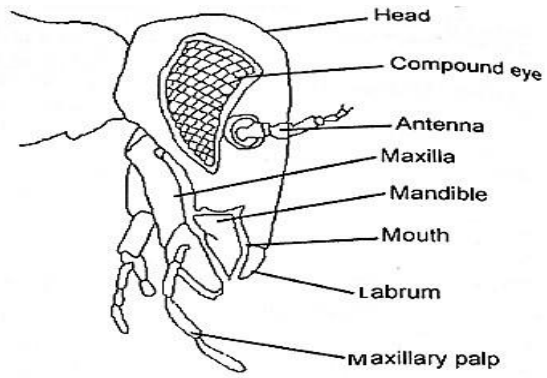
Features on the head region

- Head is oval shaped, and connected to thorax by short slender neck.
- Has two compound eyes dorso-laterally positioned able to view a wide area.
- Has a pair of long segmented and tapering antennae that are sensitive to touch and smell.
- They possess biting mouth parts consisting of sharp serrated mandibles for chopping the food, maxilla for handling food during the feeding, labrum and labium which are lips.

Anterior view of the head of a cockroach

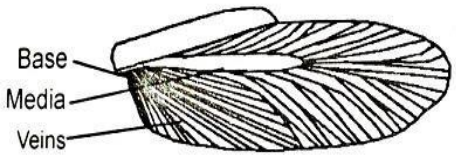
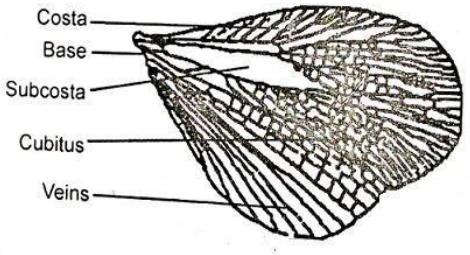


Lateral view of the head of a cockroach

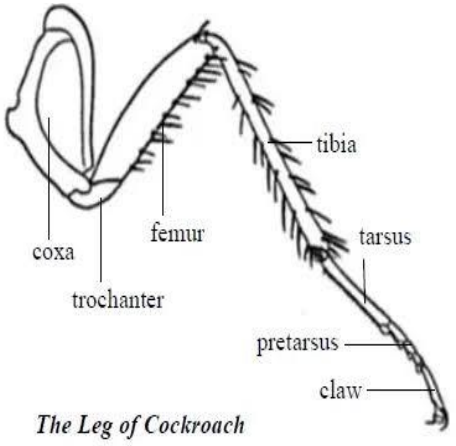


Features on the thorax

- Has three segments i.e. prothorax, mesothorax and met thorax.
- Each segment bears a pair of legs. The hind leg has spines for protection, they are long and muscular and Z-shaped to provide enough lift force. The legs possess claws to grip on objects, glandular pads for moving on smooth surfaces. Legs are jointed for swift movement. The other legs are short for swift movement.
- The mesothorax and metathorax each possess a pair of wings.
- The outer wing is hard, narrow and oval in shape whose main function is to protect the inner wings used for flying.
- The inner wing is membranous and flexible supported by a system of veins. It is broad and triangular in shape providing a large surface area.
- Have two pairs of spiracle.

Fore wings	**Hind wings**
Are brown in color and opaque	Are colorless and transparent
Are thick and stiff	Are thin, membranous and delicate
Are narrow shaped	Are broad shaped
Cover and protect hind wings not when in use	Used for flight
	

Drawing of a hind leg



The Leg of Cockroach

Features on the abdomen

- Has ten segments when which are dorso-ventrally flattened. Each segment bears a pair of spiracles.
- The last abdominal segment has a pair of jointed sensory structures called cerci.
- It is flat and broad.
- The ninth segment in males possesses a pair of styles which are reproductive structures.
- In the females the seventh segment possess the ovipositor used for holding and depositing the egg

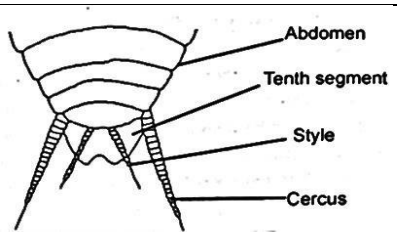
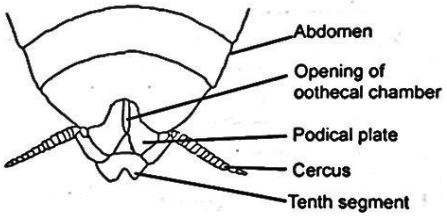
Adaptations of a cockroach to its habits and habitant

- They may be winged or wingless. Wings enable them to fly away quickly from enemies.
- They possess spines on their legs for defense.
- They have long jointed legs that they can use to run very rapidly from any potential danger.
- They are generally flat and oval in outline to enable them hide in very narrow crevices.
- They are brown or dark coloured allowing them not to be seen in darkness since they are largely nocturnal.
- They have a soft, slippery outer skin called cuticle which makes hem difficult to catch.
- They have long, highly sensitive antennae with sensory bristles which enable them to detect tiny amounts of food and moisture even in darkness.
- They have cerci which can sense minute air movements to enable a cockroach to rapidly detect and flee from potential danger.
- They have oily cuticle which protects them from dehydration.

Identification of a cockroach's sex

In males, there is a pair of slender **styles** that are used to hold and manipulate the female during copulation.

In females, there is a pair of boat shaped structures called the **podical plates** used for holding eggs.

Differences between a male and female cockroach:	
Male	**Female**
1. Has a narrow abdomen	Has a broader abdomen
2. Lack ootheca	Has ootheca which develops after fertilization.
3. Has rod-shaped structures called styles on the 9th abdominal segments.	No styles on the 9th abdominal segment.
4. No podical plates.	Has podical plate for carrying eggs.
	

2.0 Housefly

Order: Diptera

Reason:

- *Has a pair of halter*
- *Has a pair of wing*

Habitat: Dirty/filthy moist places/decaying organic matter.

Features on the head.

- Has two compound eyes
- Has three simple eyes called ocelli.
- Has a proboscis
- One pair of short antennae.
- Has a pair of short maxillary pulp

Features on the thorax

- Have three segments.
- Each segment is hairy and each possesses a pair of hairy legs.
- Mesothorax has a pair of membranous wings.
- Metathorax has a pair of halters/balancers.
- Have two pairs of spiracles.

Adaptations of a housefly to its habits and habitant

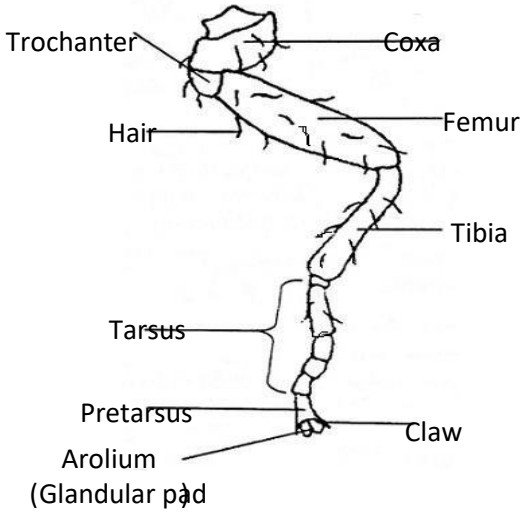
- Has hairy antennae for increased sensitivity.
- Membranous wings for flight.
- Tubular expanded proboscis for sucking liquid food and depositing of saliva.
- Large compound eyes for wide field of view.
- Curved/sharp/pointed claws for movement on rough surfaces.
- Sticky arolium for movement for moving on smooth surfaces.
- A pair of halters for balancing during flight.
- Segmented body for flexibility during movement.
- Body covered with exoskeleton for protection against water loss/desiccation/mechanical damage.
- Have glandular pads on legs for moving on smooth surfaces.
- Has jointed limbs for flexibility during movement.

Adaptation of a housefly to its function as a vector

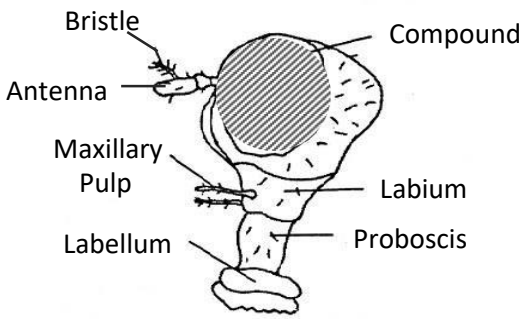
- Has hairy body for carrying germs to other areas.
- Has tubular proboscis through which germs contained in saliva are passed onto food

- Have wings for swift movement leading to easy transfer of the germs.

Drawings of a hind leg of a house fly



Drawing of lateral view of the head of a House Fly



3.0 Grass hopper

Order: Orthoptera

Reason: Has straight wings.
Habitat: Grass

Features on the head

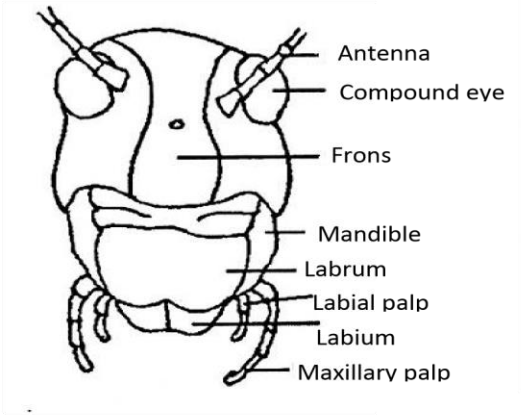
- Has a simple eye.
- Has a pair of short antennae.
- One pair of compound eyes.
- Have powerful mouthparts with strong toothed mandibles.

Adaptation of a grass hopper to its life in the habitat.

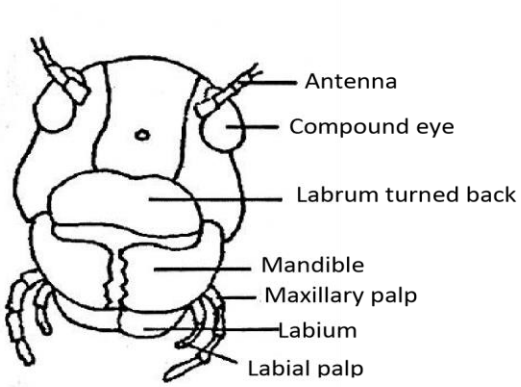
- Have a pair of antennae for increased sensitivity.
- Hard sharp mandibles for cutting solid food and defense
- Curved/sharp/pointed claws for movement on rough surfaces.
- Sticky arolium for moving on smooth surface.
- Segmented body for flexibility during movement.
- Jointed maxillary palps to hold and push food into the mouth.
- Have dull coloured body to camouflage and avoid predators.
- Eyes are large and dorso-laterally positioned to see food in a wide area.
- Outer wings are hard to protect inner wings.
- Inner wings are wider for generating a big lift force in flight.

- Wings are veined for support in flight.
- Maxilla and labium are joined for flexibility.
- Jointed legs for flexibility during locomotion.

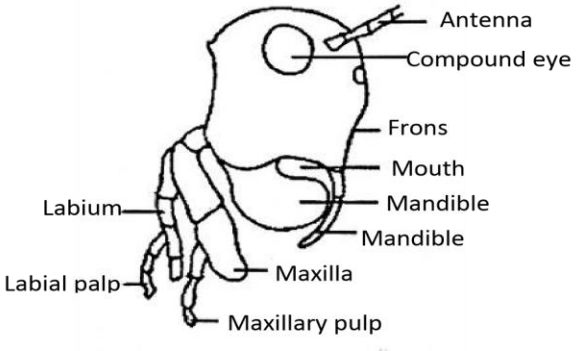
Drawing of anterior view of grasshopper head (All parts intact)



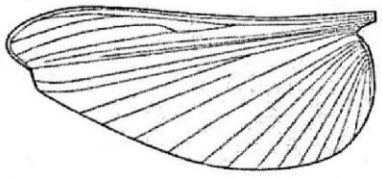
Drawing of anterior view of grasshopper head (Labrum lifted to expose mandibles)



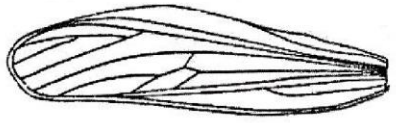
Drawing of lateral view of grasshopper head



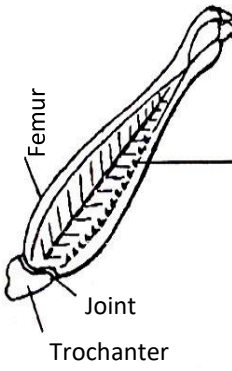
Drawing of hind (inner) wing:



Drawing of fore (outer) wing:



Drawing of hind l



4.0 Worker Bee

Order: hymenoptera

Reason: Has membranous wings.

Habitat: Bee hive

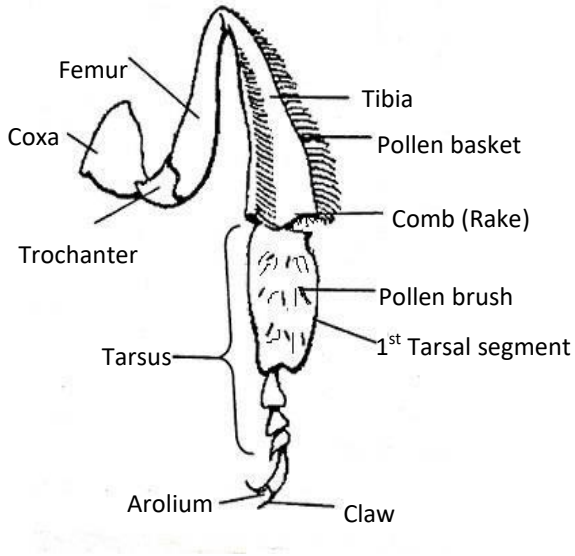
Adaptations for successful survival of bees in their habitat

- Possession of pollen baskets on limbs for carrying pollen grains.
- Possession of pollen comb on their limbs for cleaning pollen off the body.
- Possession of prongs on their limbs for removing the pollen from the pollen basket.
- Hairy body for carrying the pollen grains.
- Blunt mandibles for molding wax and pollen grains.
- Membranous wings for flight.
- Spoon like tongue for lapping/sucking.
- Segmented body for flexibility during movement.
- Tubular expanded proboscis for sucking liquid food.
- Large compound eyes for wide field of view.

Structural adaptation of the worker bee to its function as a pollinator

- Has hairy body to trap pollen grains.
- Have membranous wings for swift movement leading to fast transfer of pollen.
- Possession of pollen baskets on their limbs for carrying pollen grains.
- Possession of prongs on their limbs for removing the pollen from the pollen basket.

Drawing of the hind limb of the worker bee :



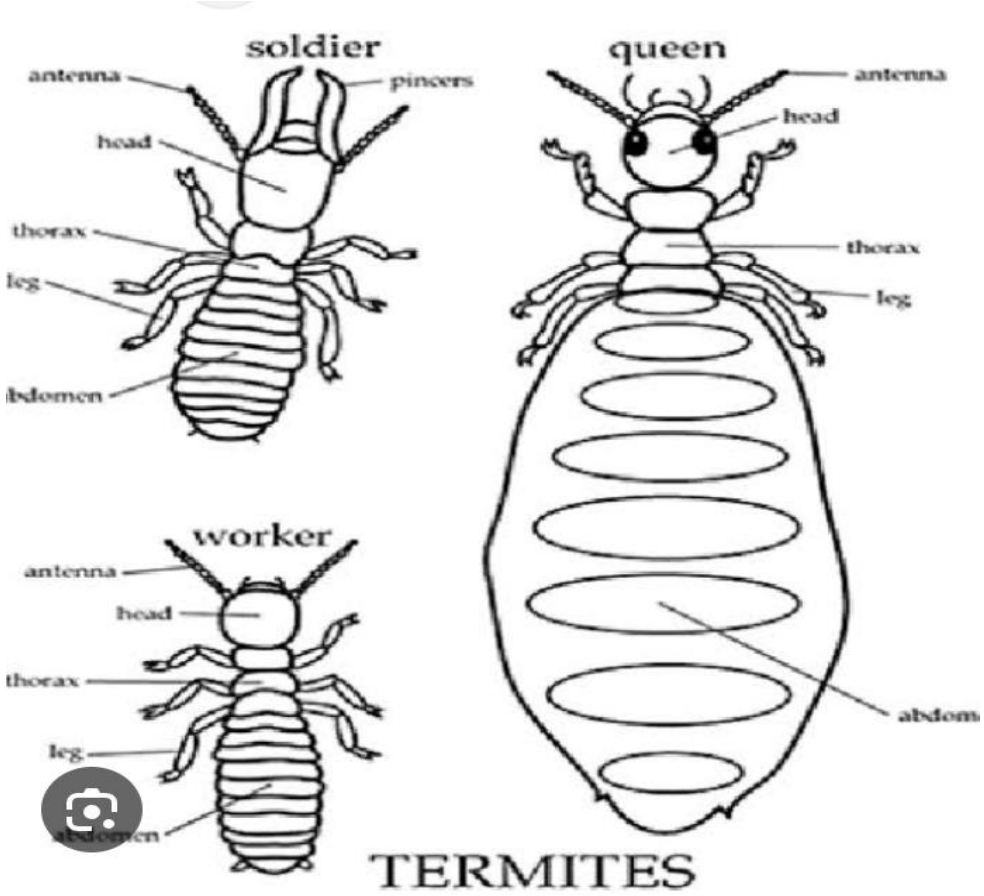
5.0 Termite

Order: Isoptera

Habitat: Ant hill.

Adaptations to the habitat

- Hairy antennae for increased sensitivity.
- Hard mandibles for cutting solid food and defense.
- Curved/sharp/pointed claws for movement on rough surfaces.
- Sticky arolium for moving on smooth surfaces.
- Segmented body for flexibility during movement.
- Body covered with exo-skeleton for protection against water loss/desiccation/mechanical damage.



Worked examples

01. Sarah had a healthy cow which gave her plenty of milk. Suddenly the cow started looking weak and milk production reduced. On inspecting her cow, she picked some organisms from the skin around the eyes and under. She also was another type of organism moving along the destroyed wooden poles of the cow shade.
You have been provided with organisms A (tick) and B (termite) which are organisms Sarah collected. **UCE 2024**

Task.

(a) i) With reasons identify any two taxa to which both specimens A and B belong.

Kingdom: *Animalia*

Reasons: *Both have;*

- ✓ *legs for locomotion*
- ✓ *Mouth for heterotrophic nutrition*
- ✓ *Antennae for sensitivity*

Phylum: *Arthropoda*

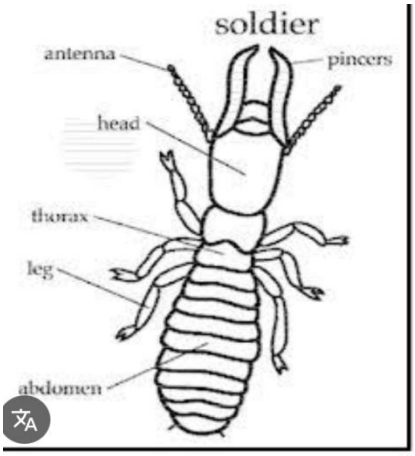
Reasons: *Both have;*

- ✓ *jointed legs*
- ✓ *Segmented body parts*
- ✓ *Exoskeleton*

ii) Explain how specimen A is able to survive on the cow.

- ✓ *Dull coloured body for better camouflage.*
- ✓ *Jointed legs for flexibility during locomotion.*
- ✓ *Large abdomen for storage of blood.*
- ✓ *Sharp mouth part for piercing into the host body.*
- ✓ *Curved claws for clinging onto the animal.*
- ✓ *Dorso-ventrally flattened body to hide under the fur.*
- ✓ *Hard exoskeleton for protection.*

(b) Draw specimen B and label its main body parts



Student activity

1. Rasto is a farmer who grows cassava plants on a large piece of land mostly for commercial use. During the rainy season he planted cassava and they sprouted very well but, currently they are being destroyed by some organisms. He collected the specimen P

(termite) and Q (caterpillar), R (grass hopper) and S (housefly) which were in abundance in his garden. He also plans to buy chemicals and spray the whole garden to eliminate the organisms.

Carry out scientific investigation on the specimens provided and answer the question that follows:

(a) i) Using the observable features and with reason(s) classify specimen P and S to any two simple taxa.

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(b) Using observable features, identify the specimen(s) which is destroying the leaves and the one which is beneficial.

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(c) Explain how the specimens were able to colonize and survive successfully on the farm.

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(d) Explain the effects of Mr. Rasto using the method he chose to the environment.

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(e) Draw the hind leg of specimen R and labelled it.

2. Mr Kigenyi is an experienced wood work teacher. In preparation to his retirement, he has ventured into growing crops. He normally sprays the garden with strong chemicals that kill both the adult insects and larvae. Harvest of his crop for the last two years was very poor. His dreams are not being realized. Mr Kigenyi collected organisms from his garden.

Agricultural officer asked him to stop using chemicals and use other means to control pests.

You have been provided with specimens' W (termite), X (butterfly) and Y (cockroach) Z (bee) from Mr Kigenyi garden. Carry out scientific investigation on the specimens provided and answer the question that follows:

Task.

(a) i) Using observable features, help Mr Kigenyi describe the specimens W, X and Y to the agricultural officer.

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ii) Use dichotomous key to identify the specimens W, X, Y and Z for the agricultural officer

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iii) How do the specimens contribute to the low yields of the crops?

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(b) Observe the specimens carefully using hand lens, draw the hind leg of identified specimen that aids crop production. Label its body structures involved in the process.

3. Mr John lives in the suburb of Bweyale town. The family is located near a garbage disposal area. His family members frequently fall sick. Recently, his daughter was vomiting and passing out watery stools. She was taken to the hospital where she was treated. The doctor then advised the family to observe hygiene at home. You are provided with specimens K(housefly), L(mosquito) and M(cockroach)

Carry out scientific investigation on the specimens provided and answer the question that follows:

Task

(a) i) make a dichotomous key of observable features of the head only to identify specimen K, L and M

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(b) How is the existence of the organisms in the ecosystem important?

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(c) Use the specimens provided to explain to the family doctor's advice.

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(d) Draw the specimen causing challenge to the family. Label the body parts that are involved in spreading diseases.

Examination Questions

01. In a rural village, farmers storing grains in different granaries noticed significant differences in spoilage. While most farmers lost large quantities of maize and beans to pests, one farmer reported minimal losses despite having visible insects. A science teacher collected two specimens from the granaries to explain the variation, specimen A and specimen B. The teacher suspected that structural differences between these insects affected their ability to damage grains.

Task:
(a) (i) Identify the phylum of each specimen.
Phylum:

Phylum		
A		
B		

(ii) Explain how the mandibles, legs, or body size of specimen A or B influence grain damage.

(c) Using observable features, draw a table showing head, mouthpart, and leg structure of each specimen and relate it to its role in the storage environment.

(c) Draw a labeled dorsal view of specimen B

02. Jane and Shakira are farmers whose gardens are located 100 meters apart. Immediately after weeding her overgrown bushy banana plantation, Jane went to help Shakira plant maize in her garden. At harvest time, Shakira observed other mature plants in her garden some of which she had seen in Jane's banana plantation, Shakira wondered how the other plants reached her garden.

Specimens W, X and Y are plant parts collected from the mature plants in Shakira's garden.

Task:

(a) (i) Using observable features, identify specimens W, X and Y
(ii) State the specimen(s) most likely to have been brought to sharia's maize garden unintentionally give reason(s) for your answer(s).
(b) Draw and label specimen X

03. During a science trip at your school, you manage to trap some specimens by yourself. Due to the limited time in the field, you don't manage to identify the specimens but you label them A, B, C, and D. classify the specimens using biological principles and prepare a report to present in the next biology class as required by the teacher. The teacher requires you to classify the specimens in their kingdom, phylum, and class. Include the reasons for putting the specimens in each taxon. The teacher also demands that you note some characteristics on the specimens and prepare an identification key for easy identification of the specimens during the lesson.

04. Mr. Okello grows maize from which he gets school fees for his children after selling them. Last season, he made losses after certain organisms destroyed all the maize by cutting the stems. As he was still figuring out what he could do to the children at home, he discovered that the children were suffering from cholera and other group of organisms that possessed wings destroyed their books in the cupboards. He became so furious and frustrated that he angrily collected all the organisms from his garden and house to burn them. Some of the organisms collected included specimens X, Y and Z.

Task:

a) Identify with reasons the group of animals to which specimens X, Y and Z belong.

Identity……

Reasons.……

b) Suggest which organism could have led to the spread of cholera and describe how it was able to spread the disease.

c) Examine the specimen that could have destroyed the maize. Draw the head and one segment of the thorax and clearly label the parts responsible for the destruction of the maize.

(Specimen X – soldier Termite Specimen Y – house fly Specimen Z – cockroach)

05. In a produce storage village, farmers complained that large quantities of their grains were being destroyed by small insects that lived inside the stores, however, one farmer reported that although insects were present in his store, the level of damage was much lower than I the other stores.

To investigate the situation, a science teacher collected three specimens A, B and C commonly found in the grain stores. The specimens were brought to the laboratory to help students understand why damage to the grains differed among farmers.

(A-soldier termite, B-worker termite and C-housefly)

Task:

(a) (i) with reason(s) identify the phylum to which specimens A, B and C belong;

Phylum

Reason(s)

(ii) Using observable features, explain the structure of specimens that contribute to the damage of the stored grains.

(b) State how the leg of specimen Cc is adapted to its functions and mode of life

06. In a food-processing factory, workers noticed that a large amount of packed food was getting spoiled before its expiry date. The management invited a health inspector, who advised them to improve hygiene and waste-handling practices. Unlike other workers, Sarah followed the advice by keeping food waste properly covered and cleaning the working surfaces regularly. Over time, the rate of food spoilage in her section reduced. Meanwhile, workers in the neighboring section continued leaving food remains uncovered. Their food products became increasingly contaminated. To explain this situation, specimens' J and K were collected from the contaminated food section. The specimens were used to demonstrate how structures found on living organisms can lead to food contamination.

Task:

(a) (i) with reason(s), identify the smallest taxonomic group to which both specimen J and K belong.

Taxonomic group: ___

Reason(s): ___

(ii) Describe how the structures on one of the specimens enabled it to cause food contamination in the factory.

(b) A drawing showing Tibia, tarsus and claws of specimen J

(J-cockroach K-termite)

BONES

01. VERTEBRAL COLUMN

Vertebral column forms the central support structure for the body. It consists of 33 individual vertebrae, separated by discs of cartilage. The discs allow movements like bending forward,

backwards and sideways and act as shock absorbers. The vertebrae are named according to the region of the vertebra where it is found.
In humans, the vertebrae include:

- **Cervical vertebra.**
- **Thoracic vertebra.**
- **Lumbar vertebra.**
- **Sacral vertebra.**
- **Caudal vertebra.**

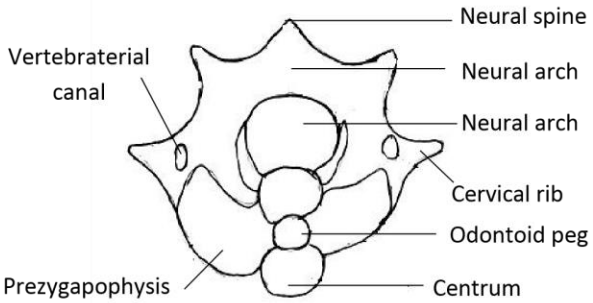
1. Thoracic vertebra

These are found in the thoracic region. There are 12 thoracic vertebrae in the humans and rabbits.

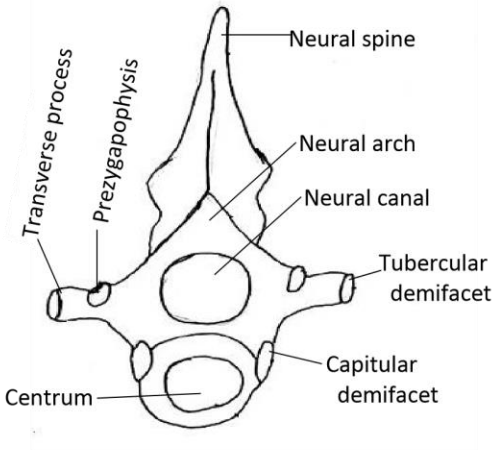
Characteristics of thoracic vertebra

i) Has a long neural spine.
ii) Has a large centrum.
iii) Possess a large neural canal
iv) Has a large neural arch.
v) Has tubercular facet on transverse process.
vi) Has short transverse processes.
vii) Has a pair of articular facets.

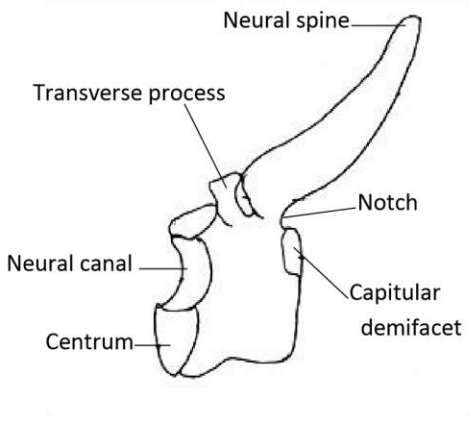
Drawing of anterior view of axis vertebra



Drawing of anterior view of thoracic vertebra:



Drawing of lateral view of thoracic vertebra:



2. Lumbar vertebra

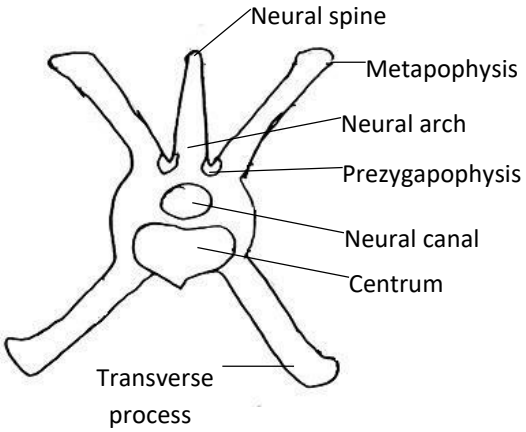
These are found in the abdominal region. There are 5 lumbar vertebrae in man and seven in rabbit. They provide the only support for the trunk in the abdominal region.

Characteristics of lumbar vertebra

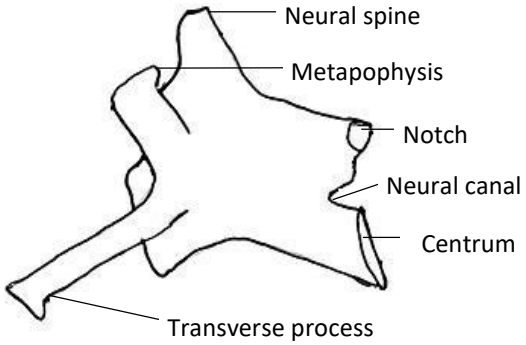
- ✓ Has long transverse process
- ✓ Has extra processes called metapophysis.

- ✓ Has a large centrum than cervical and thoracic vertebra.
- ✓ Has a broad neural spine.
- ✓ Has a small neural canal.

D rawing of anterior view of lumbar r vertebra :



Drawing of lateral view of lumber vertebra:



Differences between thoracic and lumbar vertebrae.

Thoracic vertebra	**Lumbar vertebra**
Has long neural spine	Has short neural canal
Has small centrum	Has large centrum
Has short transverse process	Has long transverse process
Has fewer projections	Has many projections
Has a wide neural spine	Has narrow neural spines
Has no anapophysis	Has anapophysis
Has demifacets	Has no demifacets
Has a narrow neural arch	Has wider neural arch

Similarities between thoracic and lumbar vertebrae.

- Both have neural canal.
- Both have neural spine.
- Both have transverse process.
- Both have arches, facets and centrum.

3. Cervical vertebrae

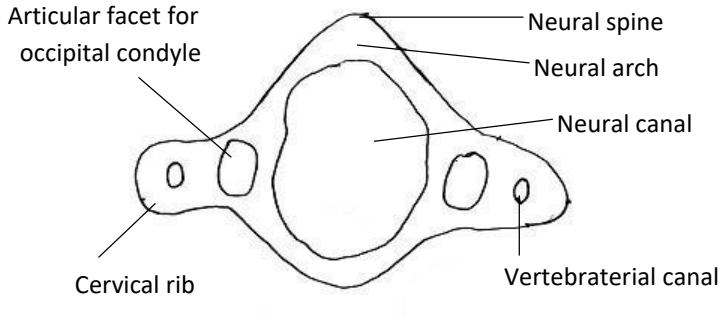
This is found in the neck region. There seven cervical vertebrae in man.

The first two cervical vertebrae, called atlas and axis respectively differ from the rest. They are respectively shaped to allow the skull move freely on the vertebral column.

(a) Atlas

This is the first cervical vertebra

Drawing of anterior view of atlas vertebra



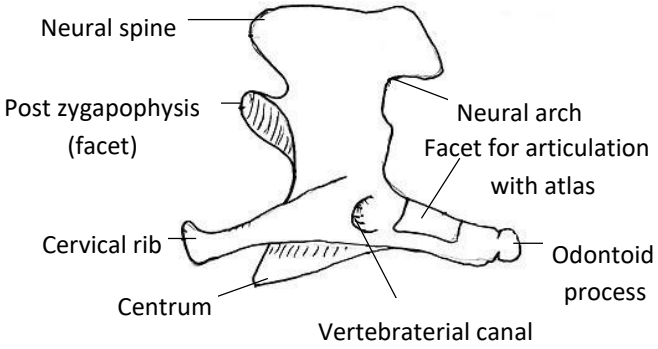
Characteristics of atlas

(i) Has very large neural canal.
(ii) It has no centrum.
(iii) Has flat broad transverse process for muscle.
(iv) Has two large facets.
(v) Has a small ridged neural spine.

(b) Axis vertebra

This is the second vertebra.

Drawing of lateral view of axis vertebra :



Characteristics of axis

(i) Has a relatively smaller neural canal than atlas.
(ii) Has a large flat centrum.
(iii) Has smaller transverse process.
(iv) It has two facets.

Differences between the atlas and axis vertebrae.

Similarities between the atlas and axis vertebrae

✓ Both have transverse processes.

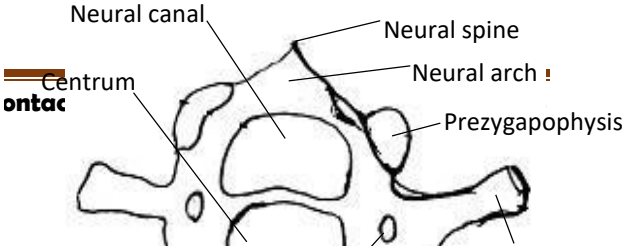
Atlas	Axis
Has no centrum	Has centrum
Has no neural spine	Has neural spine.
Has odontoid fossa	Has odontoid peg.
Has prominent process	Has no prominent process.

✓ Both have Vertebraterial canals.

(c) Cervical vertebra

Characteristics of cervical vertebra

Drawing of anterior view of cervical vertebra



✓ It has a small neural spine.
✓ Has a large neural canal.
✓ Has a small centrum.
✓ Has transverse process that form two parts called cervical ribs.

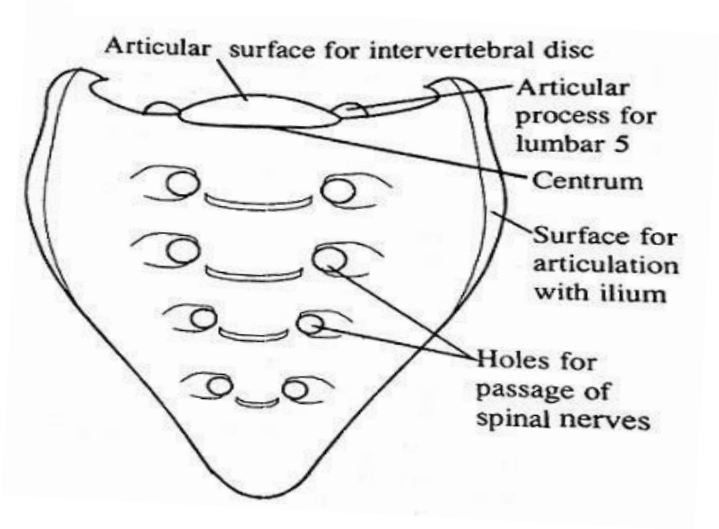
4. Sacral vertebra

These are located in the lower abdomen. They are five in man and four in rabbit. In adult mammals they are fused together to form a rigid body structure called sacrum.

Characteristics of sacral vertebra

- ✓ Each vertebra has a large centrum.
- ✓ Has a narrow neural canal.
- ✓ Has a reduced neural spine.
- ✓ First sacral canal has large and wing like transverse processes.

Anterior view of sacral vertebra:



5. Caudal vertebra

These are found in the lower abdomen. There are four vertebrae in man which are fused together to form coccyx which is functionless. In rabbits, there are sixteen.

Characteristics of caudal vertebra

- ✓ Have no neural arch.
- ✓ Have no transverse processes.

- ✓ Have no neural canal and spine
- ✓ Entire bone consists of centrum only.

Part	Function
Neural spine	For attachment of muscles
Transverse process	For attachment of muscles and articulation with ribs.
Centrum	For articulation with other vertebrae
Neural canal	For protecting spinal cord
Neural arch	For passage and protection of spinal cord
Vertebraterial canal	For passage of blood vessels of the neck
Facets	For articulation with other vertebrae and ribs in the thoracic vertebrae.

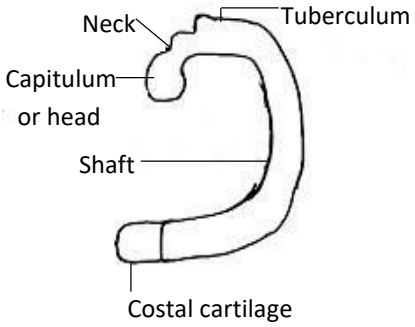
02. RIB

It is long curved bone which forms part of the rib cage.

Characteristics of a rib

(i) It has costal cartilage.
(ii) It has a neck
(iii) It has a head
(iv) It has shaft which is thin and flat
(v) It has tuberculum.

Drawing of the rib



03. APPENDICULAR SKELETON

This consists of four limbs attached to two bony girdles namely pectoral (shoulder girdle) and pelvic girdle.

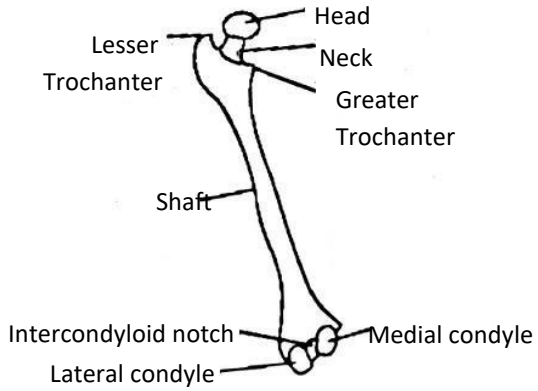
1. Femur

It has a distinct head, which fits into the acetabulum of pelvic girdle to form a hip joint.

It has a trochanter near the head for which provide surface area for muscle attachment.

It has two knobs at the distal end.

Drawing of Left Femur (posterior view):

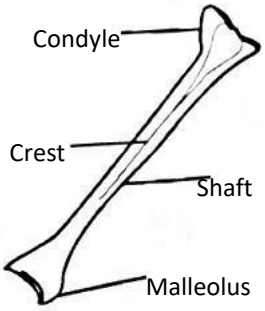


2. Tibia

This is the inner and larger bone in the lower leg, extending from the knee to the ankle.

It has two grooves into which condyles of *the femur fits.*

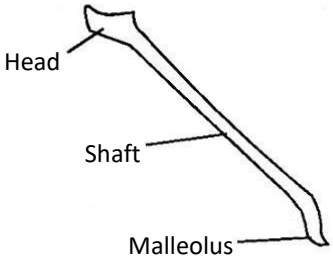
Drawing of left Tibia:



3. Fibula

This is the outer and narrower bones in the human
Lower leg between the knees and ankle.
It has unfused proximal end.

Drawing of left Fibula:



4. Humerus

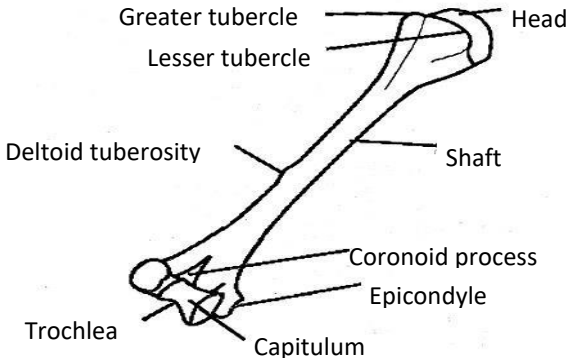
The upper (proximal) part of humerus ends in a distinct head which fits in glenoid cavity of scapula.

5. Ulna

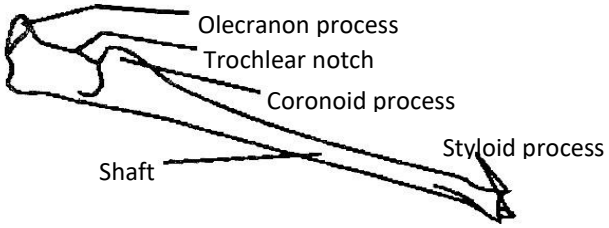
6. Radius

Drawing of Radius:

Drawing of Humerus :



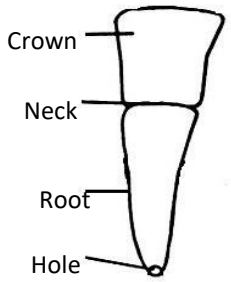
Drawing of Ulna:



TEETH

There are majorly four type of teeth i.e. incisors, canines, premolars and molars.

Drawing of Incisor:



1. Incisor

These are front teeth in both upper and lower jaws of humans.

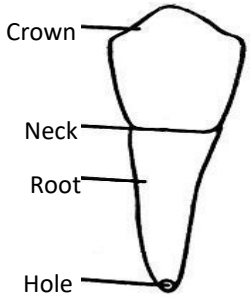
Characteristics of incisor

(i) It has a crown which is chisel-like in shape with sharp ridged edges.
(ii) It has one root.

Use

- It is used for cutting and biting foo into smaller pieces. It some mammals like cats they are also used for holding prey.

Drawing of Canine:



2. Canine

These are found next to the incisors. They are usually larger than incisors in size.

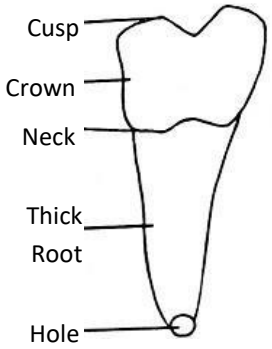
Characteristics of canine

(i) Has a conical and sharp pointed crown.
(ii) It has one root.

Use

- It is used for tearing food especially fresh.

Drawing of Premolar:



2. Premolar.

It is found behind canine.

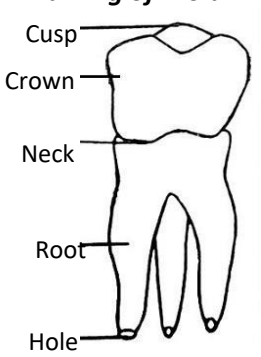
Characteristics of premolar

(i) It has a flat crown with a broad surface for grinding of food.
(ii) It has two cusps which enhance grinding of food.

Use

- It is used for grinding and chewing food.

Drawing of Molar:



4. Molar

It is found in the back of the mouth behind the premolar.

Characteristics of molar

(i) It has a wide crown top to provide large surface area for grinding and crushing of food.
(ii) It has four cusps to allow grinding and crushing of food.
(iii) It has two or three roots for fixing the tooth firmly in jaw to allow grinding of food.

Use

- It is used for grinding and crushing of food.

Examination items

01. In a village, children often complained of difficulty in chewing certain foods. A local dentist observed that some children were having trouble grinding hard foods like cassava and maize, while others had difficulty biting softer foods such as fruits.
To investigate, the dentist collected two different teeth from children during routine check-ups. You are provided with specimen Q and R. The dentist used these specimens to demonstrate how different teeth are adapted to perform specific functions in the human mouth.
You are provided with specimen Q and R.

(a) (i) Observable features enabling the teeth to perform their functions
(iii) Effect on digestion if the teeth are damaged or missing

(b) A drawing showing upper surface of the crown of specimen Q.

(Q-molar tooth R-incisor)

Sample Trail Items

01) A small food-processing company produces a natural onion extract that is sold as a health supplement. The company claims that the extract provides important nutrients such as reducing sugars and vitamin C, which can help to improve body energy and immunity. However, nutrition inspectors have raised concerns that some batches of the extract may lose important nutrients during processing and heating. The company wants to confirm which key food substances are present in the extract and whether heating affects vitamin

C content.

You have been invited as a laboratory technician to help the company test the nutritional quality of the onion extract labelled B1.

Task:

Design and carry out a scientific investigation to determine the food substances present in Extract B1 and provide an appropriate recommendation to the company based on your findings.

Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

02) A biotechnology company is researching ways to reduce the build-up of hydrogen peroxide (H_2O_2) in plant waste during processing. Hydrogen peroxide is harmful to cells, so the company wants to identify plant tissues that contain an active substance that can break down H_2O_2 efficiently. The company has obtained a plant tissue sample labelled P. The researchers suspect that the tissue contains an enzyme that decomposes H_2O_2 into harmless substances. They want to investigate how different treatments of the tissue affect the activity of the enzyme.

Task:

Design and carry out a scientific investigation to determine the effect of different treatments on

the enzyme activity in P by observing its ability to break down hydrogen peroxide.

Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

03) A community in Mbale is planning to grow crops during the dry season, but water is scarce. The community agricultural officer wants to know which local soils can retain water for longer periods to reduce irrigation needs. She collects three soil samples from different parts of the community, labelled X, Y, and Z, and brings them to the school laboratory.

The officer expects the investigation to show which soil is most suitable for planting crops during dry periods.

Task:

Design and carry out a scientific investigation to compare the water retention capacities

of the soil samples and recommend the best soil for planting crops in dry conditions. Your investigation should include the; aim, hypothesis, variables, materials, procedure, results, analysis and conclusion.

04) In a produce-storage village, farmers complained that large quantities of their stored grains were being destroyed by small insects that lived inside the stores. However, one farmer reported that although insects were present in his store, the level of damage was much lower than in the other stores.

To investigate the situation, a Science teacher collected three specimens, A, B and C commonly found in the grain stores: The specimens were brought to the laboratory to help students understand why damage to the grains differed among farmers.

Task:

(a) (i) With reason(s), identify the phylum to which specimens A, B and C belong.

Phylum:

Reason(s):

(ii) Using observable features, explain how the structures of specimen A or B or C may contribute to damage of stored grains in the farmers' stores.

(b) Using observable features, describe the mouth part, head and leg of each specimen A, B and C in a suitable table, and relate each structure to its role in the storage environment.

(c) (i) State how the legs of specimen C are adapted to its mode of life around food stores and animal shelters, and explain how this adaptation may influence spread of contamination.

(ii) In the space provided, make a labelled drawing of the dorsal view of the specimen responsible for damage of stored grains in the farmers' stores.

05) In a food-processing factory, workers noticed that a large amount of packed food was getting spoiled before its expiry date. The management invited a health inspector, who advised them to improve hygiene and waste-handling practices.

Unlike other workers, Sarah followed the advice by keeping food waste properly covered and cleaning the working surfaces regularly. Over time, the rate of food spoilage in her section reduced. Meanwhile, workers in the neighboring section continued leaving food remains uncovered. Their food products became increasingly contaminated.

To explain this situation, specimen J and K were collected from the contaminated food section. The specimens were used to demonstrate how structures found on living organisms can lead to food contamination.

Task:

(a) (i) With reason(s), identify the smallest taxonomic group to which both specimen J and K belong.

Taxonomic group: ___

Reason(s): ___

(ii) Describe how the structures on one of the specimens enabled it to cause food Contamination in the factory.

06) In a school botanical garden, the Head teacher observed that certain plants were producing more fruits and seeds than others, while some plants were wilting faster and losing water more quickly.

The teacher wanted the students to investigate how the structure of different plant parts affects pollination, growth, and water conservation, which ultimately influences plant productivity. To help the students, the teacher collected different leaves and flowers the garden:

The teacher explained that leaves may have adaptations that help them retain water, while flowers may have features that help them attract pollinators or facilitate self- or cross-pollination. By studying the specimens, students could identify how these structures contribute to the survival, reproduction, and yield of plants in the garden.

You are provided with specimens G, H, F, N, and M. Using a hand lens and other laboratory equipment, investigate the differences in structure, possible pollination agents, and water conservation features in these plant specimens.

Task:

(a) State differences between specimen M and specimen N.

(b) (i) Give the possible agent of pollination for specimen M and specimen N, and give a reason for your answer.

(ii) Explain how the specimens encourage self- or cross-pollination

(c) Observable characteristics of leaves (G, H, F)

(d) (i) How specimen F minimizes transpiration

(d) (ii) Dichotomous key to identify G, H, F