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A-level biology practical guide by digitalteachers.co.ug

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Introduction

The **UNEB A-Level Biology Practical Guidelines** are designed to assess students' ability to apply biological concepts through hands-on experimentation, observation, and analysis. These guidelines align with Uganda's **Competency-Based Curriculum (CBC)** and emphasize scientific inquiry, accuracy, and critical thinking.

Aims of teaching biology practical

- (i) Trains students in using laboratory equipment such as those measuring volume, mass and time. This helps a student to get necessary skills for shop keeping; timing games, exams and lesson; industrial operations that require measurements and timing.
- (ii) Learning biological terminologies such as transverse/cross-section and longitudinal sections, posterior view, anterior view, magnification, etc.
- (iii) Trains students how to follow scientific procedures; Note that changing the procedure like skipping or shortening time for waiting may lead to different results. Just like cooking food, taking a short tie may prevent food getting ready or taking too long cooking may over do the cooking.
- (iv) Trains students in laboratory techniques like microscopy, staining, and specimen handling. Builds precision, observation, and analytical skills.
- (v) Trains manipulation skills such as cutting, tying, peeling, measurements, washing equipment necessary in real life in cookery, home economics, industrial manufacturing etc.
- (vi) Train patience since most biology practical like those of physiology require time before results are evident.
- (vii) Develops precision, accuracy, and safety awareness in experimental work. Many activities in real life contain source of danger such as fire during cooking which a student should learn to safeguard against.
- (viii) Learning and making correct observation. Note that biological experiment observations differ from evolution of gases, color changes, tissues becoming turgid or flaccid and so on.
- (ix) Making inference from the observations.
- (x) Manipulating, and making appropriate experimental reports such as drawing biological diagrams and graphs, statistical calculations.

Note that examiners mark written responses and not experimental procedures so be very careful when presenting your work.

Key areas assessed in Practical Biology or what do examiner mark

- a. ability to Correctly follow written instructions to carry out experimental techniques or procedures in the stipulated time limits
- b. ability to correctly use appropriate instrumentation, apparatus and materials. This is observed from coherent recording.
- c. ability make correct and relevant observations
- d. ability to identify anomalies in experiments and observations or ability to identify and correct anomalous record
- e. ability to record results correctly in tables, graphs and other formats

- f. ability to interpret your observations and make correct conclusion
- g. ability to draw biological specimens with correct labeling with correct spellings **Examiners do not mark wrong spellings.**
- h. ability to use of correct biology terminologies and their correct spelling.
- i. Neatness and orderliness
- j. Making correct statistical manipulation of data such as rates, percentages, averages, addition, subtractions, multiplication, divisions, surface area, volume, surface area volume ratio and so on

Note that

- Before you begin an experiment, confirm that specimens carry proper label otherwise mix ups lead to loss of marks
- Pay attention verbal instruction during the practical exams since changes may affect your results and scores.
- Examinations are more likely to ask for description or comparison of observable features **NOT** functions. Do not waste your time describing functions unless asked for.
- Your report should be based on observations, biological knowledge behind the experimental procedure and logical thinking. For instance do not draw a housefly with five legs because yours had lost one during the collection time; it will be hard to convince the examiner that your housefly had five legs or that houseflies in your area have five legs.
- Queer observations may occur due to contamination of the reagents and specimen should be ignored; or observations that do not lead to logical conclusion should not be reported.
- Practice to make correct biological drawings. Do not expect to learn drawings in examination.
- **Use legible handwriting. Students lose up to 20% marks due to poor handwritings. Good hand writing is achieved from copying and practice. It is your duty to make your work understandable.**

Measurement

Make accurate records of measurements according to the instrument used; for instance, readings from a ruler are made to 1 d.p i.e. 1.0 cm NOT 1cm

How to make biology drawings

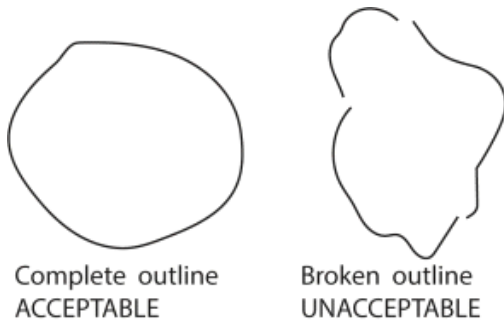
The purpose of drawing in biology exams is to test observational skills. A student must look very closely at a specimen in order to draw it accurately and must have sound knowledge of

the component structures in order to choose what to draw and what to omit from the drawing.

It possible to get all the marks of a drawing when you know what is necessary

Qualities of a good biological diagram

- Title** communicates what the drawing represents, for instance, A drawing of the longitudinal section specimen X. Specimens should be identified by their experiment labels and not their names. i.e. A drawing of a cross-section of specimen Y NOT A drawing of a cross section of a tomato.
- Neatness:** A drawing should be neat, where necessary use a clean white rubber. There should be no coloring nor shading. Untidy drawing usually with dirty rubbing marks makes your work ugly.
- Draw in pencil:** draw with a sharp HB pencil note that the darkness of the pencil increase with how many H it carry, for instance HHB draw darker lines than HB pencil.
Do not pick any pencil for a biology practical.
- Complete outline:** Biological drawing should have complete outline.



- Magnification:** It is the number of times a drawing is as bigger as the specimen. i.e.
$$\text{Magnification} = \frac{\text{length of the drawing}}{\text{length of the specimen}}$$

A proximate the magnification to the nearest quarter, half or whole number i.e. $\times \frac{1}{4}$; $\times \frac{1}{2}$, $\times 1$, $\times 2$, $\times 100$, etc.

- Proportionality:** Parts of the drawing should be drawn to relative sizes on the specimen.



Eyes **too small**



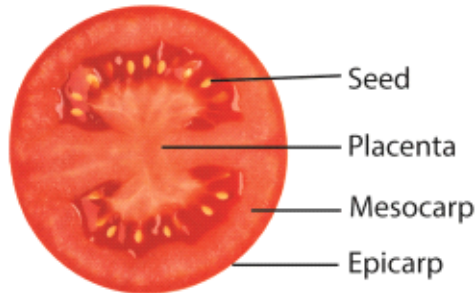
Eyes **proportional**



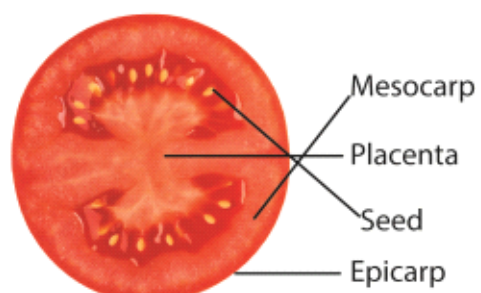
Eyes **too big**

g. Label with horizontal straight lines:

- Labeling lines should not cross one another.
- Make sure that the labeling line touches the structure being labeled
- Write actual labels horizontally
- Write the labels outside the drawing



Straight horizontal labeling line
ACCEPTABLE



Crossed labeling line
UNACCEPTABLE

The table below shows errors that commonly occur when students begin to practice drawings of biological material. Each would reduce the value of the drawing and result in loss of mark being awarded. Most result from lack of attention or care and are easily solved.

Comment	Incorrect	Correct
Cell outline		
Tissue with too much detail		
Crossing lines		
Hanging lines		
Over casual		
Sketch rather than draw		

Good diagrams can be achieved by continuous practice

Microscopic Biology Practicals

How UNEB assess microscopic work

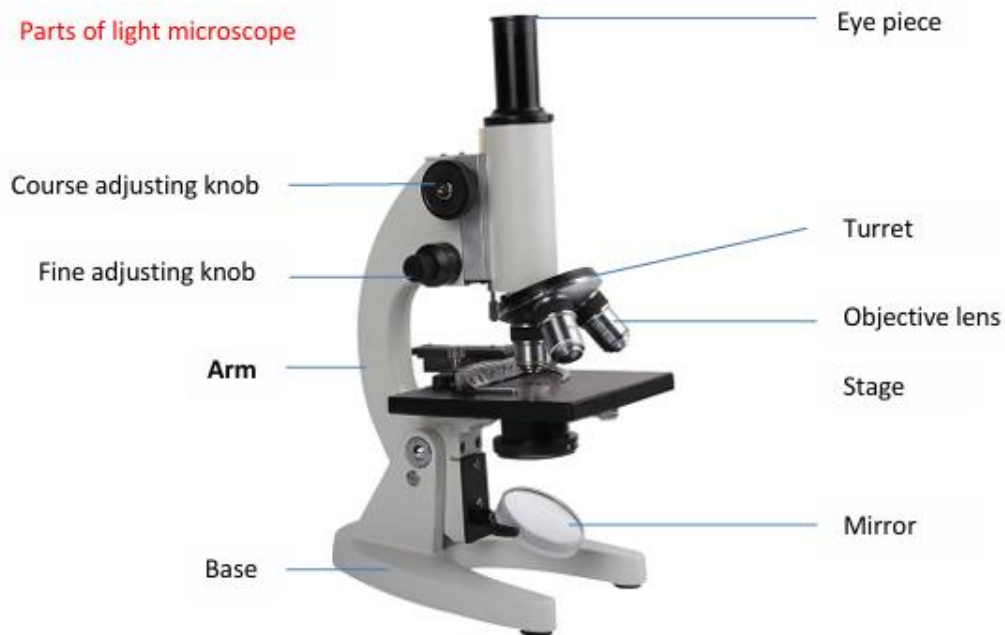
Microscopic examinations assesses the ability to

- follow prescribe instructions
- properly use of microscope; i.e., adjust coarse and fine focus knobs to get a clear image; select among objective lenses to manage magnification levels.
- handle delicate specimen
- use staining or lighting adjustments to enhance visibility.
- prepare slides for specimen: wet mounts, stained slides, or fixed samples without contamination or damaging the specimen.
- identify and distinguish the parts of the specimen observed.
- relate parts identified to their functions on the specimen

- h. **record your observations** clearly and precisely, often with labelled diagrams. **Make sure that you are familiar with parts of the specimens in the syllabus prior to the examination.**
- i. **apply correct biological terms** when describing findings.

How to use a Microscope in biology practical

A microscope is a machine or equipment that magnifies specimens and enables us to view parts of the specimen that cannot be seen by naked eye. There are different types of a microscope but most school laboratories use a light microscope.



Functions of parts of a microscope

Eye piece: magnifies the image of the specimen

Course adjusting knob: focuses the image of the specimen

Fine adjusting knob: fine tune the focus of the specimen

Turret: rotates and changes the objective lenses

Objective lenses: magnify specimens

Stage: is where the specimen is placed

Mirror: reflects light through the specimen

Base: supports the microscope.

Terminologies of microscope

Resolution is the ability of a microscope to see the fine details of a specimen. It is defined as the **minimum distance between two distinct points** that can still be seen as separate. If two points are closer than this limit, they'll appear as one blurry spot.

Focusing of a microscope is the ability to adjust the lenses and stage to get a sharp, clear image of the specimen you're observing.

Note that most Microscope models on Uganda market do not focus properly. Therefore, good microscopes should be purchased by a technical person who tests the microscope before otherwise the school may end with counterfeit/bicupuli useless microscopes that will make teaching theoretical.

Steps for Proper Focusing of a Microscope

- (i) **Prepare the specimen on the slide. Stain where necessary.**
- (ii) **Place and Center the Slide:** Secure your slide on the stage using stage clips. Use the stage controls to center the specimen under the lens.
- (iii) **Start with Low Magnification:** Rotate the nosepiece to the lowest objective lens (usually 4x or 10x). This gives a wider field of view and makes it easier to locate your specimen.
- (iv) **Use the Coarse Adjustment Knob:** Slowly turn the Coarse Adjusting knob to move the stage up or down. This brings the specimen roughly into focus. **Only use this knob with low-power objectives.**
- (v) **Switch to Fine Adjustment:** Once the image is nearly clear, use the fine adjustment knob to sharpen it. This is especially important at higher magnifications (40x, 100x).
- (vi) **Increase Magnification (Optional):** If needed, rotate to a higher-power objective. You may need to slightly adjust the fine focus again to maintain clarity.
- (vii) **Adjust Lighting and Diaphragm:** Modify the light intensity and diaphragm to improve contrast and resolution. Proper lighting helps reveal fine details.

Magnification using a microscope

Magnification is the number of times an image is bigger than the specimen.

How to Calculate Total Magnification of a microscope

- (i) **Eyepiece (ocular lens):** Usually has a magnification of **10x**
- (ii) **Objective lens:** Comes in various powers like **4x, 10x, 40x, or 100x**

To find the **total magnification of the specimen**, simply multiply the eyepiece magnification by the objective lens magnification:

Total Magnification of specimen = Eyepiece × Objective

Examples:

- 10x eyepiece × 4x objective = **40x total magnification**
- 10x eyepiece × 40x objective = **400x total magnification**
- 10x eyepiece × 100x objective = **1000x total magnification**

Determining the magnification of a drawing using a microscope

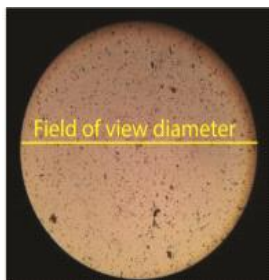
Method I

Compare the size of the drawing to that of the size of specimen as seen through the microscope and then multiply it with the total magnification of the objective and the eye piece.

For example if the drawing is twice the specimen as seen through the microscope is 2 using x10 objective and x 10 eye piece; then the magnification = $2 \times 10 \times 10 = \times 200$.

Method II

- (i) Field diameter is diameter of the circle observed when looking through a microscope.



The field diameters using different objectives are given below

4x = 4.5mm

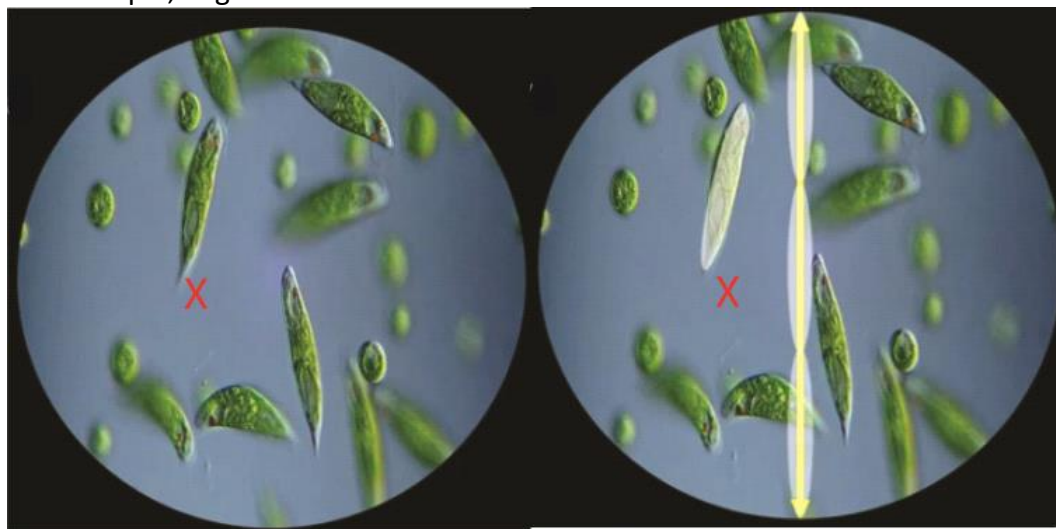
10x = 1.8mm

40x = 0.45mm

100x = 0.18mm

- (ii) Using the field of view, estimate the size of the specimen

For example, Euglena X



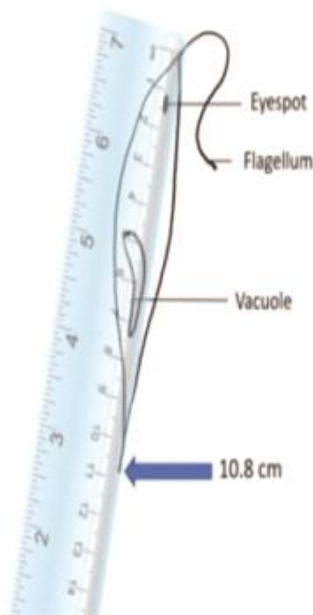
Pond water wet mount
Euglena sp. As seen under
40x objective

Estimating the size of X
that can fit in the diameter
of field of view = 3
Length of X = $\frac{1}{3} \times 0.45$
= 0.15mm

Note that the title of the drawing should inform us the name of the organism, how the specimen was prepared and under what magnification it was observed:

A drawing of pond water wet mount *Euglena* sp. as seen under 40x objective
(Label only those structures you can identify)

Pond water wet mount of *Euglena* sp. as seen under the 40X objective.



$$\text{Magnification} = \frac{\text{Drawing size}}{\text{Actual Size}}$$

$$\text{Magnification} = \frac{10.8\text{cm}}{150\mu\text{m}}$$

$$\text{Magnification} = \frac{108,000\mu\text{m}}{150\mu\text{m}}$$

$$\text{Magnification} = 1,200 \times$$

Take every opportunity to practice drawing from micrographs or microscope slides and stating the magnification, get your teacher to mark them for you. Find out what you need to do to improve, and keep working at it until you feel really confident.

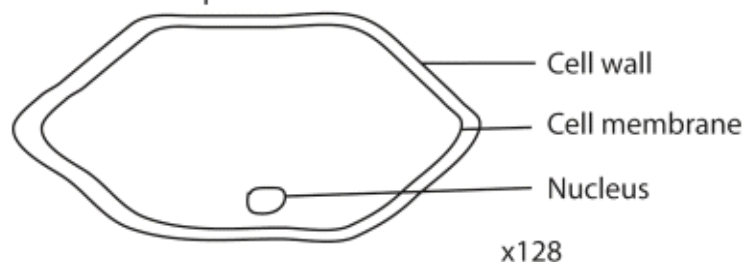
Activity 1

You are provided with specimen P (onion)

- (a) Cut it longitudinally and examine it. Describe its internal structure
Has flattened short stem at the base from which terminal bud, axillary buds fleshy leaves and scale leaves develop. The fleshy leaves are curved outside and taper at the apex.
- (b) Remove one of the leaves of specimen P. Strip off a piece of the inner layer and place it on a slide with a drop of water and cover with a cover slip. Examine under medium power of microscope.
 - (i) Describe the structure of a cell seen clearly
It is polygonal/hexagon/rectangular/four/six sided, elongated, thick cell wall, round/circular/spherical nucleus.
 - (ii) Count and record the number of cells in the field of view under medium power of microscope (2marks)
From left to right: 2 - 15
From top to bottom: 14 – 45

- (c)(i) Remove the slide from the stage, measure the field of view using a transparent ruler and record your results (01mark)
Field of view: 1mm – 2mm
- (ii) Convert the diameter of the field into micrometres (m). Show your working (02marks)
1mm = 1000m
Diameter of field of view = 2mm
= 2 x 1000
= 2000m
- (iii) Calculate the actual length of one cell in micrometres. Show your working (02marks)
Number cells observed in a field of view = 4
Actual length of the cell = $\frac{2000}{4} = 500\mu\text{m}$
- (d) Return the slide having the tissue on to the stage, draw one cell from the tissue being observed under medium power of a microscope

A drawing of a cell from the tissue of P under medium power of microscope



- (e) (i) Measure the length of your drawing in mm and record it
Length of the drawing = 64mm
- (ii) Calculate the magnification of your drawing
Length of drawing in micrometres = 64 x 1000 = 64000m
Magnification = $\frac{64000}{500} = 128$

Microscopic Plant tissues

Features of pollen grain

Procedure

A. Dry Mount Method

- (i) Place a small amount of dry pollen directly on the centre of a clean glass slide.
- (ii) Carefully place a cover slip over the sample without trapping air bubbles.
- (iii) Observe immediately under the microscope.

B. Wet Mount Method

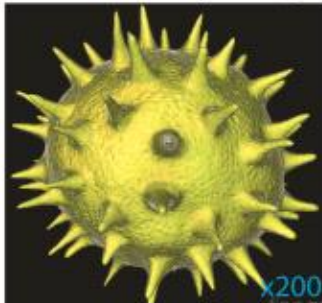
For better visualization:

- (i) Place a drop of distilled water or glycerine jelly on the slide.
- (ii) Add a small quantity of pollen grains into the drop using forceps or brush.

- (iii) Gently lower a cover slip onto the drop at an angle to avoid bubbles.

Observation

Hibiscus flower pollen grain under 10x objective



Hooks attach pollen grains on to the stigma

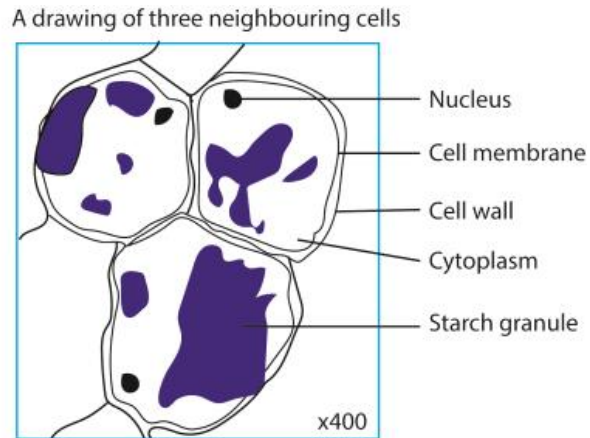
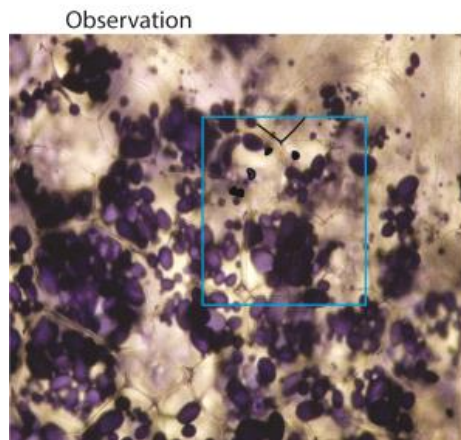
Activity 2

- Place a drop of distilled water or glycerine jelly on the slide.
- Add a small quantity of pollen grains from the anthers of hibiscus flower into the drop using forceps or brush.
- Gently lower a cover slip onto the drop at an angle to avoid bubbles.
- Observe to see the structure of the pollen grain using a medium power objective and draw.
- State the microscopic adaptive features of the pollen grains.

Features of parenchyma cells an Irish potato stained by iodine

Procedure

- Use a scalpel to cut a **very thin section** of the potato. **Thin slices** are crucial so light can pass through for clear vision.
- Transfer the thin slice onto the center of a clean glass slide using tweezers.
- Using a dropper, place 1–2 drops of iodine solution directly onto the specimen. Iodine stains starch and helps highlight cell structures like the nucleus and cytoplasm.
- Gently lower a cover slip over the specimen at an angle to avoid air bubbles. This protects the sample and flattens it for better viewing.
- Use blotting paper to absorb any excess iodine around the edges of the cover slip.
- Place the slide on the microscope stage and start with low magnification. Adjust focus and lighting as needed to view the stained parenchyma cells clearly.



Functions of Irish potato parenchymal cells:

- store starch – due to presence of starch granule
- provide support when turgid- closely packed, resistant to pressure.

Activity 3

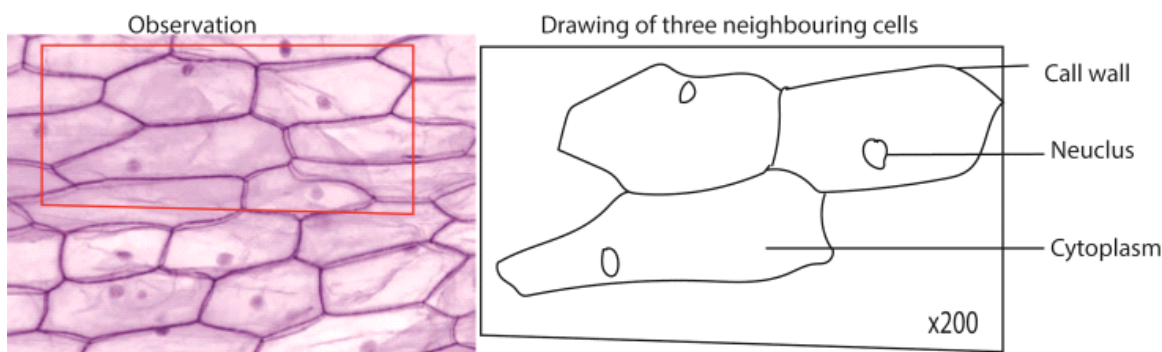
You are provided with specimen X that is an Iris potato

- (i) Draw and label external features of X
- (ii) Make a thin section of X and place on a clean glass slide provided, add a drop of iodine solution and place a cover slip on top.
- (iii) Use a filter paper to drain off excess solution
- (iv) Observe through a microscope using medium power objective.
- (v) Draw any three clear adjacent cells and state the magnification
- (vi) Identify the type of plant cells drawn in (e).
- (vii) Giving evidence, what are the function(s) of the cell identified in in (f).

Features of inner epidermal cells of an onion

Procedure

- (i) Carefully remove the epidermis – utilize forceps to delicately separate a thin, transparent layer of epidermis from the inner surface of the onion bulb.
- (ii) Position the thin onion epidermis flatly at the center of a pristine glass slide with precision.
- (iii) Enhance contrast by adding a stain—simply use a dropper to apply one or two drops of iodine solution onto the onion peel.
- (iv) Carefully position the cover slip by lowering it at an angle onto the stained onion peel, ensuring that air bubbles are avoided.
- (v) Eliminate any excess liquid by gently blotting the extra stain around the edges with a tissue or paper towel, ensuring the slide remains undisturbed.
- (vi) Position the slide on the microscope stage and secure it firmly using the stage clips.
- (vii) Begin with minimal power—concentrate on the lowest magnification (typically 4x or 10x) to identify the cells



Epidermal cells are used for protection because they are hard to tear apart.

Description of epidermal cells of an onion

They are polygonal with thick cell walls with spherical nuclei.

Activity 4

You are provided with specimen X that is an onion

- Make and draw a longitudinal section of X
- Get a peel from the internal part of the leaf of X and place on a clean glass slide provided, add a drop of iodine solution and place a cover slip on top.
- Use a filter paper to drain off excess solution
- Observe through a microscope using medium power objective.
- Draw any three clear adjacent cells and state the magnification
- With evidence, what are the function(s) of the epidermal cells of an onion

Features of plasmolysed epidermal cells of an onion

Procedure

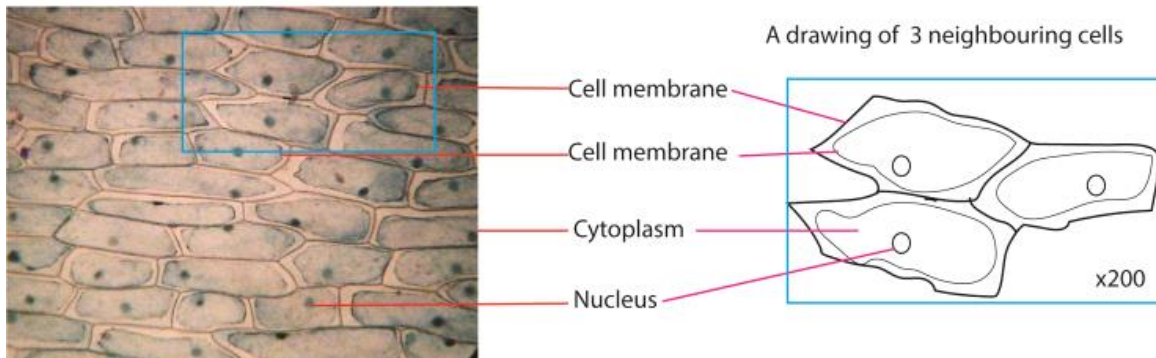
- Use forceps to gently peel a thin, transparent layer (epidermis) from the lower surface (concave side) of an onion scale (bulb).
- Place the epidermal peel flat on a clean microscope slide.
- Add a drop or two of 10% sodium chloride solution onto the peel. This solution will cause water to move out of cells by osmosis, leading to plasmolysis.
- (Optional) Add a drop of iodine solution for better contrast.
- Carefully place a cover slip over the peel to avoid air bubbles.
- Allow the slide to sit for about 5–7 minutes. During this time, plasmolysis will occur.
- Observe under the microscope: Start viewing under the low power objective (10x). Switch to high power (40x) for a clearer, more detailed view.
- Look for cells in which the contents (protoplast) have shrunk away from the cell wall, creating a gap. This is plasmolysis.

Tips

- Ensure the peel is free of folds and is as thin as possible for clearer observation.
- The plasmolysed cells will show the cell membrane pulled away from the cell wall due to water loss, while turgid cells will not have this gap.

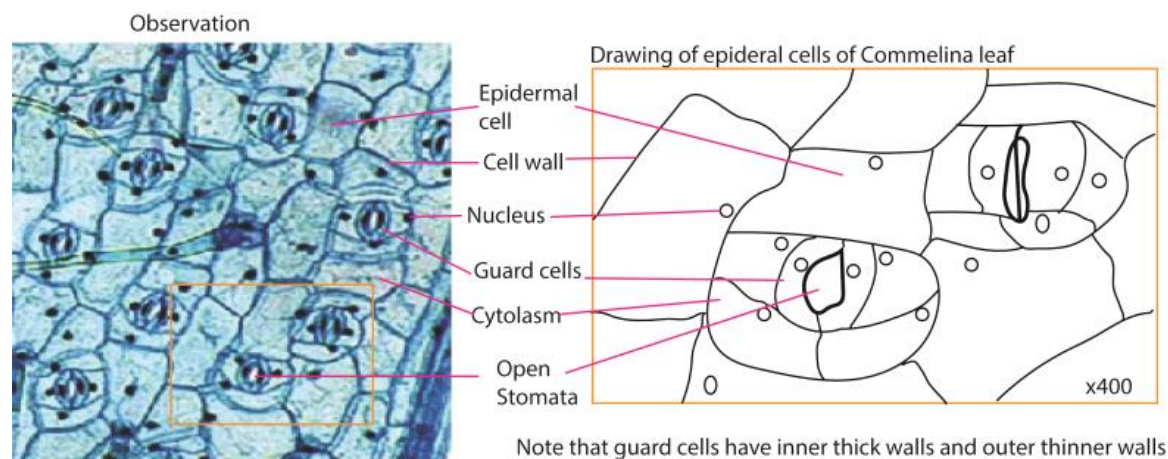
Note that: Plasmolysis compromises the barrier protection and structural support of epidermal cells due to water loss, which reduces internal pressure and causes membrane

Observation



Note that under plasmolysis, cell membrane separates from cell wall as cell loses water by osmosis detachment, weakening cell firmness.

Features of epidermal cells of Commelina leaf



Note that guard cells have inner thick walls and outer thinner walls

Activity 5

Requirements

R1 - Commelina (Nanda) leaf (open environment)

R2 - Commelina (Nanda) leaf (permanent shade)

You are provided with specimen R1 and R2 from two different habitats.

- Peel of a cortical from the upper and lower surface of each leaf.
- Mount the upper cuticle of the specimen R1, add a drop of water, wait for 3 minutes and draw and label a stoma with a few a few adjacent cells. State your magnification.
- Repeat (a) and(b) with solution S
- Comment the tonicity of solution S and develop and hypothesis for the opening of the stomata.
- Mount separately the peels of the upper and lower cuticle of each of specimen R1 and R2.

- f. Apply a drop of water to each. Count the number of stomata per field of view on the cuticle under medium power objective.
- g. Enter your results in the table below (enter and find the average of 2 field of view)

	R1			R2		
Surface	1	1	average	1	2	average
Upper cuticle						
Lower cuticle						

- h. Comment on the result in the table in d) above
- i. With reason suggest the habitat of the plant from where the leaves were obtained.
Answer

Given that both leaves have fewer stomata on the upper surface than on the lower surfaces; they should be got from a dry habitat. But R1 has very few stomata on the upper surface compared to R2 which implies that it was obtained from a drier place than R2

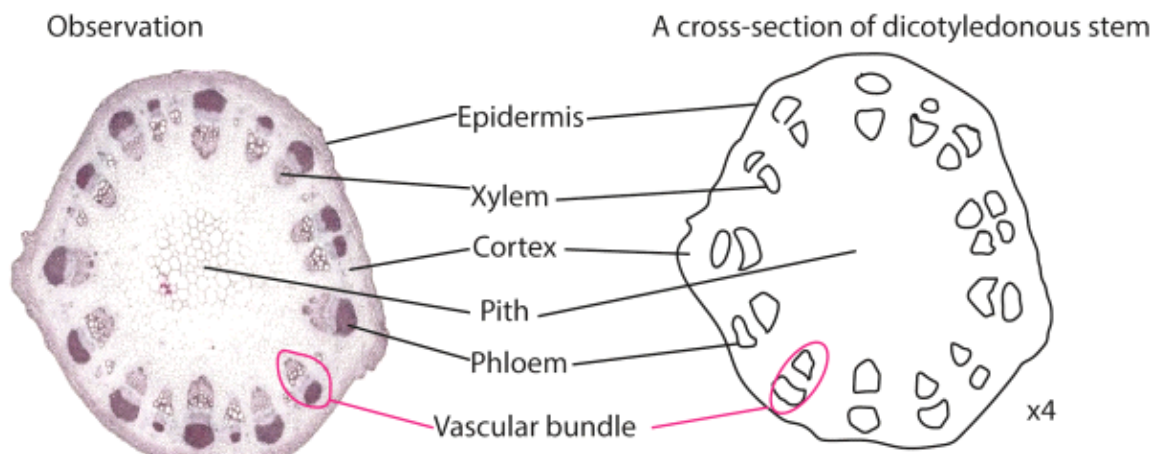
The fewer stomata on upper surface of the leaves are meant to reduce transpiration.

Microscopic features of cross-section of dicotyledonous and mono stem and root

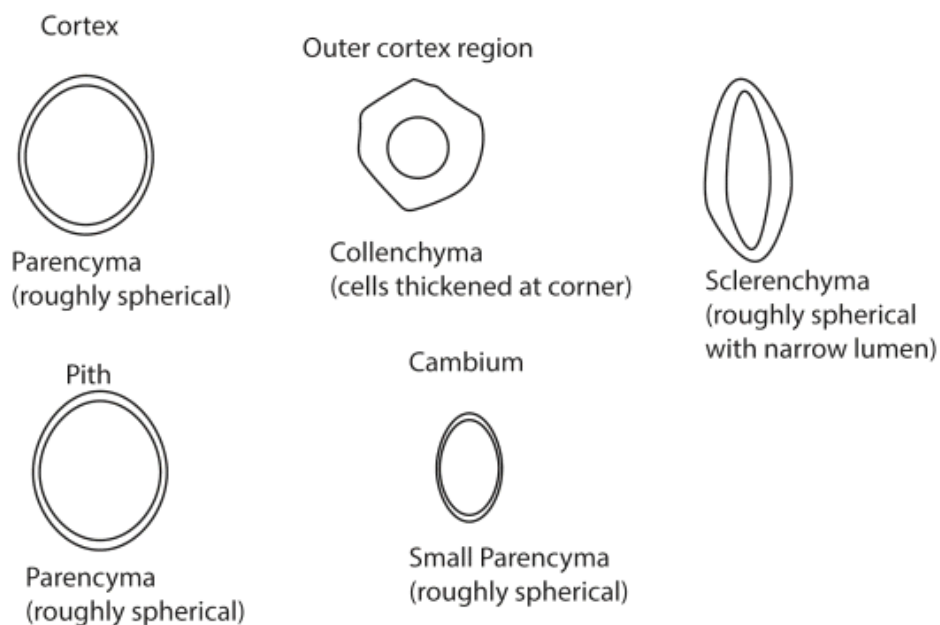
Procedure

- a. Study dicot stem and roots using bean seedling stem and radical while for monocot stem use maize, canna or grass spp while for monocot root use maize prop root, onion and wheat roots
- b. Use a scalpel to cut a **very thin cross-section** of the stem or root. **Thin slices** are crucial so light can pass through for clear viewing.
- c. Transfer the thin slice onto the center of a clean glass slide using tweezers.
- d. Using a dropper, place 1–2 drops of acidic phloroglucinol solution directly onto the specimen. Phloroglucinol stain xylem red due to its high content of lignin.
- e. Gently lower a cover slip over the specimen at an angle to avoid air bubbles. This protects the sample and flattens it for better viewing.
- f. Use blotting paper to absorb any solution around the edges of the cover slip.
- g. Place the slide on the microscope stage and start with low magnification.

Transverse section of dicotyledonous plant stem (bean seedling)



The structure of cells from each tissue type found in the section



Parts of a Stem Cross Section & Their Functions

Epidermis: Outermost layer; protects against water loss, pathogens, and mechanical injury. It may have a waxy cuticle.

Cortex: Composed mainly of parenchyma cells; stores food and may assist in transport.

Endodermis (*in some stems*): Regulates flow of substances into the vascular tissue; more prominent in roots.

Xylem: Transports water and minerals from roots to leaves; provides structural support.

Phloem: Transports sugars and other organic nutrients from leaves to other parts.

Pericycle (*in dicots*): May give rise to lateral roots or contribute to secondary growth.

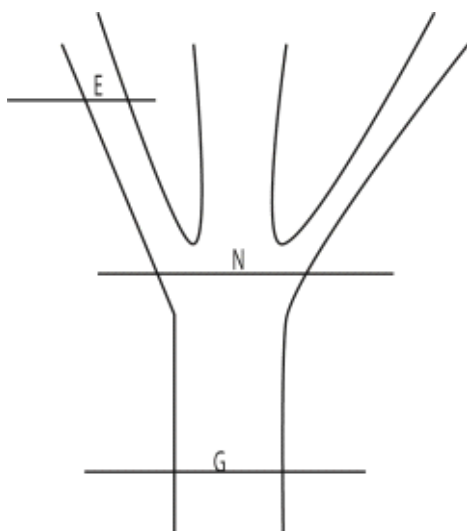
Pith (Medulla): Central region of parenchyma cells; stores nutrients and may help in transport.

Activity 6

You are provided with specimen K (Bryophyllum shoot) which is a shoot. (1 hr)

- Cut a series of thin transverse sections through the stem and leaf petiole (at the 4th or 5th node from the apex) with the aim of finding out the structure of the stem at levels N and G and of the leaf at level E as illustrated below for your guidance.
- Stain the sections with Phloroglucinol and concentrated Hydrochloric Acid (corrosive and fumes).
- Draw plans to show the distribution of lignified tissue at N, G and E. make your drawings in the spaces provided below the illustration.

Illustration for your guidance and spaces below for your drawings.



E

G

N

- d. How does the structure of the stem at N differ from that at G? Suggest one reason to account for this difference (if any).

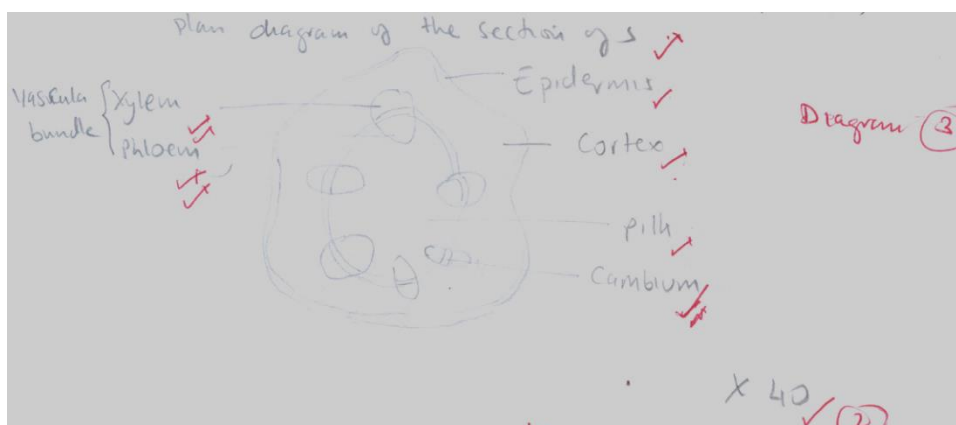
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Activity 7

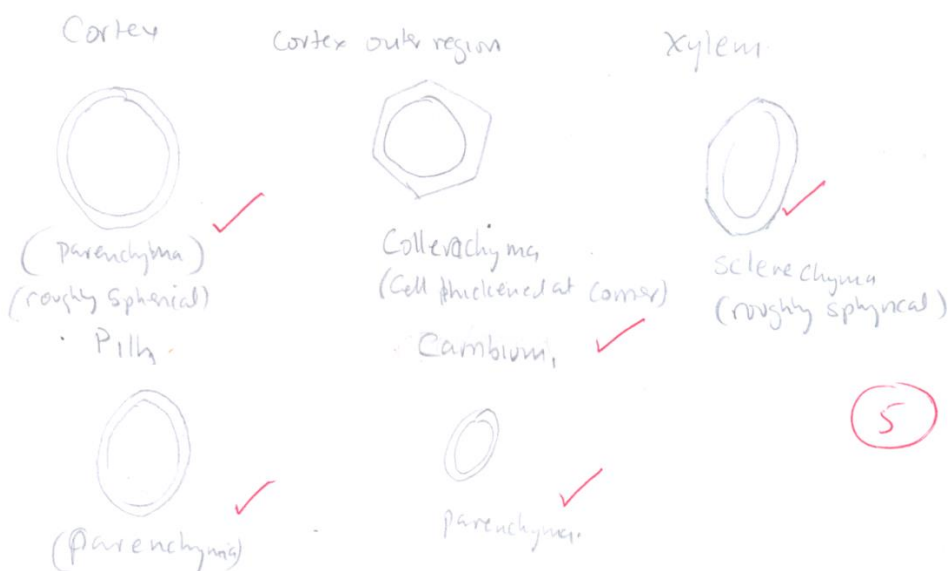
You are provided with specimen S (stem of bean seedling).

- Cut three thin cross-sections from it and immediately transfer them into a Petri dish of water
- Mount one section in a drop of acidified phloroglucinol on a slide and cover with a cover slip. Observe under the low power of a microscope.
- (i) Draw and label the tissue plan section of specimen S (10 ½ marks)



- Draw the structure of one cell from each tissue type found in the section (marks)

(05



(b) Identify the stained tissue in the section of specimen S (01 mark)

Xylem (1)

(i) Give reasons, state the major group of plants to which specimen S belong (03 marks)

Dicotyledonous plant (1)

Because it has a pith with vascular bundles in a ring (2); endodermis, presence of cambium

(ii) Give Structural adaptations of the coloured tissue for its functions (02 marks)

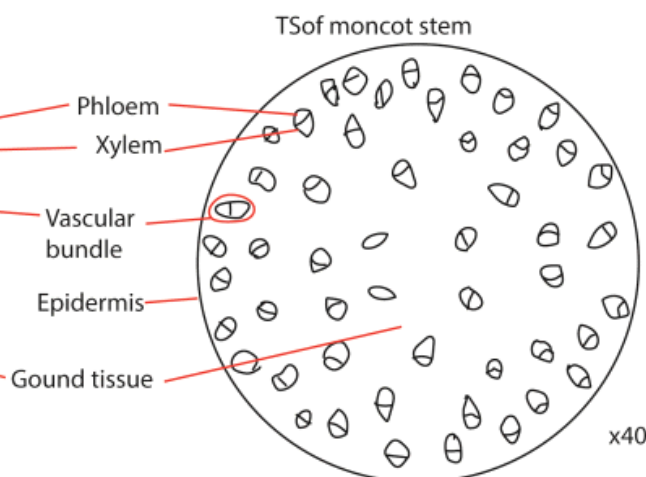
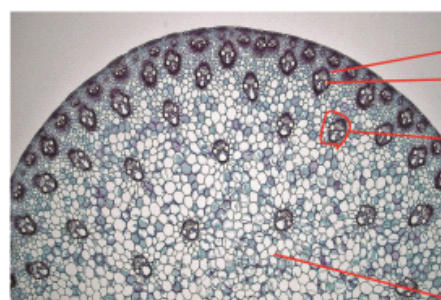
Lignified for support (1)

Has open tube/lumen for conducting water (1)

Has narrow lumen to facilitate capillarity.

Transverse section of monocotyledonous plant stem (stem grass or maize seedling)

Microscopic section of monocot stem



Differences between dicotyledonous and monocotyledonous section of the stem

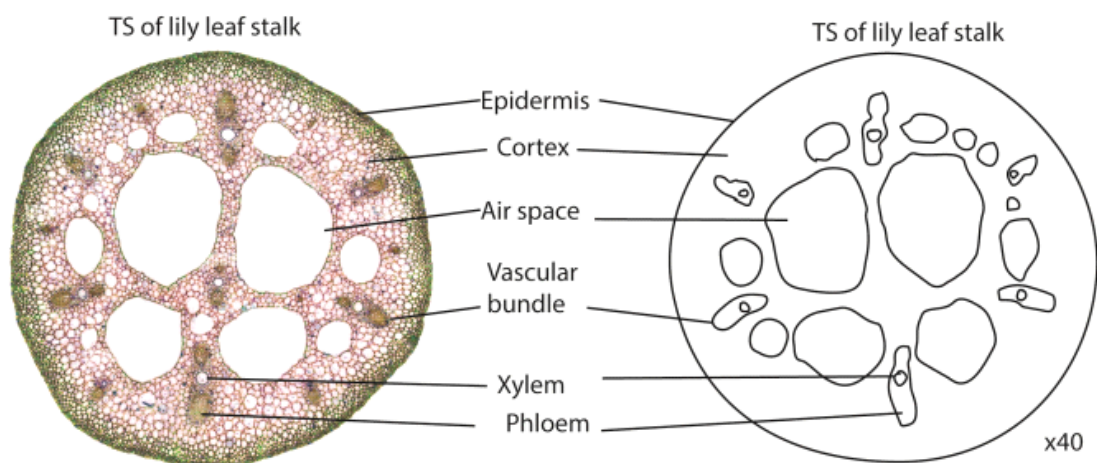
Dicot root	Monocot stem
Vascular bundles in a ring	Vascular bundle scattered
4 to 8 vascular bundle	Numerous vascular bundles
Has pith	Has no pith
Xylem elements polygonal	Circular xylem elements

Activity 8

You are provided with specimen P (canalily stem).

- Cut three thin cross-sections from it and immediately transfer them into a Petri dish of water
- Mount one section in a drop of acidified phloroglucinol on a slide and cover with a cover slip. Observe under the low power of a microscope.
- Observe under low power objective and draw.
- Identify specimen P

Transverse section of floating plant stem (Water lily leaf stalk)



In aerenchyma plants like water lily and rice, air spaces reduce weight of the plant and also facilitate gaseous exchange between aerial and submerged parts.

Activity 9

Materials



Nymphaea species (water lily)



Cyperus rotundus (nut grass)

Nymphaea species (water lily), labelled A

Cyperus rotundus (nut grass) labelled C

You are provided with specimens B and C

(i) Examine specimen B (water lily) and suggest its habitat. (01 marks)

Aquatic/water

(ii) Give five adaptations of the specimen in (a)(i) (10mrks)

- Broad lamina provide large surface area for transpiration to remove excess water and for photosynthesis
- Green leaves due to presence of chlorophyll to trap light energy for photosynthesis
- Long petiole to rise the lamina above water so that it receives adequate light.
- Numerous buds for vegetative reproduction
- Long peduncle to expose flowers for pollination
- Conspicuous petals to attract pollinators
- Waxy cuticle repel water and prevent it from blocking stomata
- Numerous strong roots to anchor the plant into mud and to absorb mineral salts
- Flexible stems/peduncle to avoid damage from water current

(iii) Examine both specimen B and C and give two difference between their leaves, stem and roots

Parts leaves	B –water lily Broad, Flat Thick waxy cuticle Reticulate venation Long stalk	C – nut grass Long, Narrow Thin cuticle Parallel veins Short stalk
Stems	Round Flexible/pliable Spongy	Triangular Stiff/rigid Firm/solid
Roots	Spongy Big/thick long	Firm/solid/hard Small/thin short

(iv) Using a razor blade cut a small piece of the leaf from each of the specimen, B and C, mount each separately on a microscope slide in a drop of water under low power of microscope. Record your observation. (02marks)

Specimen B: numerous/many small; brightly lit patches/air spaces/spaces

Specimen C: small rectangular/polygonal, closely packed cells/cells are joined end to end

(v) Peel off epidermis on the both sides of each specimen; mount in water and view them under low power of microscope. Describe how each specimen is adapted to its habitat

Specimen B has numerous stomata only on upper cuticle which is exposed to air to increase the rate of transpiration and gaseous exchange.

Specimen C has more stomata on lower cuticle and very few on lower cuticle to minimize water loss.

(vi) Cut very thin transverse sections through the stem of specimen B and C and observe them under low power of microscope. Draw the tissue plan of both sections do not label (04marks)

Drawing of the tissue plan of the transverse section of stems of specimens B and C



Specimen B

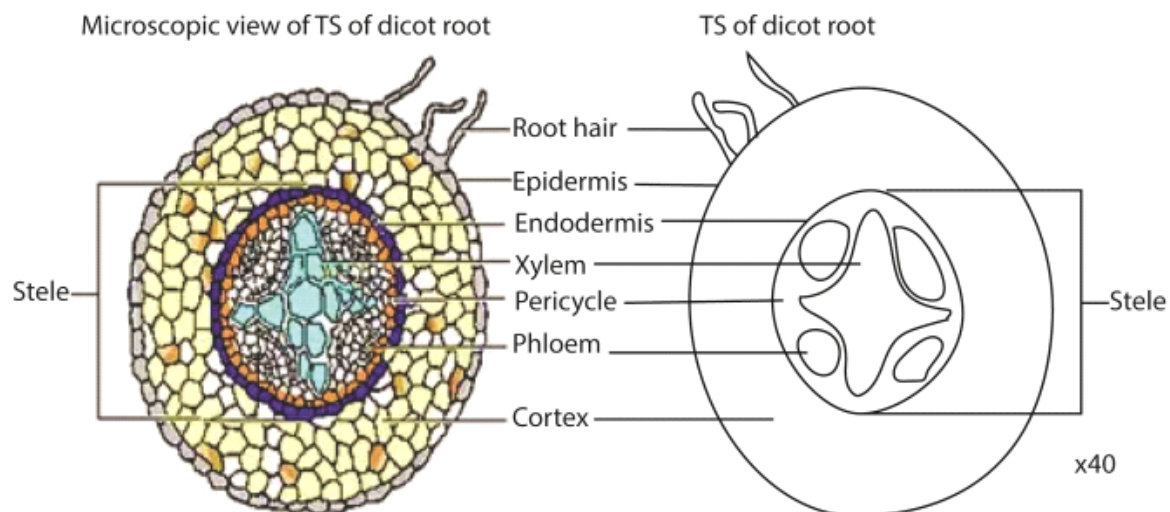


Specimen C

Reject if - detailed cells are drawn

- transverse sections dicot root or stems are drawn

Transverse section of dicotyledonous plant root (3-4 days bean radicle, root of young amaranthus)

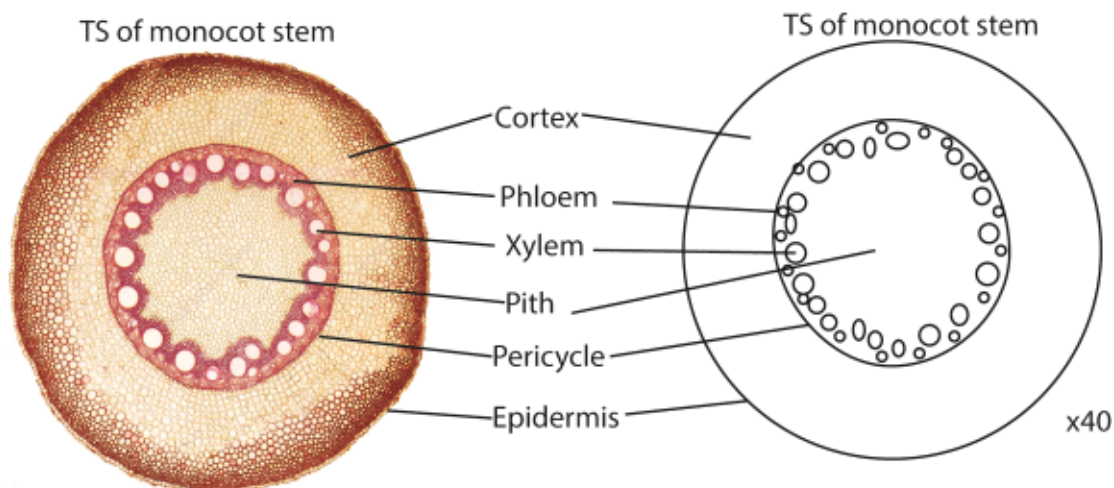


Activity 10

You are provided with specimen Q ([gyanodra gyanondrapsis \(Jobyo\) taproot](#) /3-4 day bean seedling taproot). Cut thin transverse section through Q. Place the section on a glass slides and add a drop of phloroglucinol followed by a drop of concentrated Hydrochloric acid. Leave to stand for one minute. Drain excess liquid and place a cover slip. Examine under low power magnification of the microscope. A hand lens may be used.

- (i) Draw a plan diagram to show the distribution of the coloured substance in Q
- (ii) Identify the type of the plant from which Q was obtained.
- (iii) What substance in the tissue takes up the colour?
- (iv) What is the role of the coloured substance in the plant?
- (v) Which tissue of the plant is the coloured substance likely to be found?

Transverse section of monocotyledonous plant root (3-4 days bean radicle)



Differences between dicotyledonous and monocotyledonous root

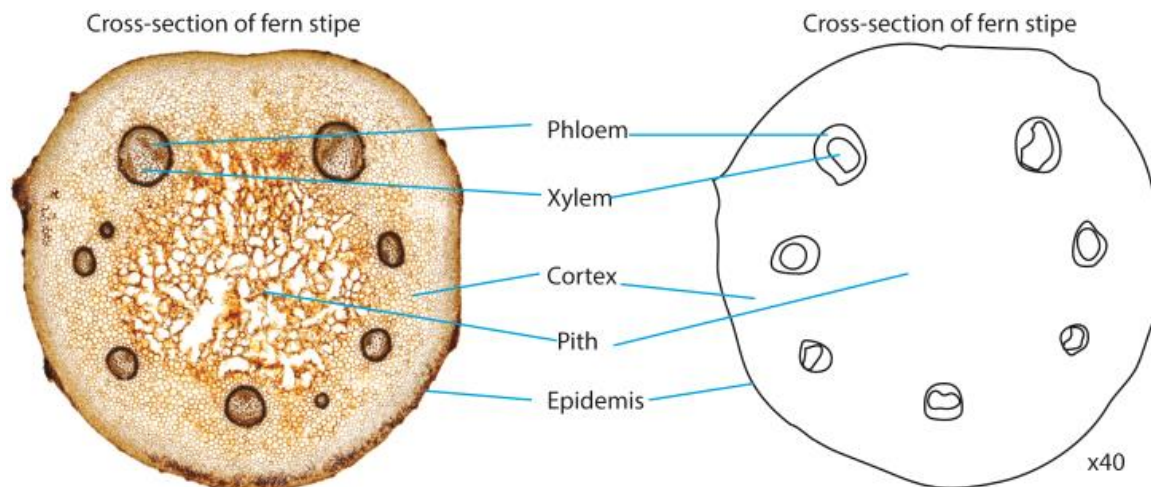
Dicot Root	Monocot root
Pericycle gives rise to cork cambium, parts of the vascular cambium, and lateral roots	Pericycle gives rise to lateral roots only
Has a limited number of Xylem and Phloem	Has a higher number of Xylem and Phloem
Angular or Polygonal xylem	Round or Oval round
Has no pith	Larger and well developed pith

Activity 11

You are provided with specimen T (Maize prop root).

- Cut three thin cross-sections from it and immediately transfer them into a Petri dish of water
- Mount one section in a drop of acidified phloroglucinol on a slide and cover with a cover slip. Observe under the low power of a microscope.
- Observe under low power objective and draw.
- Identify specimen T.

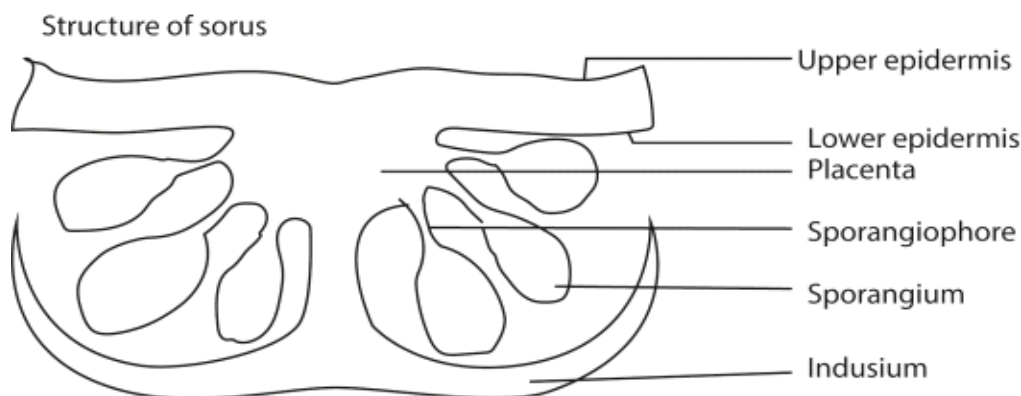
Transverse section of fern stipe



Activity 12

What evidence from the cross-section of the stipe of the fern above shows that a fern is more advanced than moss.

Structure of sorus



Adaptations of the Sorus in Ferns

Adaptation	Description	Purpose
Clustered Sporangia	Sori are groups of sporangia (spore-producing structures)	Increases spore output and ensures synchronized development
Indusium Covering	A thin flap of tissue (indusium) often covers the sorus	Protects developing sporangia from desiccation, UV damage, and pathogens
Underside Leaf Position	Located on the lower surface of fronds	Reduces exposure to direct sunlight and physical damage

Gradual Maturation	Sporangia within a sorus mature at different times	Extends the spore release period, improving chances of dispersal
Mixed-Age Sporangia	Contains sporangia at various developmental stages	Ensures continuous spore production over time
Specialized Meristematic Zones	Sori arise from active growth regions on the leaf	Allows for sustained development and regeneration of sporangia

Lower plants

Microscopic features of a spirogyra

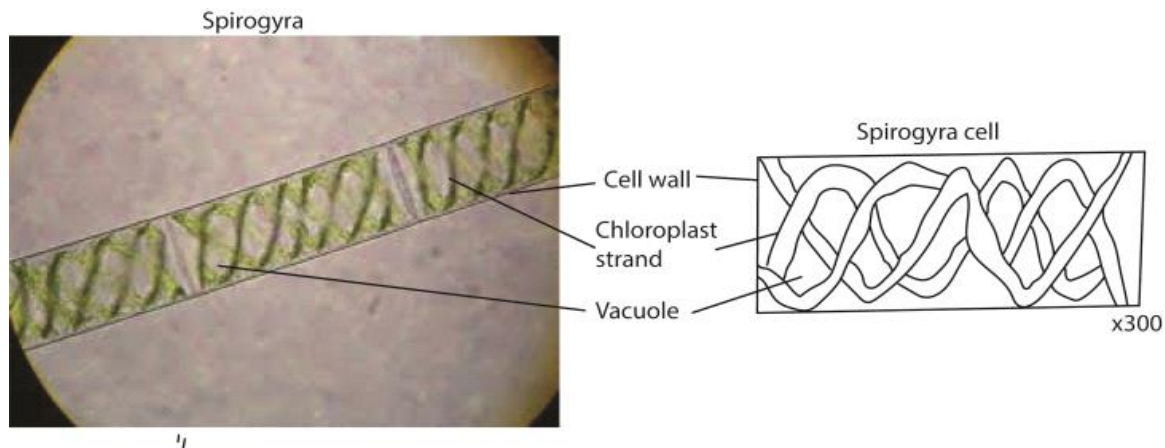
Classification

Domain	Eukaryota	Justification Has membrane bound organelles
Kingdom	Protista	Has chlorophyll Store starch Multicellular Has cellulose cell wall Lack complex differentiated tissues like plants Lack vascular tissues like plants
Phylum	Charophyta (green algae)	Has Spiral chloroplasts Store starch filamentous

Procedure

- (i) Place a drop of water containing spirogyra filaments on a clean slide.
- (ii) Use tweezers to gently spread out the filament so that they do not clump. You may stain with a drop of iodine or methylene blue solution.
- (iii) Place a cover slip avoiding air bubbles, drain the excess water or dye solution
- (iv) Observe using microscope

Observations: Long chains of rectangular cells.



Characteristics

- (i) Has **filamentous body**
- (ii) Has **spiral chloroplast**
- (iii) Has **big vacuoles**
- (iv) **Has pyrenoid**

Adaptations of spiroyra to its ecology:

- (i) Have chloroplasts for photosynthesis
- (ii) Thick cell wall for protection
- (iii) Circular prenoid store much food.
- (iv) Thin/large surface area to volume ratio to facilitate gaseous exchange
- (v) Has protective mucilage slimy layer
- (vi) Reproduces fast by fragmentation

Economic importance

- (i) Primary producer
- (ii) Produce oxygen in water through photosynthesis.
- (iii) Algal bloom increases water purification cost
- (iv) Alginic acid derivatives are used as thickener in foo, cosmetic and drug industry.
- (v) Algal bloom may lead to depletion of oxygen and death of fish.

Advantage of spiroyra over bread mould:

- it makes its own food

Microscopic features of a Bread mould

Classification

Domain: Eukaryota

Kingdom: Fungi

Phylum/Division: Zygomycota/Zygoycetes.

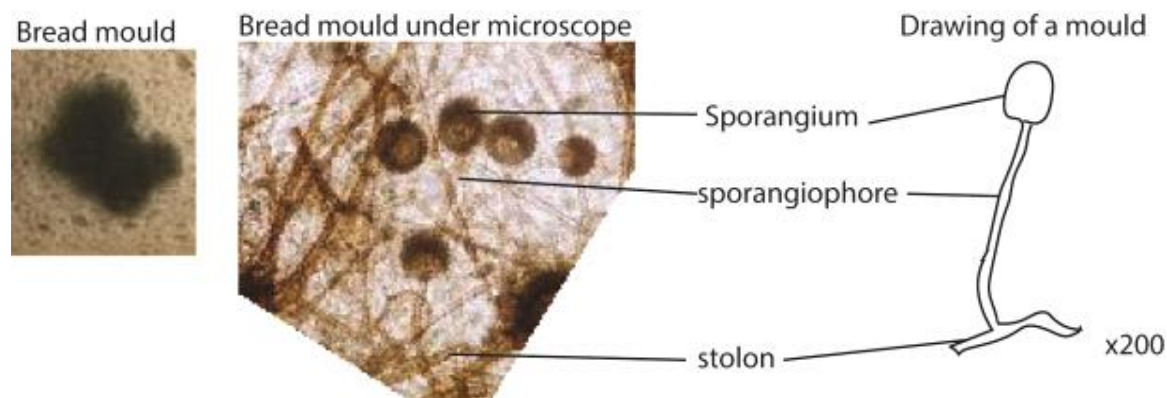
Reasons for the division

- (i) possession of sporangium/spore case
- (ii) sporangiophore/vertical hypha/stalk with round sporangium

- (iii) network of branched hypha/mycelium
- (iv) non septate
- (v) Rhizoids/rooting hyphae
- (vi) Linking/stolon/horizontal hyphae

Procedure

- (i) Place a single drop of distilled water in the center of a clean glass slide.
- (ii) Gently scrape a very small, fuzzy piece of the mould from the surface of the bread. Try to pick up a sample with both the black spore-producing structures and the white, thread-like filaments.
- (iii) Transfer the mould sample and place it carefully into the drop of water on the slide.
- (iv) Hold a coverslip at a 45-degree angle to the slide and slowly lower it over the sample. This technique helps to prevent air bubbles from getting trapped underneath.
- (v) Gently blot any excess water from the edges of the coverslip using a paper towel.
- (vi) Observe using a microscope



Parts of mould

- (i) Sporangium is pherical/round black head on vertical hyphae/sporangiophore
- (ii) Sporangiophore is thread-like/small/slender and long, vertical hyphae
- (iii) Rhizoids/rooting hyphae are thread-like/small/slender
- (iv) Stolon/linking hyphae is thin/slender, branched

Adaptations of bread mould to its ecology

- (i) Grows as filamentous hyphae that spread rapidly across surfaces and penetrate deeper into bread to access nutrients
- (ii) Numerous rhizoids for anchorage and absorption of nutrints.
- (iii) Fast reproduction by spores from a large number of sporangia
- (iv) Does not require light to survive.
- (v) Long sporangiophore/vertical hyphae to rise sporangium high in order to disperse spores easily
- (vi) Thin/slender sporngiophore for flexibility to increase chances of spore dispersal by wind

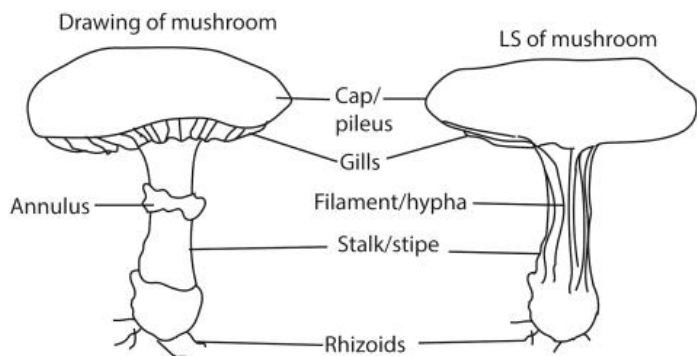
Advantage of bread mould over spirogyra

-it does not require light for survival

Economic importance of the bread mould

- Causes decomposition and recycling of matter
- Makes bread stale leading to economic loss

Features of a mushroom



Classification of mushroom

Domain: Eukaryota

Kingdom: Fungi

Phylum: Basidiomycota

Characteristics of phylum Basidiomycota

Features of mushroom

- Large cap/pileus with gills underneath
- Has stalk/stipe made of fine filaments/hyphae
- Has rooting hyphae/rhizoids

Activity 13

You are provided with specimens **S** (spirogyra) and **T (mould)**.

- (a) Observe the specimens and state the nutrition that occurs in each, giving a reason.
(2marks)

S- It is phototrophic because it contains a green color of chlorophyll

T - is saprophytic because it lack a green chlorophyll and it is growing on decaying organic substance

- (b) Examine one filament of Specimen **S** using a microscope.
(i) Give two structural characteristics of the specimen (2marks)

it has cell wall

spiral chloroplasts

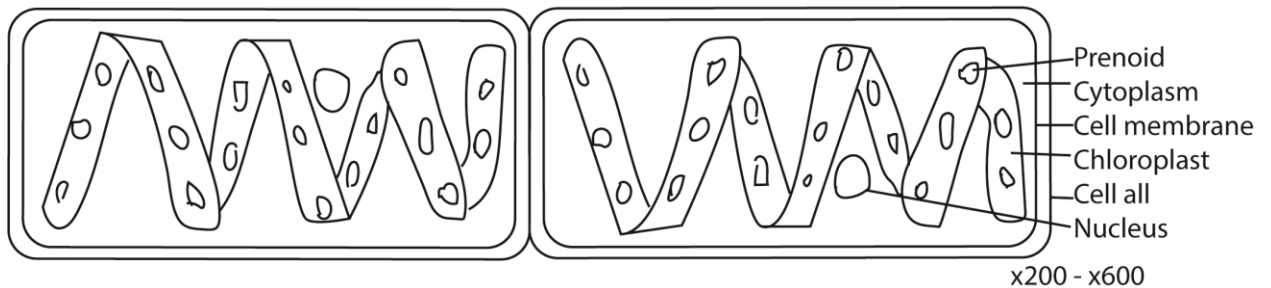
vacuole

(ii) State three structural features which enable specimen **S** to survive in its habitat.
(3marks)

- **has chloroplasts that enables it to manufacture its own food**
- **has slimy mucilage that inhibits predators**
- **has large vacuole that enables to float on water**
- **Thin filament provide large surface area for easy diffusion of gases**

(c) Draw and label two cell of **S** that you can see clearly (6marks)

A drawing of two cells of specimen S (Spirogyra)



NB drawing one cell or more than two cells lead to loss of marks

(d) Remove a small portion of specimen **T** and examine it under a microscope.

(i) Name and describe four major vegetative parts of specimen **T** in table 2 (06marks)

Table 2

Part	Description
hyphae	Branching Filaments
sporangiophore	stalk/filament holding a sporangium
sporangium	dark spherical head on top of sporangiophore
Rhizoids	Filaments entering and absorbing nutrients from rotting bread

(ii) From the descriptive features in Table 2, state how any two parts are adapted to their functions (02)

- **Rhizoids: penetrate food and produce digestive enzyme to obtain enough nourishment**
- **Sprangiophores are long to suspend sporangium above the ground for easy dispersal of spores by wind**
- **Sporangium are big to accommodate large number of spores**

(e) For survival in its habitat, state one advantage

(i) Specimen **S** has Over **T**.

S has chloroplast and can manufacture its food while T cannot

(ii) Specimen **T** has over **S**

T can survive in absence of light /water while S cannot.

T produces spores that can survive adverse conditions

(f) From the structural characteristic of S and T, classify the specimens according to the groups in table 3 (02marks)

Table 3

Specimen	Phylum	Class
S	chlorophyta	chlorophyceae
T	Zygomycota/eumycota	Zygomycetes/phycomycetes

Bryophytes/moss

Classification

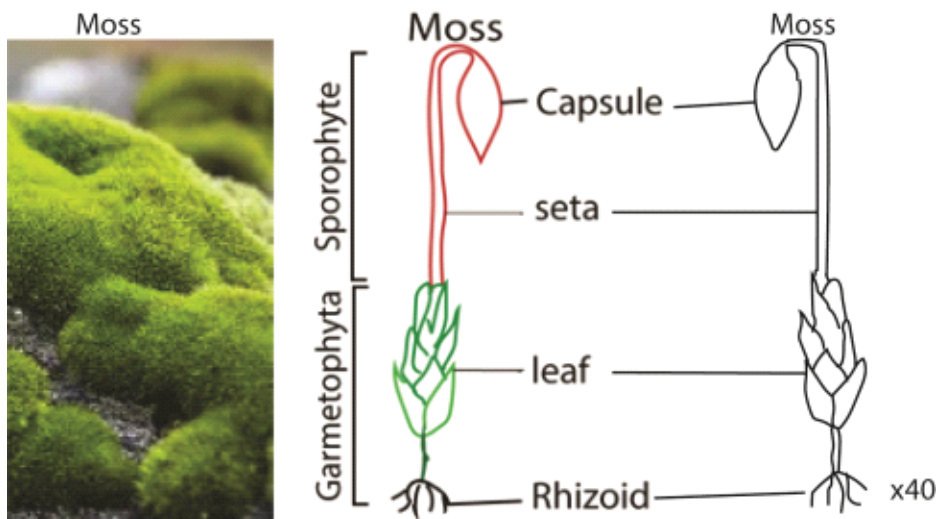
Domain: Eukaryota

Kingdom: Plantae

Phylum: Bryophyta(moss)

Characteristics of moss

- form dense green mats,
- having simple leaves without cuticle
- has sporangium
- has sporangiophore
- has rhizoids instead of roots.



Adaptations of moss to its ecology

- has chlorophyll for photosynthesis
- leaves increase surface area for absorption of light.
- thin leaves for easy penetration of light
- erect to expose leaves to light
- large sporangia produce many spores for vegetative reproduction
- numerous rhizoids absorb water for photosynthesis
- sporangiophore/stalk expose the spores from sporangia to wind for dispersal

Economic importance of moss

- primary producers
- stabilize soil and reduce soil erosion
- are pollution indicators

Fern

Classification

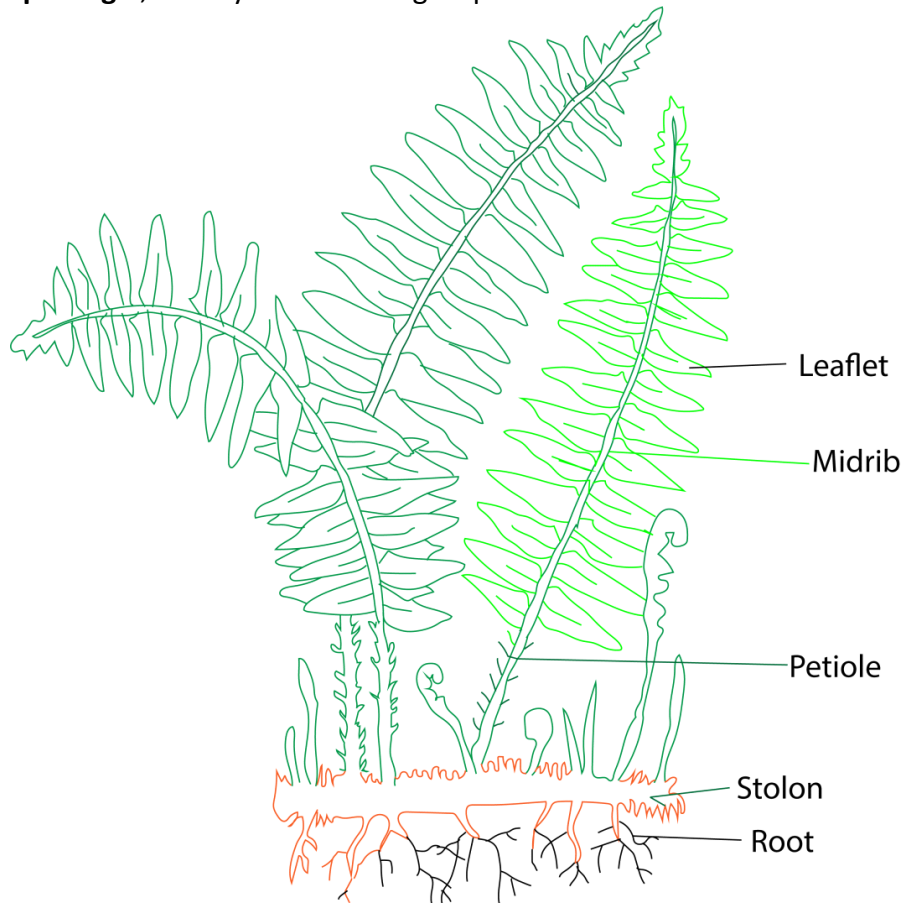
Domain: Eukaryota

Kingdom: Plantae

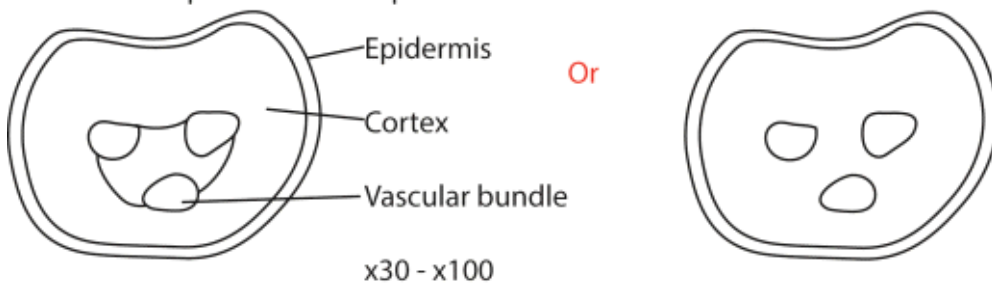
Phylum: Filicinophyta (ferns)

Characteristics of ferns

- They have **true roots** (often fibrous), **underground stems** (rhizomes), and **large green compound leaves** called **fronds**.
- Ferns possess **xylem and phloem**, allowing efficient transport of water, minerals, and nutrients. This distinguishes them from non-vascular plants like mosses.
- Ferns reproduce **asexually** through **spores**, not seeds or flowers. Spores are produced in **sporangia**, usually clustered in groups called **sori** on the underside of fronds.



A drawing of trasverse section of rachis of specimen G (fern) observed under low power microscope



Adaptations of ferns to their ecology

- Have chlorophyll for photosynthesis
- Large leaves to provide large surface area for trapping light
- Well-developed transport system for moving materials in the plant
- Produce a lot of light spores for wind dispersal
- Numerous veins to increase support
- Numerous hairs to reduce water loss/transpiration
- Sori to protect spores

Economic importance of ferns

- ornamental plants for landscaping and houseplants
- Have medicinal properties
- Some ferns help improve indoor air quality by absorbing pollutants.
- Reduce soil erosion

Lichen



Characteristics of lichen

- Broad/large body
- Flattened and thin,
- Amorphous
- Leaf-like structure with distinct upper and lower surface

Adaptations of lichen to their ecology

- Have chlorophyll for photosynthesis to manufacture their food
- Can survive under extreme dryness
- Grow on different surfaces from rocks – living organisms for support
- Low nutrient requirements

Ecological significance

- Has chlorophyll for photosynthesis hence acting as a primary producer in ecosystem
- Through photosynthesis and respiration, they regulate carbon dioxide - oxygen concentration in atmosphere

- Grow on and breakdown rocks to produce soil
- Provide habitats and shelters where insects and birds can hide away from predator
- act as bio-indicators of air quality: Many lichens are highly sensitive to air pollution, particularly sulphur dioxide, and are used to assess air quality.
- Through respiration and photosynthesis, they recycle matter

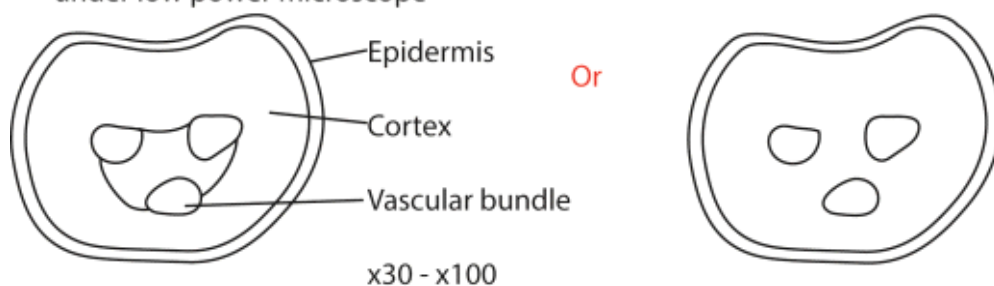
Activity 14

Materials: E- mould, F- lichen, G – whole fern plant

You are provided with specimen E, F and G

- Mount a small portion of specimen E in a drop of water and observe under low power of light microscope.
 - Giving two reasons state the division to which specimen E belongs
Division: Zygomycota/Zygomycetes
Reasons
 - possession of sporangium/spore case
 - sporangiophore/vertical hypha/stalk with round sporangium
 - network of branched hypha/mycelium
 - non septate
 - Rhizoids/rooting hyphae
 - Linking/stolon/horizontal hyphae
 - From your observations, state the features of specimen E (mould) that ensures its survival in the habitat (04marks)
 - Grows as **filamentous hyphae** that spread rapidly across surfaces and penetrate deeper into bread to access nutrients
 - Fast reproduction by spores from a large number of sporangia
 - Does not require light to survive.
 - Long sporangiophore/vertical hyphae to rise sporangium high in order to disperse spores easily
 - Thin/slender sporngiophore for flexibility to increase chances of spore dispersal by wind
- Using a hand lens, examine the upper surface of the pinna of specimen G. Describe the role of the observable structures in the survival of the organism
 - Numerous pinnules to increase surface area for absorption of light for photosynthesis
 - Numerous veins to provide support and supply the leaf with water for photosynthesis.
 - Hair to reduce water loss by transpiration
 - Cut a thin transverse section of the rachis of specimen G. observe under low power light microscope. Draw and label the tissue observed. (07marks)

A drawing of trasverse section of rachis of specimen G (fern) observed under low power microscope



- (c) Using a hand lens, examine specimen F (lichen)
- Describe the structure of specimen F (lichen)
 - Thin flattened leaf –like structure
 - Explain the ecological significance of specimen F
 - Has chlorophyll for photosynthesis hence acting as a primary producers in ecosystem
 - Through photosynthesis and respiration, they regulate carbon dioxide - oxygen concentration in atmosphere
 - Grow on and breakdown rocks to produce soil
 - Provide habitats and shelters where insects and birds can hide away from predator
 - act as bioindicators of air quality: Many lichens are highly sensitive to air pollution, particularly sulphur dioxide, and are used to assess air quality.
 - Through respiration and photosynthesis, they recycle matter

Activity 15

You are provided with specimens H (mould), I(spirogyra), J(moss), K (bean seedling) and L (star grass with two leaves)

- (a) Mount a little of specimen H and I on two separate microscope slides, mount and observe in each case. Also observe the other specimens critically. State two characteristic features of each specimen (10 marks)

H: **Filamentous; a septate hypae; sporangiophore; rhizoids (any 2)**

I **Filamentous body; pyrenoid; spiral chloroplast (any 2)**

J **Sporangia; rhizoid; overlapping leaves; oral leaves (any 2)**

K **leaves with reticulate venation; tap root; chodate/heart shaped leaves; has 3 leaflets; has leaf stalk (any 2)**

L **leaves with parallel venation, fibrous root system, linear leaf, leaf sheath (any 2)**

- (b) Suggest one ecological advantage of each of the following specimen

- (i) I over H (any 1)

I has chloroplast and can manufacture it food while H cannot

I can reproduce more rapidly by fragmentation unlike H

(ii) J over K

J is reduced in size hence can survive on small/thin substratum/soil unlike K which is huge with large roots requiring deeper soil

(c) (i) Describe the structure of the leaves of specimens K and L (2marks)

Leaf K Has stipules at the base of each leaflet; long leaf stalk; reticulate venation; cordate/heart shaped leaflets **(any 2; 1 mark):**

Leaf L: Has entire/ undivided lamina; linear shape, leaf sheath; parallel venation (any 2; 1 mark)

(ii) Make an accurate drawing of lamina of specimen K half its size

Do not label

(4 marks)



Reject if it has a stalk

(d) **Using only the features stated in (a) above construct a dichotomous Key to Identify the specimens starting with H, I, J, K and ending with L** (7 marks)

- | | | |
|-------|---|---|
| 1.(a) | Specimen with filamentous body | 2 |
| (b) | Specimen with non-filamentous body/distinct stem and leaves..... | 3 |
| 2.(a) | specimen with no chloroplast/with spores/rhizoid/hyphae | H |
| (b) | Specimen with chloroplast/pyrenoid/ no spore/ no rhizoid..... | I |
| 3(a) | specimen with rhizoids | J |
| (b) | Specimen with roots | 4 |
| 5(a) | Specimen with tap root/leaflets/heart shaped leaves/reticulate veins ... | K |
| (b) | Specimen with fibrous root system/entire lamina/linear shape/parallel veins | L |

Phylum Angiospermophyta: Flowering plants

They are made of two classes, monocotyledoneae (monocotyledonous plants) and dicotyledoneae (dicotyledonous plants).

Comparison of monocotyledonous plants and dicotyledonous plants.

Monocotyledoneae	Dicotyledoneae
Embryo has one cotyledon	Embryo has two cotyledons
Narrow leaves with parallel venation Scattered vascular bundles in stem	Broad leaves with network veins Ring vascular bundles
Rare cambium present and normally no secondary growth	Vascular cambium present which can lead to secondary growth
Many xylem groups in root Flower parts in threes	Few xylem groups in root Flower parts in fours or fives
Calyx and corolla not usually distinguishable Often wind pollinated e.g. maize and rice	Calyx and corolla are distinct. Often insect pollinated e.g. bean

Dicot e.g. Bean



Monocot e.g. maize



Commelina (nanda)



It is a flowering plant found in phylum angiosperm a phyla /spermatophyte/tracheophyta.

Adaptations to terrestrial habitat

- (i) Have veins in leaves to transport dissolved foods, water and mineral salts.
- (ii) Have stomata for gaseous exchange.
- (iii) Thin leaves to reduce distance of diffusion of gases.
- (iv) has chlorophyll to enable in trapping sunlight for manufacturing food.
- (v) Flat surface increases surface area for photosynthesis.
- (vi) Have more stomata on the lower surface and less on the upper surface to reduce water loss. Thick and fleshy for storage of water.

Use of commelina Leaves in biology practical

Cuticle is used to demonstrate epidermal and guard cells, opening and closing of stomata.

Differences between commelina growing in an open land and that in a shady Area

Open land	Shady area
Short internode	Long internode
Pale green leaves	Dark green leaves – to increase ability to trap light
Thin lamina	Thick lamina

More hairy- to reduce water loss	Less hairy
Narrow lamina	Broad lamina- increase surface area to trap light
numerous stomata on the lower epidermis than upper epidermis-to reduce water loss	Equal number of stomata on both sides of the leaf.

Adaptations of commelina growing in open land

- (i) Hairy leaves to minimize water land
- (ii) Narrow or short leaves minimize exposure to heat and so minimize water loss
- (iii) Few stomata on upper surface and more on the lower surface to reduce on water loss.

Adaptations commelina shady area

- (i) Less hairy leaves as there is little to do with minimizing water loss.
- (ii) Have broad or long leaves to maximize capture of sunlight for photosynthesis.
- (iii) Few stomata on upper surface and many on lower surface to reduce on water loss.

How to identify commellina growing in Sunny / open terrestrial habitat

- (i) Fewer numbers of stomata to reduce water loss.
- (ii) Narrow leaf surface / lamina reduce surface area to minimize water loss.
- (iii) Much more stomata on lower surface and fewer stomata on upper epidermis to reduce water loss.
- (iv) More number of stomata to increase water loss hence rapid cooling.

How to identify commellina growing in shady/damp terrestrial habitat

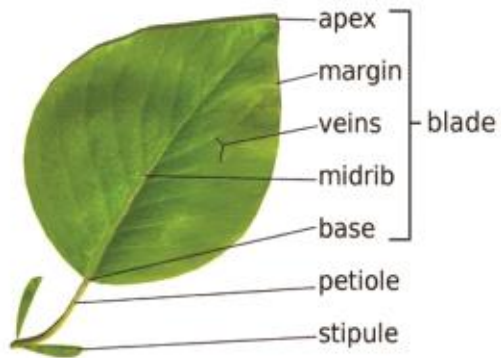
- (i) More number of stomata on the lower surface than upper surface to minimize water loss.
- (ii) Deep green, much chlorophyll to maximize light absorption.
- (iii) Broad lamina to increase surface area exposed to sunlight/for maximum light absorption.
- (iv) Less hairy because no need to conserve water / to enhance transpiration.

Uses of commelina Stem:

In osmosis to demonstrate the curling of longitudinally cut stem in solutions of different salt concentrations.

Leaves

Parts of a leaf



Modification of leaves



Leaflets or apex modified into tendrils to provide support



Leaves colored to attract pollinators



Leaf able to grow new plants for vegetative reproduction



Spiny leaves protect from herbivores



dionaea muscipula leaf trap insects for nitrogen

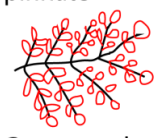
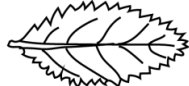


Floating leaves



Fleshy leaves for water storage

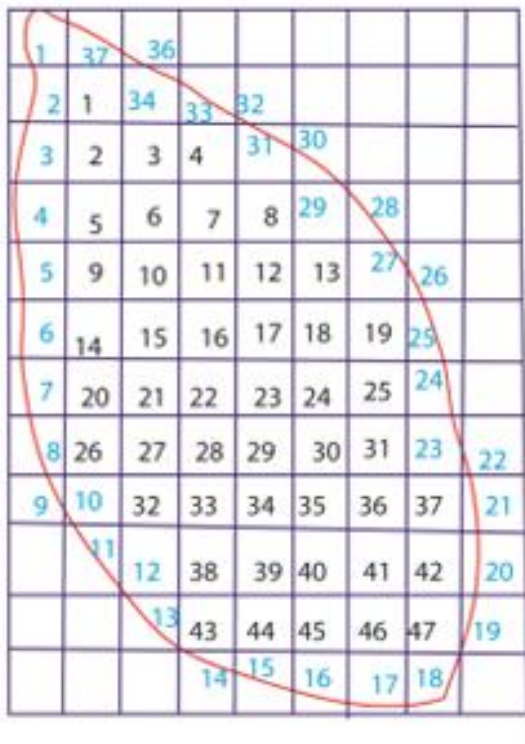
Characteristics of leaves

Venation	Shapes of simple leaves	Shapes	Margins	Arrangement on stem
 Pinnate  Parallel  Palmate	 Linear  Obovate  Ovate  Pinnately lobed  Palmately lobed  reniform  Lanceolate  Sagittate	 Simple  Compound palmate  compound pinnate  Compound bipinnate	 Entire  Crenate  Dentate  Serrate  Lobed	 alternative  Opposite  Whorled

These characteristics of leaves may be used to construct a dichotomous Key

How to determine the area of a leaf using a graph paper

- Place the leaf flat on graph paper.
- Trace its outline carefully.
- Count the full squares inside the outline.
- Estimate partial squares and add them up.
- Multiply the number of squares by the area of one square (e.g., 1 cm²).



Area of the lamina above = $47 + \frac{1}{2} \times 37 = 65.5\text{cm}^2$

Activity 16

Specimen **P** (Simple leaf with smooth lamina and pinnate venation (dodo)), **Q** (Simple leaf with hairy lamina and smooth margin), **R** (Trifoliate leaf (bean)) **S** (Compound pinnate (Acacia)), **T** (Simple leaf with parallel veins (grass)), **U** (Sessile simple leaf), **V** (Simple leaf with palmate venation (hibiscus)) and **W** (Fleshy leaf (bougnaville)) are leaves of common plants.

(a) (i) Classify specimen V:

Phylum

Class

(ii) Give 3 characteristics possessed by the plants in this class.

.....

.....

.....

(b) Examine specimens P, Q, R and U, for each specimen give four descriptive features of the leaf blade (lamina).

Specimen P

- (i)
- (ii)
- (iii)
- (iv)

Specimen Q

- (i)
- (ii)
- (iii)
- (iv)

Specimen R

- (i)
- (ii)
- (iii)
- (iv)

Specimen U

- (i)
- (ii)
- (iii)
- (iv)

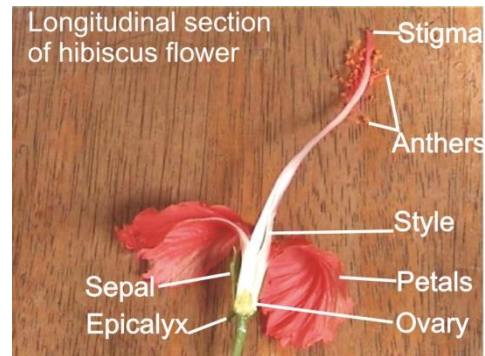
(c) Construct a dichotomous key which can be used to identify the 8 specimens (P-W) in the order given.

Flowers

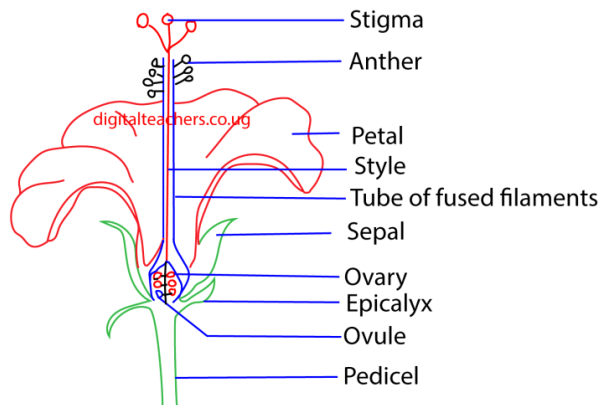
The flower is the sexual reproducing organ of the flowering plants.

Hibiscus flowers

Parts of hibiscus flower



Longitudinal section of hibiscus flower



Essential parts of flower: Parts necessary for development of Embryo

- Anthers produce pollen grains
- Stigma receives pollen grains
- Style allows movement of pollen grains from stigma to ovules
- Ovules are fertilized to embryo then seed
- Ovary protects the ovules

Non - essential parts/parts unnecessary in development of seed:

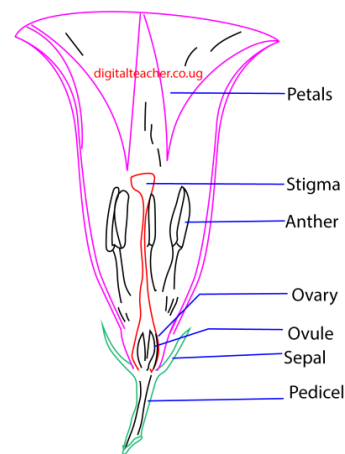
- Petals
- Sepals
- Filament

Sweet potato flower

Sweet potato flower



Cross section of potato flower



Crotalaria/Bean flower

Bean flower



Standard

Wing

Keel

Cross section of bean flower

3 kinds of petals

Standard petal

Wing petal

Keel petal

Male parts

Stamen

Anther

Filament

Female parts

Stigma

Style

Ovary (pod)

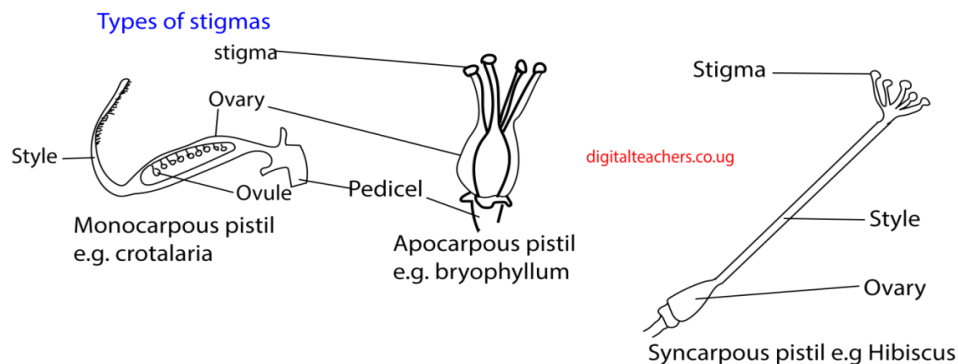
Ovule

Sepals

Stalk

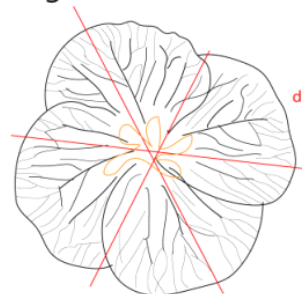
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Types of pistils



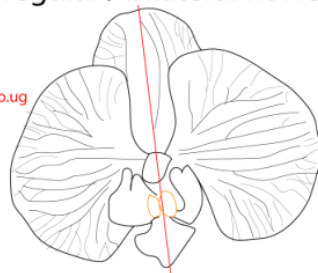
Flower symmetry

Regular / radial flower



Primrose

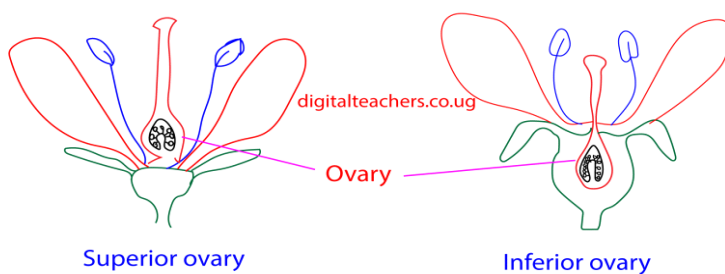
Irregular / bilateral flower



Orchid

Position of an ovary in a flower

Superior and inferior ovaries



Differences between hibiscus and potato flowers

	Hibiscus flower	Potato flowers
1.	Lobed stigma	fused stigmas
2.	Free petals	Fused petals
3.	Many anthers	Five anthers
4.	Has epicalyx	Has no epicalyx

5.	Fused sepals	Free sepals
6.	Fused filament	Free filament

Differences between hibiscus and bean flower

	Hibiscus flower	Bean flower
1.	Lobed stigma	Single stigma
2.	All filaments fused	Nine of the filament are fused one free
3.	Many anthers	Ten anthers
4.	Regular flower	Irregular flower
5.	Fused carpel	One carpel
6.	Fused sepals	Free sepals
7.	Has epicalyx	Has no epicalyx
8.	All petals are free	Two of the five petals are fused
9.	All petals are similar	Petals dissimilar

Differences between bean and potato flowers

	Potato flower	Bean flower
1.	Fused carpel	One carpel
2.	Regular flower	Irregular flower
3.	Fused petals	Two of the five petals are fused
4.	Five anthers	Ten anthers
5.	Free filament	Nine of the ten filaments are fused

Characteristics of insect pollinated flower

- (i) brightly coloured petals/conspicuous
- (ii) scented
- (iii) Flowers have nectar
- (iv) Flower have sticky pollen grains

Characteristics of wind pollinated flowers

- (i) Large production of light pollen grains.
- (ii) inconspicuous

- (iii) no scent
- (iv) Feathery and sticky stigma.
- (v) Flowers do not possess nectar.
- (vi) Anthers are well exposed e.g. maize flower.

Activity 17

Requirements

P – Hibiscus flower

Q – Crotalaria

R – sweet potato/morning glory flower

S – Guinea grass/Panicum maximum

T – Male maize inflorescence

Specimens P, R, S, and T are flowers of inflorescence

- (a) Describe the androecium and gynoecium of each of the specimens P, Q and R and of one of the florets from specimens S and T into table 3. (15marks)

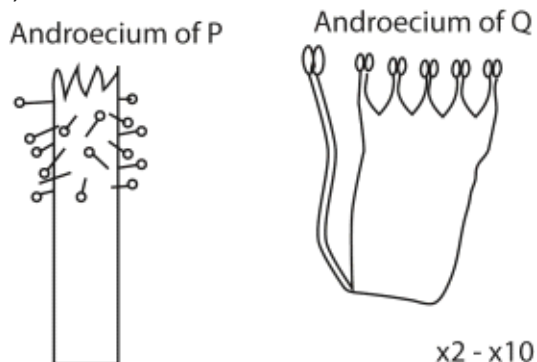
Table 3

Specimen	Characteristics of androecium	Characteristics of gynoecium
P(hibiscus)	Many anthers, fused filaments, anthers are uniform	Five fused carpel, sticky stigma, long style, superior ovary
Q (crotalaria)	Ten stamen, free anthers, nine filament fused, one filament free, anthers of different shapes and size	Superior ovary, one carpel, one stigma, hairy stigma
R (Morning glory)	Five free anthers, filaments attached to the petal, large anthers	Superior ovary, 2/3 fused carpel,
S - spikelet of Guinea grass)	3 free large anthers 3 free thin long filaments	Two fused carpel, superior ovary, two free styles, feathery stigma
T - (maize spikelet)	3 free big anthers 3 free thin long filaments	No gynoecium

- (b) Using the characteristics of the androecium and gynoecium, construct a dichotomous key to identify the specimens

- 1(a) lack gynoecium T
- (b) Gynoecium present go to 2
- 2(a) Very many anther P
- (b) Few anther Go to 3
- 3(a) Partially fused filaments Q
- (b) free filament 4
- 4(a) five anthers R
- (b) three anthers S

- (c) In the space below, draw the androecium of P and Q



- (d) State whether specimen P is more likely to be self-pollinated or cross pollinated. Explain your answer
 Cross-pollinated because stigmas are above the anthers heads, pollen grains from other flowers are likely to fall on the stigmas of the flower before pollen grains from anthers of the same flower
- (e) Explain how pollination is facilitated by androecium of specimen T
- Large anther heads produce much pollen grain.
 - Long filament exposes the anthers to the wind
 - Flexible filaments easily shaken to scatter pollen grains from anthers.

Inflorescence

Acacia inflorescence

Cassia inflorescence



Cassia flower



Patter of arrangement of florets on acacia inflorescence

Stalked flowers attached alternately/spiral arrangement at different parts of the peduncle /elongated axis, emerging from the leaf axils with older flowers at the bottom and young flowers at the top.

Characteristics of Acacia flower

Pistil: monocarpous elongated superior ovary, short style and laterally flattened stigma

Stamen: 10 in number; free filament with varying length; bilobed /grooved anthers

Petals: five free brightly colored petals arranged star-like pattern

Sepals: five free and brightly colored

Bract: has no bracts/some species have bracts.

Maize male inflorescence

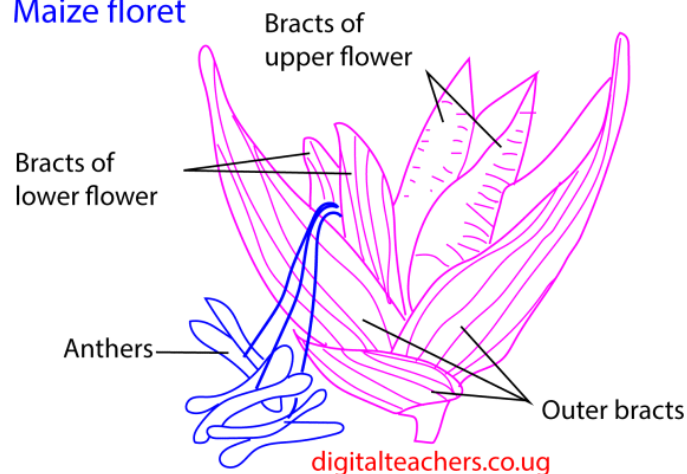
Maize inflorescence



Structure of male maize inflorescence

The main axis/peduncle/rachis with lateral branches of different height attached in whorls and spread out widely. The branches bear paired spikelets along their length; one sessile while another has a stalk. The spikelets are alternatively attached on the branch

Maize floret



Structure of a maize floret/spikelet

Floret: irregular

Pistil: absent

Stamen: consists of a big elongated bilobed anthers attached to long thin flexible filament.

Petals: absent

Sepals: absent

Bract: outer bract/glumes are thick/ hard/tough, curved inwards, parallel veined

Inner bracts/palea are papery/membranous, curved inwards, parallel veined

Advantages of structural arrangement of spikelets on inflorescence

- (i) Long flexible filaments exposes anther making distribution of pollen grain easy.
- (ii) Large others produce numerous pollen grains to increase the chances of pollination.

Disadvantages of structural arrangement of spikelets on inflorescence

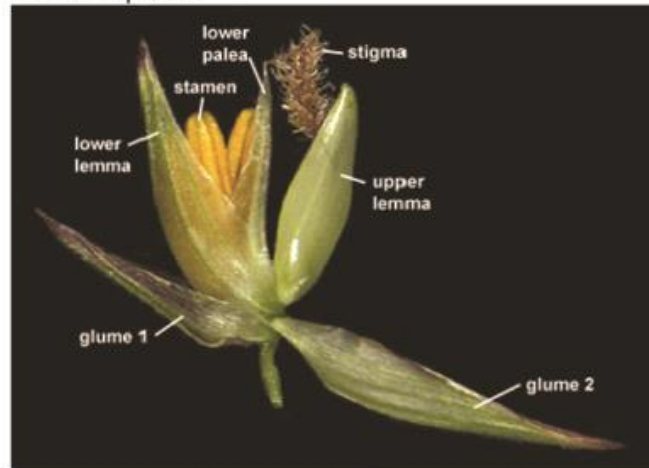
- (i) Crowded spikelets attract predator/herbivores
- (ii) Crowded spikelets increase the rate of spreading diseases/pest/infections

Panicum inflorescence

Panicum inflorescence



Panicum spikelet



Structure of Panicum inflorescence

The main axis/peduncle/rachis with lateral branches of different height attached in whorls and spread out widely. The branches bear spikelets along their length.

Advantages of structural arrangement of spikelets on inflorescence

- (i) Alternate arrangement places the florets for easy pollination
- (ii) Long flexible filaments exposes anther making distribution of pollen grain easy.
- (iii) Large anthers produce numerous pollen grain to increase the chances of pollination.

Disadvantages of structural arrangement of spikelets on inflorescence

- (i) Crowded spikelets attract predator/herbivores
- (ii) Crowded spikelets increase the rate of spreading diseases/pest/infections

Structure of a floret/spikelet

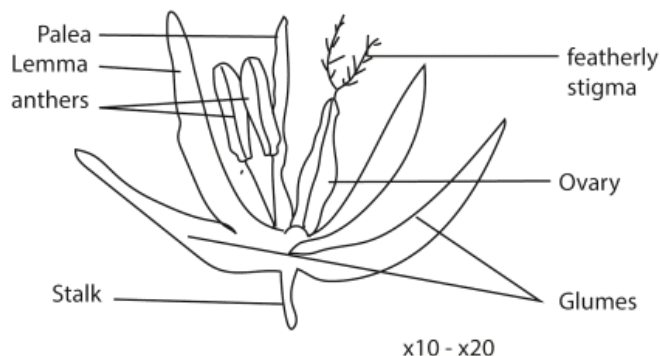
Each spikelet is irregular/zygomorphic, stalked and has two florets; a sterile flower at the base and a fertile, hermaphroditic flower at the top. These are enclosed by **bracts**, the outer being tough/hard/thick, parallel veined and curved inwards while the inner are thin/membranous/papery and boat shaped. The florets are bisexual;

Stamen: consists of a big elongated bilobed anther attached to long thin flexible filament.

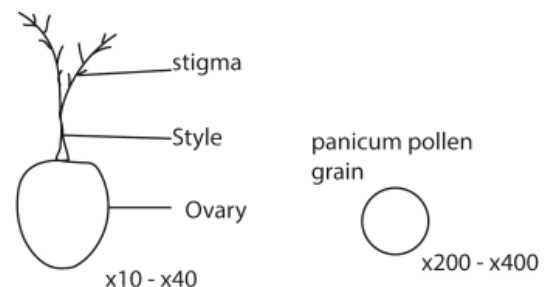
The pistil: consists of a superior ovary with short style that bears two/forked feathery stigmas.

Stigma: provides large surface area to receive pollen grain.

A drawing of panicum flower



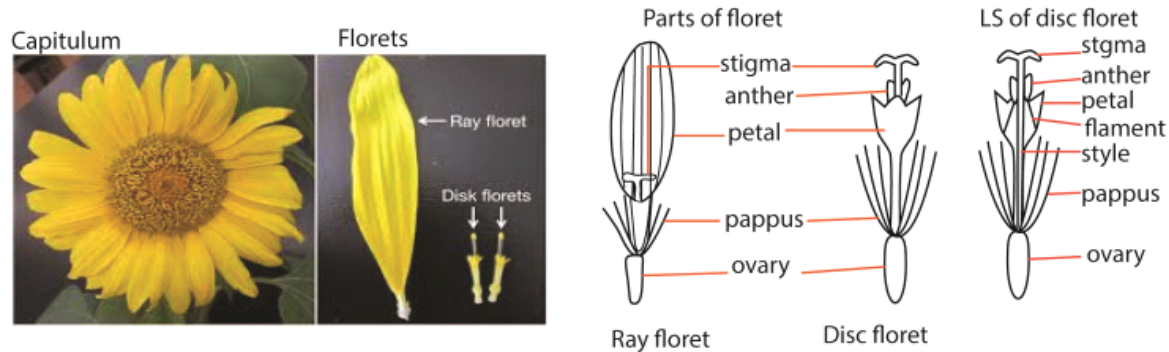
A drawing of panicum gynoecium/pistil



Note that Panicum spikelet has both male and female parts unlike maize spikelet that has stamens only. The pollen grain of panicum is small and light to be easily dispersed by wind

Capitulum of sun flower and *Biden pilosa*

Capitulum of sunflower



Arrangement of florets of sunflower

What appears to be a single large flower is actually a composite of hundreds of tiny individual flowers, or florets, arranged in a specific order.

- (i) **Ray florets:** The bright yellow, petal-like structures on the outer edge of the sunflower are typically sterile and exist primarily to attract pollinators.
- (ii) **Disc florets:** The fertile, tubular flowers packed in the central disk of the sunflower are the ones that produce seeds. These are the florets arranged in the spiral pattern with older flowers at the periphery and young ones at the centre.

Capitulum of *Biden Pilosa*

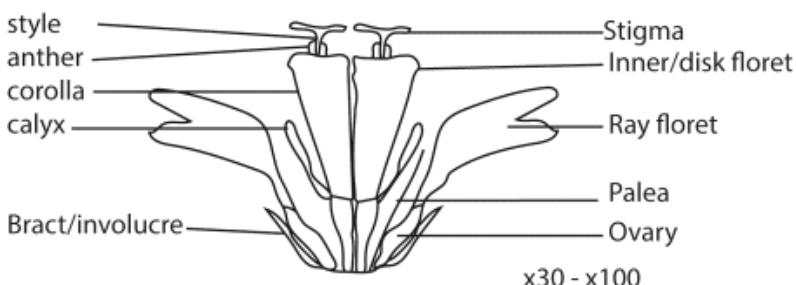


Structure of *Bidens pilosa* infloresces

- (i) **Ray florets:** The flower head has an outer ring of usually 4 to 5 broad, white ray florets, which are the petal-like structures. However, depending on the variety, these ray florets may be absent or very small. The ray florets are typically sterile and serve to attract pollinators.

- (ii) **Disc florets:** In the center of the flower head is a dense cluster of tubular, yellow disc florets. They are circular/spiral arrangement with the older floret at the periphery and the young ones at the center

A drawing of longitudinal section of black jack capitulum using hand lens



Differences between disc and ray florets of *Biden Pilosa*

Disc florets	Ray floret
Located in the center of flower head	Located on the outer edge, forming a ring around the disc florets
Small, tubular, and yellow	Larger, strap-shaped, and resemble petals
Dull colored	Brightly colored petals
Fertile and contain both male (stamens) and female (pistil) reproductive organs, produce seed	Sterile and lack functional reproductive structures. They do not produce seeds.

Significance of floret-pattern in capitulum

A capitulum acts as a **pseudanthium**, or "false flower," that mimics the appearance of a single, large flower.

- (i) **Increased visibility:** A large, showy flower head with bright ray florets is far more visible and attractive to pollinators like bees, butterflies, and flies than a cluster of tiny, inconspicuous individual flowers would be.
- (ii) **Increased chance of pollination:** A single visit to a capitulum can result in the pollination of numerous florets, making the plant a highly rewarding stop for a foraging insect for nectar.
- (iii) **Involucre:** The cluster of modified leaves, or bracts, that surround the capitulum forms a protective barrier, much like sepals do for a single flower.
- (iv) **Capitulum head** facilitate the landing of the pollinators increasing the chances of pollination
- (v) **Specialization of florets:** The showy ray florets draw in pollinators, while the prolific disc florets are dedicated to seed production.

Description of disc floret

Petals: five fused petals to form a tube, brightly colored,

Sepals: thin tapering sepals

Bract: has no bracts

Stamen, has five elongated fused, bilobed anthers and thin/slender/short filament

Carpel: Pistil with elongated inferior ovary and two/forked fused, hairy stigma

Banana inflorescence

Banana inflorescence



Rachis
bract
florets
terminal bud

Banana floret



Stigma
Anther
Fused tepal
Free tepal
Ovary

Banana floret



Arrangement of florets in banana

Arranged/clustered/crowded/grouped in two rows; attached at the base/one point of the spathe/bract. The florets are sessile.

Description of banana floret

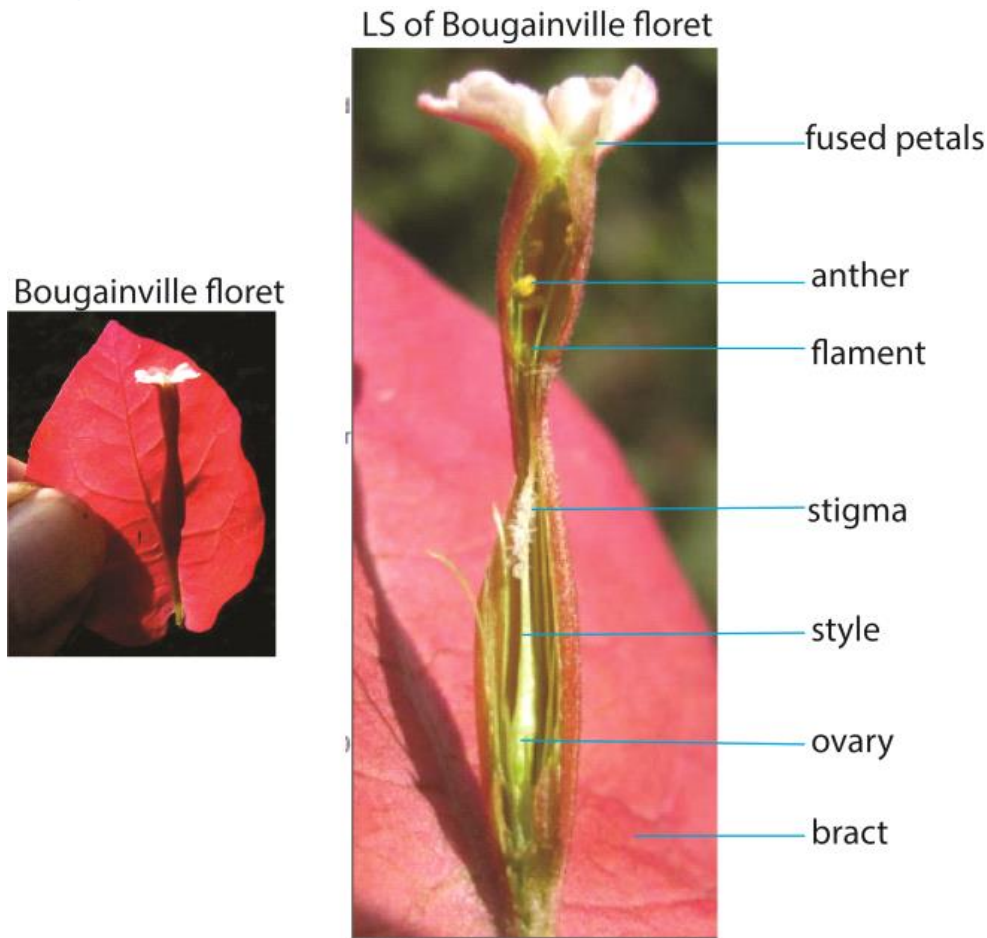
Pistil: syncarpous, has elongated inferior ovary, style and trilobed stigma

Anther: flattened/elongated/grooved, bilobed, brightly colored

Petals : absent/none

Bracts: dull coloured, parallel veined, thick/flesh, boat shaped

Bougainville inflorescence



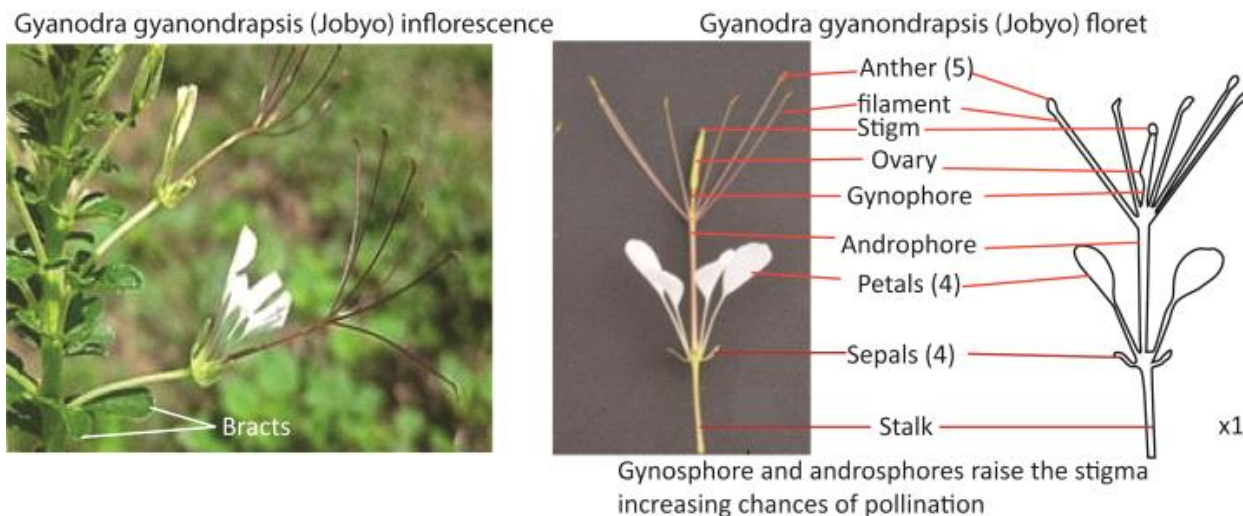
Structure of the inflorescence bougainville inflorescence

- (i) **The true flowers:** The actual flowers are small, waxy, and tubular, typically white or yellowish in color, and are not very showy.
- (ii) **Arrangement of florets:** The flowers appear in clusters of three, at the center of the showy bracts. Each tiny flower is attached to the central vein of one of the bracts.
- (iii) **The bracts:** Each triplet of flowers is subtended by three (and sometimes up to six) large, papery, brightly colored bracts. It is these vibrant bracts that create the brilliant display and are the most visually prominent part of the plant. The bracts can vary in color, including magenta, purple, pink, red, orange, and white.
- (iv) **The overall cluster:** The entire arrangement of three flowers and their surrounding bracts constitutes the inflorescence. These clusters are produced in the leaf axils at the tips of branches

Description of essential parts of bougainvillea

- (i) **Pistil** is monocarpous/single carpelled with superior, elongated ovary with short style attached to a spear shaped, elongated, hairy stigma
- (ii) **Stamen** is composed of eight free bilobed anthers with long slender filaments

Gynandra (Jobyo) inflorescence



Peculiar features of features of Gynandra flower not found in a typical flower

Stamen with stalk/androphore; ovary with stalk/gynophore, distinct nodes and internodes, androphore and gynophore rise and expose the stigma and anthers and increase the chances of pollination

Activity 18

Requirements

K – bougainvillea inflorescence

M – Gynandra gyanondrapsis (African spiderflower)

You are provided with specimen K(Bougainvillea inflorescence) and M (Gynandra Gyanondrapsis inflorescence)

- (a) Describe the flower arrangement on specimen K and M

K: The flowers appear in clusters of three, at the center of the showy bracts at the end of a stem branch. Each tiny flower is attached to the central vein of one of the bracts.

M: Individual stalked flowers along elongated main axis/peduncle, arranged spirally/alternately with older flower bottom most and young flower upper most, ending at the same level.

- (b) Pick one flower from each inflorescence and examine it using hand lens. Describe the structure of each flower with respect to parts as indicated in table below

Parts of flower	Flower from K	Flower from M
Calyx	Fused with corolla to form a tubular parianth	Small free, hairy, taper towards the tip
Corolla	Fused with sepals to form a tubular parianth	Four petal, Free, smooth, veined , narrow at the base and broad at the tip
Bract	Large brightly coloured, thin, smooth	Small trifoliate with a pedicel
Stamen	Long slender/thin free with varying length filaments, oval/bilobed anthers	Free long slender filament with bilobed anthers
Pistil	Superior ovary, style is short thick stalk, stigma long and hairy	Superior elongated ovary with short style and spherical stigma

- (c) What peculiar features of specimen M not found in a typical flower?

Stamen with stalk/androphore; ovary with stalk/gynophore, distinct nodes and internodes,

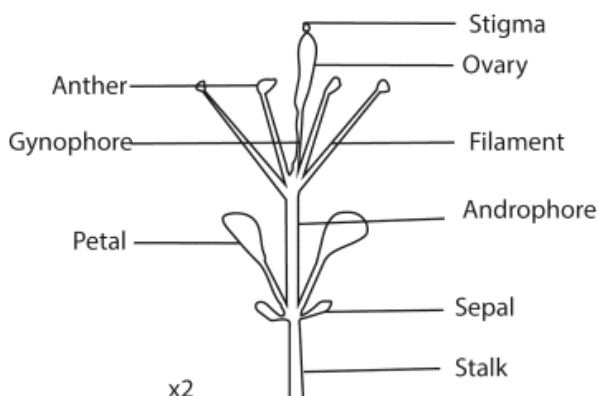
- (d) What ecological significance of the features in (c) to the plant from which M was obtained

Androphore and gynophore rise and expose the stigma and anthers and increase the chances of pollination

- (e) Draw and label the external features of a flower from specimen M

A drawing of the external features of a flower from specimen M

Drawing of external features of a flower from specimen F



Canna lily inflorescence

Canna lily flowers



Showy outer parts

- (i) **Staminodes:** These are the large, brightly colored, and petal like structures that most people assume are the petals. A canna flower typically has four of these staminodes.
- (ii) **Labellum:** One of the staminodes is often bent backward and forms a landing platform for pollinators.
- (iii) **Petals:** The actual petals of a canna flower are small, greenish, and inconspicuous. They are located behind the showy staminodes.
- (iv) **Sepals:** The three sepals are narrow, greenish structures found at the base of the flower, behind the petals.

Reproductive parts

- (i) **Stamen:** Unlike most flowers, a canna has only a single fertile stamen that produces pollen. This stamen is fused with the style and has a half-anther attached to its edge.
- (ii) **Anther:** The pollen-bearing part of the stamen, which often has a hardened edge.
- (iii) **Pistil:** The female reproductive part is centrally located.
- (iv) **Style:** A flattened, tongue-like structure that protrudes from the center of the flower.
- (v) **Stigma:** The flattened tip of the style, which receives pollen.

- (vi) Ovary: A three-chambered, warty or spiny structure located inferiorly (below the other floral parts). It contains the ovules, which become seeds after fertilization.

Lantana camara flowers



Arrangement of florets in Lantana camara

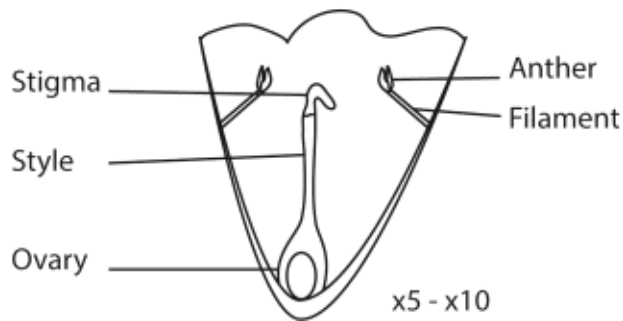
Numerous sessile/unstalked tiny tubular florets arranged radially/ring form/circular/concentric at the clubbed/expanded apex/end/tip on a long peduncle axis with young floret at the centre and the older periphery. The florets change colour as they **mature and each floret arises from the axil of a bract**.

Significance of arrangement of the arrangement of the florets of lantana camara

The florets are arranged in a dense, hemispherical cluster known as an umbel. This inflorescence provides several advantages for reproduction:

- (i) Numerous florets make the inflorescence conspicuous and strengthen the fragrance to attract pollinators
- (ii) The colour change of florets with age signals to pollinators, like butterflies, which flowers are mature and/or offer nectar.
- (iii) The overall flat-topped shape of the flower cluster provides an ideal landing pad for butterflies, which are important pollinators for Lantana
- (iv) Encourages efficient foraging: Once a pollinator, like a butterfly, lands on the cluster, it can visit many individual flowers in one stop. This behavior encourages the insect to spend more time on the plant, increasing the chance of pollen transfer.
- (v) Each floret arises from the axil of a bract for protection from mechanical damage.

A drawing of longitudinal section of a floret on *Lantana camara* showing essential parts



Activity 19

Inflorescence of: *Biden pilosa* (H), *Bougainvillea* (I) and *Lantana camara* (J)

You are provided with specimen H, I and J

(a) Using a hand lens, describe the

(i) Arrangement of the florets of specimen J (*Lantana camara*) (02 marks)

Numerous sessile/unstalked tiny tubular florets arranged radially/ring form/circular/concentric at the clubbed/expanded apex/end/tip on a long peduncle axis with young floret at the centre and the older periphery. The florets change colour as they **mature and each floret arises from the axil of a bract**.

(ii) Structure of essential parts of a floret of specimen I- *Bougainvillea* (05marks)

Pistil is monocarpous/single carpelled with superior, elongated ovary with short style attached to a spear shaped, elongated, hairy stigma

Stamen is composed of eight free bilobed anthers with long slender filaments

(b) (i) Explain the significance of the arrangement of florets of specimen J (04marks)

- Numerous florets make the inflorescence conspicuous and strengthen the fragrance to attract pollinators
- The colour change of florets with age signals to pollinators, like butterflies, which flowers are mature and/or offer nectar.
- The overall flat-topped shape of the flower cluster provides an ideal landing pad for butterflies, which are important pollinators for *Lantana*
- Encourages efficient foraging: Once a pollinator, like a butterfly, lands on the cluster, it can visit many individual flowers in one stop. This behavior encourages the insect to spend more time on the plant, increasing the chance of pollen transfer.
- Each floret arises from the axil of a bract for protection from mechanical damage.

(ii) State the differences between gynoecium of the florets of specimen J and specimen I. (03marks)

J-Lantana camara	I-bougnaivillea
Hooked shaped stigma	Spear shaped stigma
Short stigma	Long stigma
Short ovary	Long ovary
Round ovary	Elongated ovary
Longer style	Shorter style
Non-hairy stigma	Hairy stigma

- (c) (i) Rub the anthers of specimen I on a glass slide and observe them under medium power light microscope. Describe what you observe

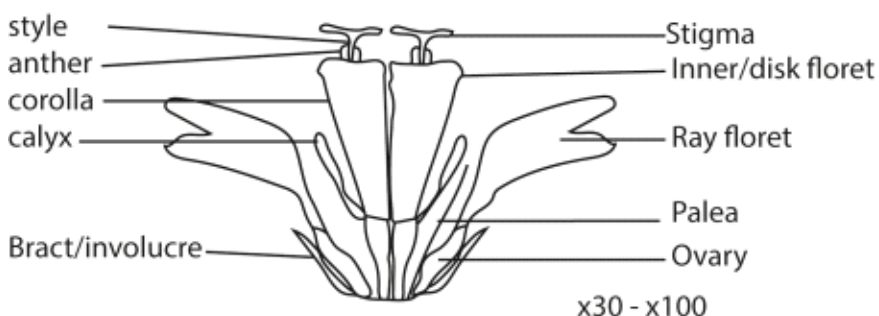
Small circular/round rough surface/wrinkled pollen grain

- (ii) From your observation c(i) state the mode of pollination of the floret of bougnaivillea. Give reason for your answer

Insect pollinated because pollen grains have rough surfaced that can easily stick on insect's hairy body/surface and later to the hairy stigma.(5 ½ marks)

- (d) Using a sharp blade, cut of the peduncle of specimen H. cut the remaining part longitudinally, slice a thin section longitudinally along the same plane from one half. Observe the slice under low power of light microscope. Draw and label

A drawing of longitudinal section of H observed using using hand lens



Activity 20

Materials

K – biden pilosa inflorescence

L – Commelina inflorescence

M – Lantana camara inflorescence

N – Bougainvillea inflorescence

O – Hibiscus flower

You are provided with specimens K, L, M, N, O which are plant organs.

(a) State the phylum of the plants from which specimens were obtained.

Angiospermatophyta/angiospermatophyta/spermatophyta

(b) (i) Examine the flowers or florets of each, and state three structural descriptive features indicated in table 3

Table 3

Flower or florets of specimen	Symmetry	Corolla	Calyx
K (Biden pilosa)	Actinomorphic/radial/regular (disk florets) Or zygomorphic (ray floret)	Small fused, open at apex, tubular at base	Free, slender, small, thin, pointed
L (Commelina)	Irregular/zygomorphic	Three, free variable sizes, smooth, thin, narrow at base	Free, small, smooth, curved
M (Lantana)	Actinomorphic	4/5 fused, small, tubular, smooth, broad at apex	Fused small short
N(Bougnaivillea)	Actinomorphic	5, fused, small, net veined	No calyx/absent
O(Hibiscus flower)	Actinomorphic	5, free, long, smooth, net veined, broad at apex	5, fuses, small, hairy

(ii) For each specimen, name the outermost part of the flower or floret and give one descriptive features of it. (05 marks)

Specimen	Descriptive features
K – sepal	Free, slender, small, thin, pointed, dull coloured
L-sepal	Three, varied sizes, free, small, curved, dull coloured
M- sepal	Short, fused, small, dull coloured
N – petal	5, fused, small, network veined, brightly coloured

O – Epicalyx

Six/seven, free, veined tapering

(c)(i) Using the features in (b), construct a dichotomous key to identify K, L, M, N and O (06marks)

- 1(a) zygomorphic flower go to 2
(b) Actinomorphic flower go to 3
- 2(a) Pointed sepal K
(b) curved sepals L
- 3(a) No sepal N
(b) sepal present 4
- 4(a) No epicalyx M
(b) Has epicalyx O

(d)(i) What is the structural limitation for the mode of pollination for florets of specimen K, L, M and N? (1½ marks)

They have small petals and hence inconspicuous to the pollinators

(ii) What is the structural advantage of specimen O to its mode of pollination?

Has large petals making it easily noticed by pollinators

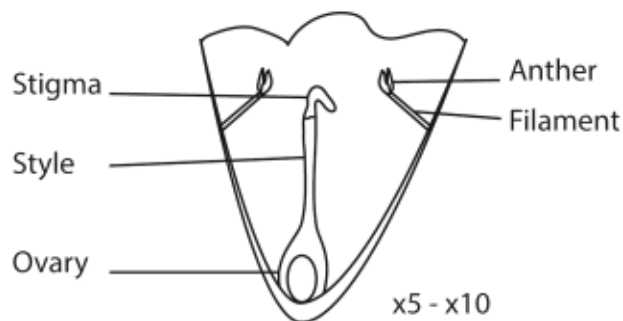
(iii) How has specimen N overcome the limitations in (d)(i)?

Each floret has a brightly coloured bract to attract pollinators.

(e) Obtain a floret from specimen M (lantana) and cut it longitudinally

(i) Draw one half of the floret and label essential parts

A drawing of longitudinal section of specimen M showing essential parts



(ii) How is the floret of specimen M adapted to its type of pollination?

Has both stamen and pistil/bisexual/hermaphrodite to allow self – pollination

Anthers above/higher than stigma for self-pollination

Activity 21

You are provided with specimens, C (banana inflorescence), D (cassia inflorescence), E (male maize inflorescence), and F (bougnaievillea inflorescence) which are inflorescences

(a) Observe each specimen and describe the pattern of arrangement of floret (04 marks)

C.....
.....

D.....
.....

E.....
.....

F.....
.....

(b) Remove a single floret from specimens C, D and E

(i) Give two descriptive features on each of the following floral parts of each floret.

Floral part	Floret of specimen C	Floret of specimen D	Floret of specimen E
Pistil			
Anthers			
Petals			

Bracts			
--------	--	--	--

- (ii) With reference to the information in the table in b(i) , state how the florets from specimens D and E are adapted to their modes of pollination.

Florets from D

.....

.....

.....

Florets from E

.....

.....

.....

- (iii) Remove one floret from specimen F. Cut it symmetrically into two halves. Observe the internal structure using a hand lens. Draw on half of the floret and label only the essential reproductive floral structures.

Activity 23

You are provided with specimens

C	male maize flower
D	Bean flower
E	Hibiscus flower
F	Ipomea batatus flower

- (a) Give six differences between specimen C and specimen D and four differences between specimen E and F.

Specimen C	Specimen D
Has ovary	Has no ovary
Has brightly colored petal	Has no petals
Has sepal	Has no sepals
Has no bract	Has bracts
Has 10 stamen	Has 3 stamen
Has nectar	No nectar
Has stigma	Has no stgm

Specimen E	Specimen F

(b) Give three characteristics features of each specimen.

C.....
.....
.....

D.....
.....
.....

E.....
.....
.....

F.....
.....
.....

(c) Using only the features in (b) construct a dichotomous key to identify the specimens

(d) State the agent of pollination of each specimen and give adaptive structural features in each case.

C.....
.....
.....

D.....
.....
.....

E.....

 F.....

 ...

Activity 24

You are provided with specimens X (fern leaf) and Y (male maize inflorescence) which are plant organs.

(a) For both specimens;

(i) Describe the structure.

Specimen X.....

Specimen Y.....

(ii) State three structures similarities.

.....

(iii) State one functional similarity.

.....

(b) Remove one spikelet from specimen Y and carefully cut off one sorus from specimen X. observe the spikelet using a hand and the sorus using the low power of the microscope.

(i) State the descriptive features of the vegetative structures of;

The spikelet:-.....

The sorus:-.....

- (ii) Relate the descriptive features of the vegetative structures of the sorus to the role performed.

.....

.....

- (iii) Draw and label the sorus

Classify the plants from which the specimens were obtained according to the following taxa.

Specimen	Phylum	Class
X		
Y		

Fruits

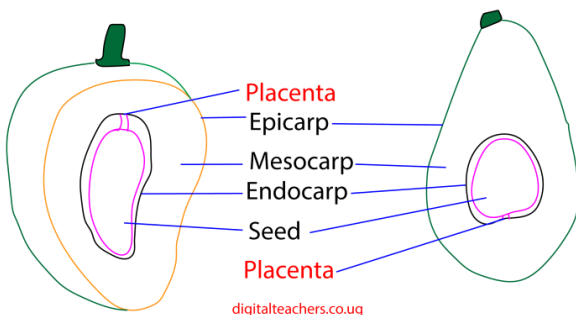
Fruits are classified as succulent/fleshy fruits and dry fruits

Succulent fruits

They are divided into **drupe**, e.g. mango and avocado and **berries** e.g. orange, tomato, passion fruits

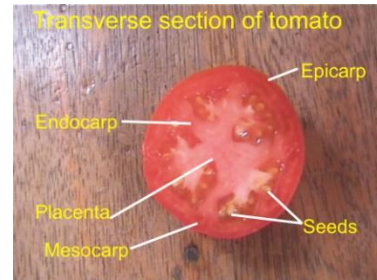
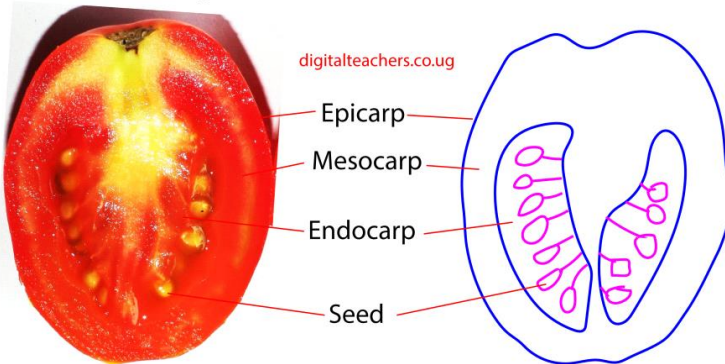
Drupe

Longitudinal section of a mango Longitudinal section of avocado

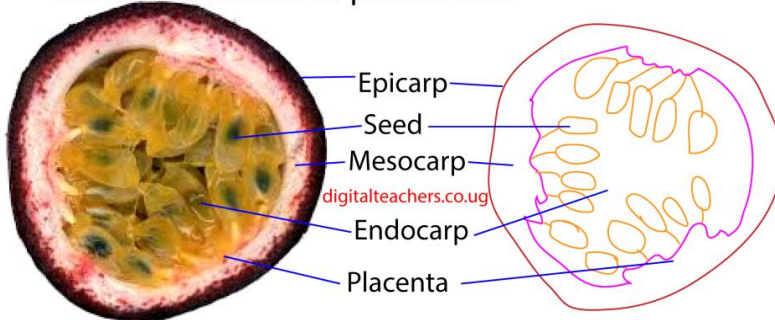


Berries

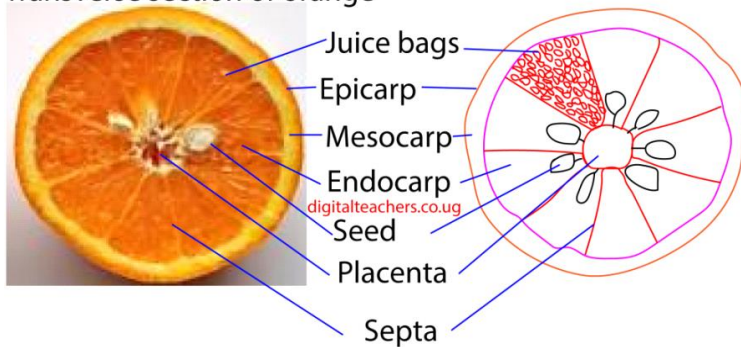
Longitudinal sections of a tomato



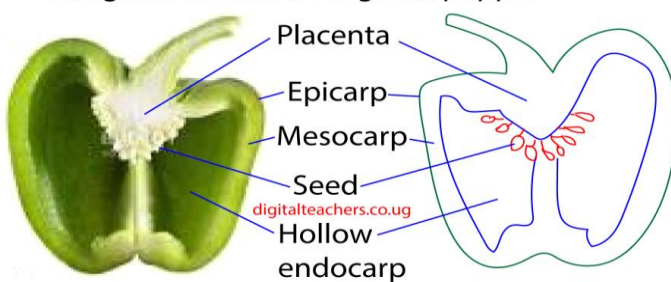
Transverse section of passion fruit



Transverse section of orange



Longitudinal section of green pepper



Differences between drupes and berries

Drupe	Berries
One seed	Many seeds
Woody endocarp	Fleshy/hollow endocarp

Activity 25

Requirements

P –unripe mango/Ovacado, Q – bean pond, R – orange, S – cucumber, T – green pepper, U – unripe pawpaw

You are provided with specimens P, Q, R, S,T and U

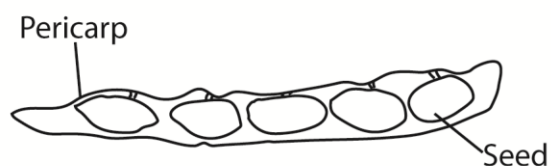
- (a) Open specimen Q longitudinally and cut the rest transversally.
- (b) Describe the seed arrangement in each of the following specimen
- P (Mango/Ovacado): one large seed at the centre/middle/within a single chamber
- Q (bean): many seeds attached along the side/margin/peripheral/on one side of the pericarp
- R (Orange): many seeds radiating outwards from the central point/placenta/in circular pattern
- S (cucumber): many seeds suspending/radiating/pointing inwards at $\frac{3}{4}$ point/sites, in a regular manner
- T (Green pepper) many seeds clustered/crowded/concentrated, on/at central placenta
- (c) (i) Give two internal features common to both specimen T and U
- Both have placent
 - Possession of many seeds
 - Mesocarp fleshy/succulent, rej. Edible/color
 - Large open/open locule/ hollow
- (ii) State one difference in internal structures of specimen T and U

Specimen T	Specimen U
Central placenta	Peripheral placenta
Posses septa/divided locule	No septum/undivided locule
Thin mesocarp	Thick mesocarp

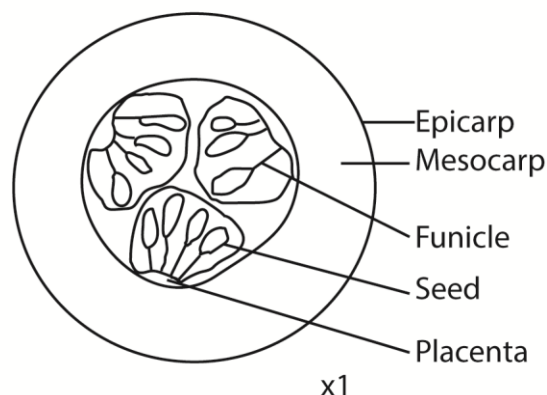
Rej. Types of placentation

- (d) Draw and label section of specimen S and half of specimen Q which is containing seeds

A drawing of section of Q (bean pod)



A drawing of section of S (cucumber)



(e) Limiting yourself to the internal features of specimen construct a dichotomous key to identify the specimens in that order.

- 1(a) One seed P
- (b) Many seeds go to 2
- 2(a) Solid/fleshy endocarp go to 3
- (b) Hollow endocarp got to 4
- 3(a) One seed per locule R
- (b) Many seeds per locule S
- 4(a) Central placenta T
- (b) Peripheral placenta U

Activity 26

You are supplied with fruit specimens

W	Tomato
X	Avocado
Y	Passion fruit
Z	Orange

(a) Make longitudinal cuts of each of the fruits W and X to obtain equal parts.

(b) Draw and label all structures seen in the one half of W .

(i) State two structural similarities between W and X.

.....

.....

.....

(ii) State six structural differences between W and X.

	W	X
(i)		
(ii)		
(iii)		
(iv)		
(v)		
(vi)		

- (c) Carry out the following experiment to determine the amount of ascorbic acid (vitamin C) in fruits W, Y and Z.

Proceed as follows:

- (i) Mash W in a mortar and with the help of a glass rod and funnels squeeze the juice 2cm^3 through a muslin cloth into a test tube labeled W.
- (ii) Repeat the procedure above with fruit Y and Z, using a fresh muslin cloth each time.
- (iii) Label three small beakers W, Y, Z and to each add EXACTLY 2.0 cm^3 of (0.1%) DCPIP and 5.0 cm^3 of (1M) glacial acetic acid. The blue colour in each beaker will turn pink.
- (iv) Using a graduated pipette, draw up the fruit juice W and note the amount drawn up. Slowly run it drop wise into beaker W with constant shaking until the pink colour in the beaker disappears, leaving the colour of the original fruit juice. Note and record the volume of juice used to neutralise 2.0 cm^3 of DCPIP.
- (v) Repeat procedure (iv) for fruit juice Y and Z, using a clean pipette each time.
- (vi) Tabulate your results below:

Sample	Volume of juice used (cm^3)
W	
Y	
Z	

- (d) You are given that 2 cm^3 DCPIP is equivalence to 0.2 mg of vitamin C.

- (i) Calculate how much vitamin C is present in each sample volume used to neutralise 2.0 cm^3 DCPIP?
- (ii) Calculate the amount of vitamin C in 100cm^3 of each sample. Show clearly your working. Enter the results in the table below.

.....

.....

.....

.....

Results:

Sample	Amount of Vitamin C in 100cm ³ in (mg)
W	
X	
X	

(iii) Which fruit has the highest concentration of vitamin C?

.....

(iv) Give two reasons why vitamins are important in nutrition.

.....

Dry fruits

Can be classified as dehiscent fruits (when they break to release their seed) or indehiscent fruits those that do not break to release their seed.

Dehiscent Fruits

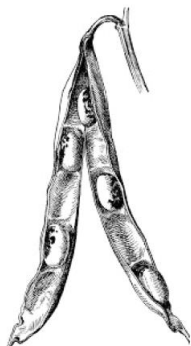
Dry fruits which at maturity open by definite natural means to shed the contained seeds. They are classified according to line of sutures.

- (i) **Follicle** A dry dehiscent fruit developed from 1 carpel and at maturity splitting along only one suture. (larkspur, delphinium)
- (ii) **Legume** A dry dehiscent fruit developed from 1 carpel and at maturity splitting along both the dorsal and ventral sutures, e.g. beans, peas.
- (iii) **Capsule** A dry dehiscent fruit developed from several carpels e.g. Dutchman's capsule.

Dehiscent fruits



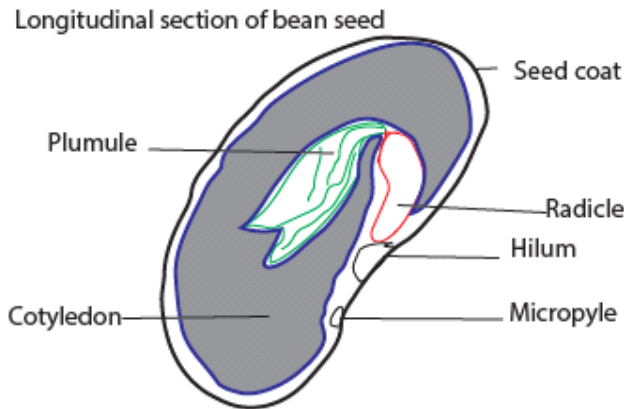
Follicle has one line of suture e.g. larkspur, columbine



Legume has two lines of suture e.g. bean and peas



Capsule has many lines of suture e.g. dutchman's capsule



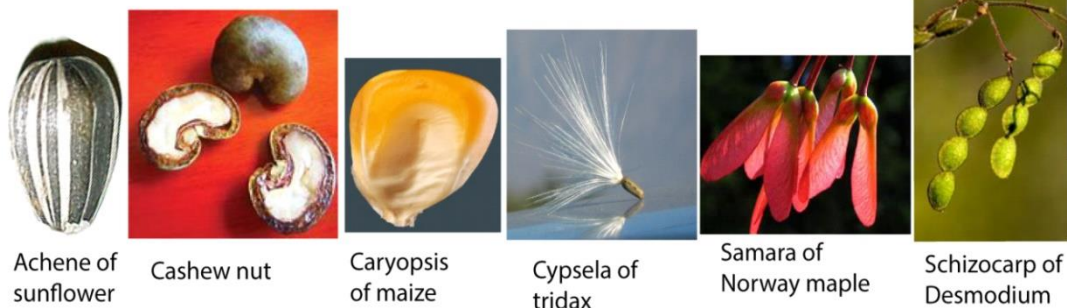
Uses of parts of bean seed

- (i) seed coat protects inner parts of the seed
- (ii) Plumule grows into shoot system
- (iii) Radicle grows into root system
- (iv) cotyledon stores food reserves and protects the embryo
- (v) Micropyle allows in pollen nucleus during fertilization and water during germination
- (vi) Hilum attachment of to plant during development

Indehiscent fruits

Dry fruits which do not open when mature to shed their seeds. Many of this group are one seeded fruits.

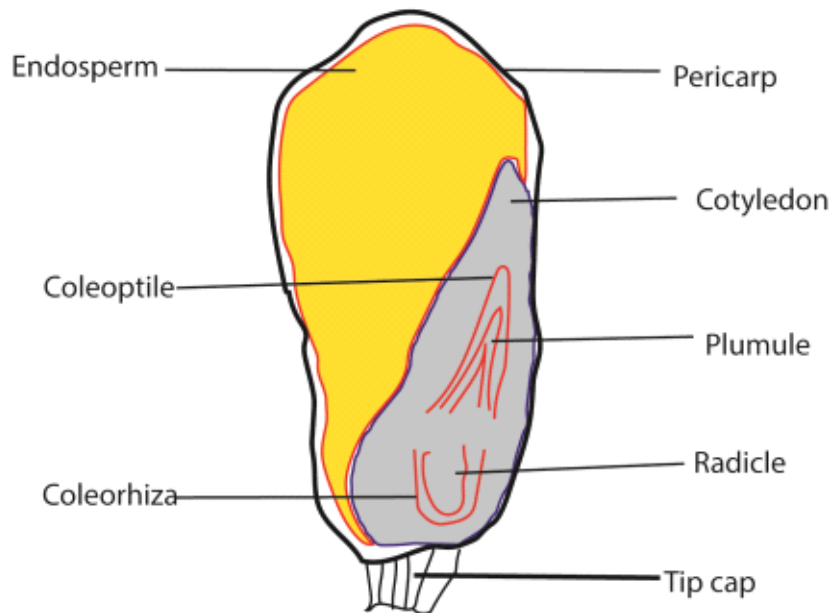
Indehiscent fruits



- (v) **Achene** - A one-seeded, dry, indehiscent fruit; the one seed is attached to the fruit wall at a single point. (buttercups, dandelion, sunflower).
- (vi) **Nut** - A dry, indehiscent, one seeded fruit similar to an achene but with the wall greatly thickened and hardened. (beech, chestnut, oak, hazel; walnut and hickory - note: because of extrafloral bracts, or "husk", the latter two fruits are sometimes called "drupes").
- (vii) **Samara** - A one- or two-seeded dry, indehiscent fruit in which part of the fruit wall grows out into a wing. (elm, maple, ash).
- (viii) **Caryopsis** - A one-seeded dry, indehiscent fruit in which the fruit wall and the seed coat are fused. (wheat, corn, grasses).

- (ix) **Schizocarp** - A fruit formed from several carpels, each carpel of this pistil enclosing a single ovule, at maturity the carpels separate as separate indehiscent fruits. (mallow, wild carrot, dill).

Longitudinal section of maize fruit



Functions of parts of maize fruit

Pericarp protects the internal parts

Endosperm stores food reserves

Cotyledons protect and nourishes the embryo

Coleoptile protects the plumule

Plumule grows into shoot system

coleorhiza protects the radicle

Radicle grows into root system

Phylum: Arthropods

General characteristics

- (i) have segments bodies
- (ii) have exoskeleton
- (iii) have jointed legs
- (iv) they have a dorsal heart with open vascular system

Class Diplopoda

Characteristics

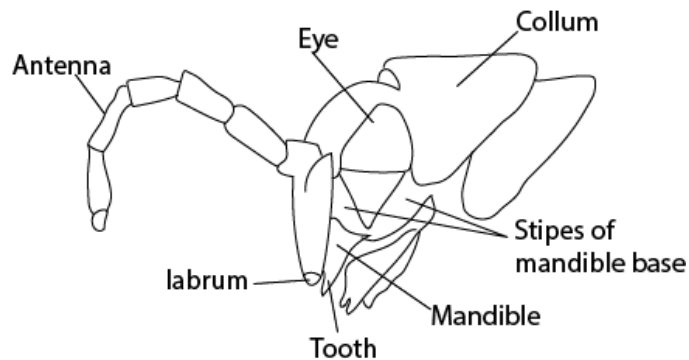
- (i) their bodies are cylindrical with numerous segments that are similar except around the head region.
- (ii) Each segment has two pair of walking legs
Example: millipede



Adaptations of millipedes to the environment

- (i) Exoskeleton prevents excess water loss.
- (ii) Has a dark color for camouflage from predators.
- (iii) Have eyes to see food and predators.
- (iv) Have legs for locomotion to look for food and run away from predator.
- (v) Has strong mandible for chewing.

Detailed structure of the head of a millipede



Adaptations of the head of a millipede to survival of organism

- (i) Eyes to see food
- (ii) Strong mandibles for feeding
- (iii) Antennae for feeling

Economic importance

- (i) Millipedes are herbivores and pest to farm crops.
- (ii) They burrow and aerate the soil and improve drainage.
- (iii) Death and decomposition add nutrient to the soil

Class: Arachnida

Characteristics

- (i) the body is divided into two main body parts, cephalothorax and abdomen
- (ii) have no antennae
- (iii) have four walking legs on cephalothorax

Examples



Spider



Tick

Adaptations of the tick to the mode of life

- (i) Hard cuticle to prevent water loss and protects in parts
- (ii) Has dark color for camouflage
- (iii) Has strong teeth to cling on the host
- (iv) Has eyes to look for host.

Economic importance Arachnida

- (i) Tick and mites are parasites to domestic animals
- (ii) Tick spreads diseases to man e.g. coastal fever
- (iii) Spiders feed on vectors.
- (iv) Scorpions and spiders inflict fatal stings

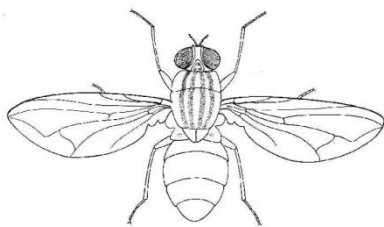
Class: Insecta

Characteristic

- (i) has three main body parts; head, thorax and abdomen.
- (ii) Has three pairs of legs.
- (iii) Thorax is divided into pro-, meso-, and metathorax.

Housefly

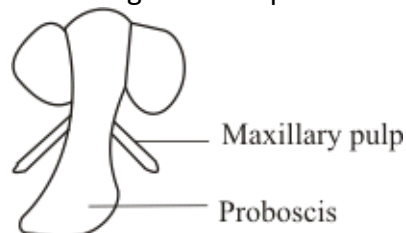
Order: Diptera



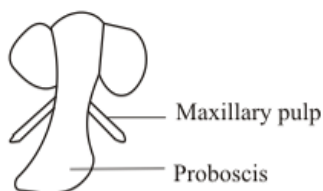
Characteristics of housefly

- (i) has a pair of compound eyes for wide field of vision.
- (ii) has expanded or club shaped proboscis to absorb food materials
- (iii) has a pair of wings and a pair of halteres for balancing.
- (iv) Has prominent movable head
- (v) The body is hairy.
- (vi) Has a pair of short hairy antennae.

A drawing of mouthpart of housefly



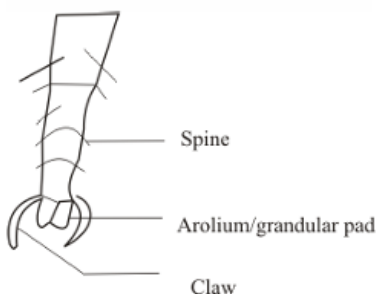
A drawing of mouthpart of housefly



Adaptation of housefly mouth parts

- maxillary pulps are flexible for handling and tasting food.
- Proboscis is expanded to increase absorptive surface.
- Proboscis is tubular to suck liquid food

A drawing showing the tarsus of the hind limb of a housefly



Ecological significance of the structures of a tarsus of housefly

- (a) claws are for gripping on to the surface during walking
- (b) hairs increase sensitivity
- (c) jointed legs increase flexibility
- (d) Arolium secrete a sticky substance that allows them to stick on smooth surface during walking.

Economic importance

Transmits diseases e.g. dysentery, cholera, trachoma, typhoid fever and poliomyelitis.

Control of spread of diseases by housefly

General cleanness and hygiene

Cover food

Eat hot food.

Use insecticides.

Order: Blattodea

Cockroach



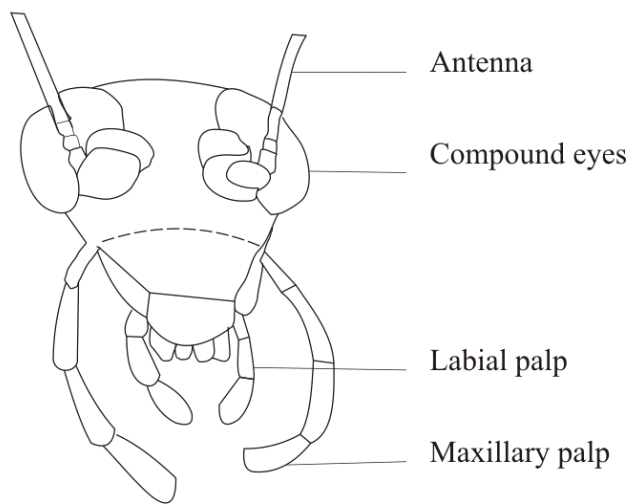
Characteristics

- (i) Has an oval, dorso-ventrally flattened body that helps them squeeze into tight spaces.
- (ii) has **pronotum** - a shield-like plate largely or completely covering the head
- (iii) it possesses generalized chewing mouthparts.
- (iv) has long, thin, and flexible antennae.
- (v) Has forewings that are thick and leathery, covering the membranous hind wings.

The head of cockroach

It is triangular

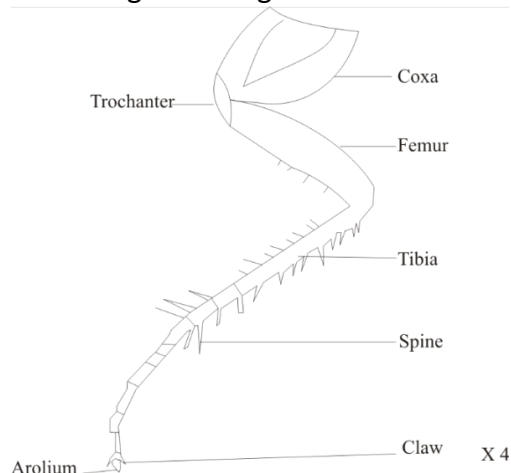
Anterior View of cockroach head showing structures for sensitivity



Adaptations of the cockroach head for its ecology

- (i) **Flattened, oval-shaped body:** A cockroach's body is dorsoventrally flattened and flexible, allowing it to squeeze into extremely narrow cracks and crevices to hide from predators or seek shelter. This design also helps it withstand significant crushing forces.
- (ii) **Tough, waxy exoskeleton:** Made of a strong yet flexible material called chitin, the exoskeleton provides structural support and protects internal organs from physical damage. Its waxy coating is water-impermeable, which helps prevent dehydration and is crucial for survival in arid environments.
- (iii) **Long, spiny legs:** These are designed for rapid movement, enabling cockroaches to run very quickly to escape danger.
- (iv) **Hooked claws:** Found on their legs, these allow them to climb on various surfaces, including walls and ceilings.
- (v) **Cerci:** These tail-like sensory organs at the back of the abdomen are highly sensitive to air currents and vibrations. This early-warning system allows a cockroach to detect approaching threats and respond before its brain registers the danger.
- (vi) Has modified mouth parts with strong mandibles for feeding.
- (vii) Pair of compound eyes for vision

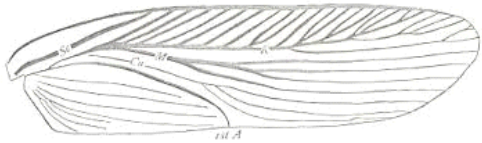
A drawing of the leg of a cockroach



Wings of a cockroach

The cockroach has two pairs of wings, outer and inner wing

Differences between outer and inner wings

 Outer wing	 Inner wing
1. Dark colored 2. inflexible 3. not folded 4. Thick 5. narrow 6. opaque	1. Light in color 2. flexible 3. folded 4. membranous 5. broad 6. transparent

Adaptations of wing to their functions

Outer wings	Inner wings
(i) it is hard or stiff for protection (ii) dull / dark colored for camouflage (iii) slippery for protection against grip of predator (iv) has veins for strengthening the wing	(i) broad to generate repulsive force for flight (ii) flexible not to break in strong wing (iii) has veins for circulation of gases and strengthening the wing

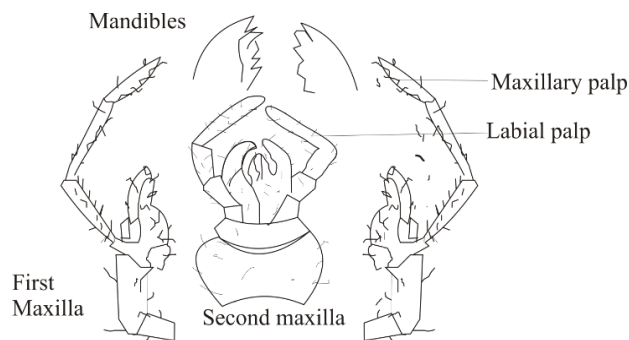
Identifications of the sex of a cockroach

Structures on ventral side of the last segments are used:

Male cockroach has styles while female cockroach has podical plates.



Mouth parts



Functions of mouth parts of a cockroach

A table below shows the functions and adaptations of the mouth parts of a cockroach

Parts	Functions	Adaptations
Mandible	Cutting and masticating food	Strong and sharp edges
Maxillae	Cutting and chewing food	Have sharp edges
Maxillary palp	Taste food	(i) sensitive to food (ii) jointed for flexibility (iii) hairy to increase sensitivity
labium	Taste food	Hairy to increase sensitivity

Economic importance

- (i) Transmit germs from the toilets
- (ii) Their feces stain clothes
- (iii) Destroy document and clothes

Order: Hymenoptera

Bee

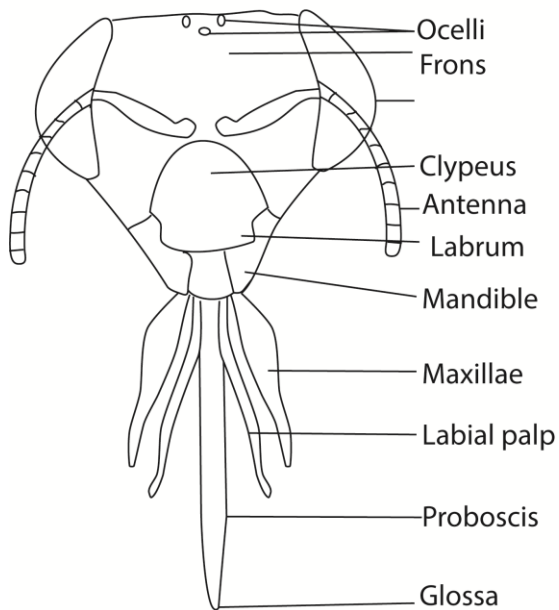


Characteristics of the order

- (i) have two pairs of membranous wings
- (ii) have a waist between the thorax and abdomen
- (iii) They live in colonies

- (iv) Has **modified mouthparts**, i.e. have chewing mandibles, bees have a unique elongated proboscis for sucking nectar.

Head of a bee



Thorax of a bee

- (i) Bears 3 pairs of legs
- (ii) Has hymen between the thorax and abdomen
- (iii) The third pair of legs have the tibia deeply grooved to form a pollen basket that retain pollen

Leg of a bee



Abdomen

- (i) abdomen constricts anteriorly to form a waist but tapers at the posterior end
- (ii) the last segment has a sting
- (iii) it is hairy

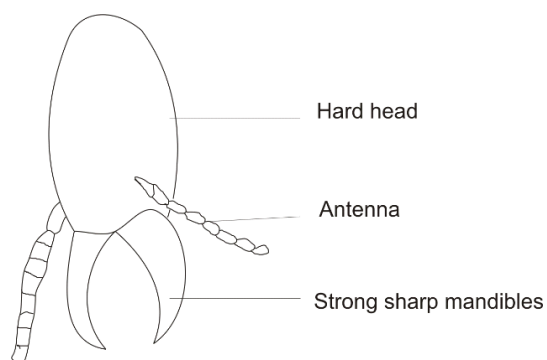
Differences between a bee and a housefly

Bee	Housefly
2pairs of wings	One pair of wings
Lack halteres	Has a pair of halteres
Hind limb has pollen basket	Hind limbs lack pollen basket
Has enlarged /thickened tibia	Tibia shorter/not enlarged
Abdomen cuticle thickened/hardened	Abdomen cuticle thin
Has proboscis and mandible	Has only proboscis
Pointed proboscis	Expanded proboscis
Has sting on last segment of abdomen	Lacks sting
Has no simple eyes	Has simple eyes
Has tapering abdomen	Has rounded abdomen

Order: Isoptera

Termites

Soldier termite



Economic importance

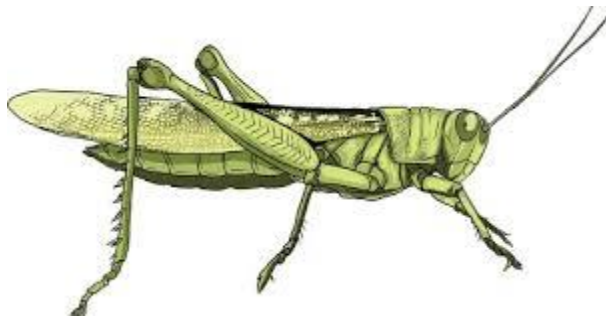
- (i) turns the soil over to keep it loose and aerated
- (ii) source of food
- (iii) destroy wooded properties
- (iv) destroy plants

Worker termite



Order: Orthoptera

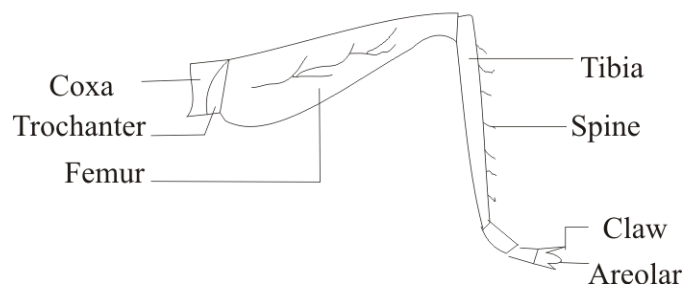
Grasshopper



Characteristics

- has cylindrical body
- large compound eyes
- chewing mouth parts
- thread-like antenna
- long muscular hind legs for jumping

A drawing of hind leg of a grasshopper



Adaptations of hind limbs to its function

- muscles to create a repulsive force during movement
- jointed for flexibility

- (iii) long for quick movement
- (iv) arolium allow grip on smooth surface
- (v) crawls enable the grasshopper to grip to cracked surface
- (vi) spines pinch the enemy during defense

Difference between the hind limbs of a bee and grasshopper

Hind limb of grasshopper	Hind limb of a bee
No pollen basket	Has pollen basket
No pollen comb	Has pollen comb
Has spine	Has no spines
hairless	Has hairs
Thick and expanded femur	Has thin and short femur

Order: hymenoptera

Wasp



Characteristics

- (i) has two pairs of membranous wings
- (ii) has a narrow waist between the thorax and abdomen
- (iii) has three main body parts; head, thorax and abdomen.
- (iv) Dark colored for camouflage

Order: hymenoptera

Sugar ant



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Activity 27

Requirements

F = soldier termite

G = tick

- (a) State one visible feature shown by both specimens F and G which are characteristics of a major group
- Segmented body
 - Exoskeleton
 - Jointed appendages
- (b) Identify the class of F and G
- F – insecta
- G- arachnida
- (c) State the differences between F and G

F (soldier termite)	G (tick)
Three main body parts	2 main body parts
3 pairs of legs	4 pairs of legs
Has antennae	Has no antenna
Has unsegmented abdomen	Has segmented abdomen
Has compound eyes	Lack compound eyes.

Activity 28

Requirements

Specimens E(spider), F (soldier termite), G(tick), H(bee), I(housefly) and J (cockroach) to same kingdom

- (a)(i) Giving two reasons name the phylum of the specimen
- Phylum: Arthropoda
- Reasons
- (i) Exoskeleton
 - (ii) Segmented body
 - (iii) Jointed appendages
- (ii) Name the class of the specimens
- Class for E and G : Arachnida
- Reasons
- (i) the body is divided into two main body parts, cephalothorax and abdomen
 - (ii) have no antennae
 - (iii) have four walking legs on cephalothorax

Class for F, H,I and J: Insecta

Reasons

- (i) has three main body parts; head, thorax and abdomen.
- (ii) Has three pairs of legs.
- (iii) Thorax is divided into pro-, meso-, and metathorax.

(c) How is specimen G adapted to its mode of life?

- (i) Hard cuticle to prevent water loss and protects in parts
- (ii) Has dark color for camouflage
- (iii) Has strong teeth to cling on the host
- (iv) Has eyes to look for host.
- (v) Has legs for locomotion

(iv) Distinguish between H and I

H (Bee)	I (Housefly)
2pairs of wings	One pair of wings
Lack halteres	Has a pair of halteres
Hind limb has pollen basket	Hind limbs lack pollen basket
Has enlarged /thickened tibia	Tibia shorter/not enlarged
Abdomen cuticle thickened/hardened	Abdomen cuticle thin
Has proboscis and mandible	Has only proboscis
Pointed proboscis	Expanded proboscis
Has sting on last segment of abdomen	Lacks sting
Has no simple eyes	Has simple eyes
Has tapering abdomen	Has rounded abdomen

(v) Using the features on the head and thoracic only construct a dicotymous key for the species

- 1(a) Four pairs of legs 2
- (b) Three pairs of legs go to 3
- 2(a) Hard cuticle G
- (b) Soft cuticle E
- 3(a) Sucking mouth parts..... 4
- (b) Chewing mouth parts 5
- 4(a) A pair of halteres present I
- (b) Halteres absent H
- 5(a) No wings.....F
- (b) Two pairs of wings J

Food test

Precautions followed when carrying out food tests

- (i) Work systematically. **Do not panic** because the practical time is more than necessary.
- (ii) Use clean apparatus like droppers, test tubes or boiling tubes as dirty apparatus especially contaminated droppers will affect your results.
- (iii) Avoid interchanging droppers in test solutions or reagents. Or **DO NOT USE ONE DROPPER** in more than one solution or reagent.
- (iv) Pick the correct food solution/substance and/or the reagent to avoid wrong results.
- (v) Use the measurements you have been told, use as little as possible solutions and reagents in order to get clear results.
- (vi) Stir the solutions before as some food substances like starch tend to settle down the beaker.
- (vii) Record the color changes that you observe not what you think or know e.g. if the colour of Benedict's turns from blue to green only, record that do not force to red colour this is because the colour series appears due to the quantity of the food substances present.
- (viii) Record your observation in past tense e.g. persisted, remained, turned or present tense. **NOT FUTURE** tense as 'will turn' 'will persist'.
- (ix) Do not use lyrics like bluish, darkish, brownish, greenish, and blackish.
- (x) Statements such as no colour change; no change must not be used when making observations
- (xi) When asked to carry out a test one should always write down the test, reagent used in the test column before making the observations and conclusions.
- (xii) Do not boil where you are not instructed and do not fail to boil where you are instructed to do so.
- (xiii) When stating your observation use simple language everyone can easily understand. Avoid using terms that are difficult for the examiner to interpret, such as 'Yellowish-green'. Think about what is important- perhaps it that this tube is darker or light green than that tube. Using simple language such as 'dark green' or a lighter green than tube I' is fine.

Testing for starch

Test	Observations and Deductions	
To 1 cm ³ of food mixture add 3 drops of iodine solution	Solution turn blue  Starch present	Solution remain brown  Starch absent

Testing for reducing sugars

Test	Observations and Deductions	
To 1 cm^3 of food mixture add equal amount of Benedict's solution and boil for 1 minute	Colour changes from blue to green to yellow to orange precipitate  Reducing sugars present	Blue colour persist  Reducing sugars present
NB: the final color can be used to quantify the amount of reducing sugars in solution. Blue –none; Green – trace; Yellow – moderate and Orange ppt. - much		

Note that when required to write a test procedure, the **quantity** of food extract, **reagent** and **time** must be specified. For instance, to 1 cm^3 of food extract, add 1 cm^3 of Benedict's solution and boil for **1 minute**.

Testing for non-reducing sugars

NB: We can test for non-reducing sugars only when the test for reducing sugars is negative.

Test	Observations and deductions	
To 1 cm^3 of food mixture add 1 cm^3 dilute HCl boil and cool, add 1 cm^3 of NaOH and 1 cm^3 of Benedict's solution and boil for 1 minute	Colour changes from blue to green to yellow to orange precipitate  Non-reducing sugars present	Blue colour persist  Non- reducing sugars absent
NB: the final color can be used to quantify the amount of non-reducing sugars in solution. Blue – none; Green – trace; Yellow – moderate and Orange ppt – much HCl – Hydrolyses non- reducing sugars to reducing sugars NaOH – neutralizes excess acid because Benedict's solution does not work in acidic medium		

Testing for proteins

Test	observations	Deductions
Burret's test To 1 cm³ of food mixture add 1 cm³ of sodium hydroxide solution followed by 3 drops of copper sulphate	The purple or violet color appears  Proteins present	A blue precipitate formed  Proteins absent
The deeper the purple color the higher the amount of proteins present		

Testing for Vitamin C

Test	observations	Deductions
³ To 1 cm³ of DCPIP add food mixture drop wise until no further change	DCPIP turns colorless  Vitamin C present	The color of DCPIP remains  Vitamin C absent
Note that: (i) The fewer number of drops required to decolorize a given volume of DCPIP, the higher the concentration of vitamin C in the solution. This can be used compare the relative amount of vitamin C in different solutions (ii) Solutions that contain vitamin C give a positive test with Benedict's solution (iii) Solution that contain decolorize iodine solution so do not get confused		

Effect of heat on ascorbic acid

Higher temperatures accelerate the degradation of ascorbic acid, as it is a thermolabile compound susceptible to oxidation. Therefore, exposure to heat, especially prolonged and excessive, leads to significant losses of vitamin C content in foods like fruits and vegetables. The extent of vitamin C loss at different temperature and time of exposure can be explored by determining the number of drops required to decolourise a given amount of DCPIP solution after such exposure.

Biological significance of the effect of heat on Vitamin C

Storage and/or processing of fruits or foods at lower temperatures helps to preserve ascorbic acid level

Activity 29

Requirements

S – (ripening orange)

1% DCPIP

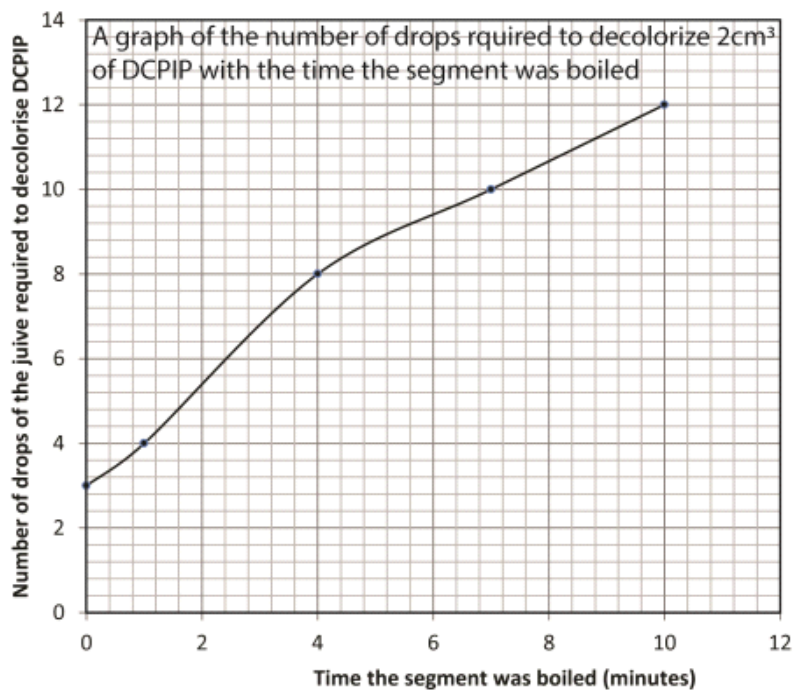
You are provided with specimen S. You are required to carry out tests on the specimen using the procedure provided in the question below

Procedure

- (i) Label test tubes A, B, C, D and E
- (ii) Peel specimen S, choose five large locular segments and separate them individually.
- (iii) Squeeze the juice from segment into a test tube A
- (iv) Place the remaining four segments in a beaker of boiling water and start a clock immediately.
- (v) Remove one segment at a time after 1 minute (B), 4 minutes (C), 7 minutes (D) and 10 minutes (E).
- (vi) Squeeze the juices from cold segments B, C, D and E into respective test tubes
- (a) To 2cm³ of DCPIP solution in a test tube add juice from test tube A drop wise and count the number of drops required to decolorize DCPIP.
- (b) Repeat procedure (a) with juices from B, C, D and E. Record your results in the table below

Juice	Duration the segment was boiled	Number of drops of juice required to
A	0	3 - 10
B	1	4 - 15
C	4	8 – 26
D	7	10 – 30
E	10	12 - 35

- (c) Represent your results on a graph below



(d)(i) State the conclusion drawn from the results

Boiling decreases the concentration of vitamin C with time.

(ii) State two explanations for your answer

- Boiling destroys/breaks down/ oxidizes vitamin C, the longer the boiling the higher the percentage destruction of vitamin C.
- Boiling makes the locules permeable and leaches out vitamin C or vitamin C diffuses out reducing the concentration of vitamin C in the locule; the longer the boiling the more vitamin C diffuses out

(ii) Suggest how one of the suggestions in (c)(i) can be verified

Test the water from which the locule was boiled for vitamin C.

(e) What is the significance of your results from the test

- fruits should not be boiled and should be eaten fresh
- fruits should be stored in cool places
- Fruits and vegetables should not be boiled for a long time so that vitamin C content does not reduce.

Testing for lipids

Test	observations	Deductions
Add a drop of food on a piece of paper and dry it on a Bunsen flame	A translucent mark formed  Lipids present	No translucent mark formed  Lipids absent

NB: The colour changes will indicate the amount of food substances present e.g.

- (i) Benedict's blue colour changes to green only then little reducing sugars present
- (ii) Benedict's blue colour turns to green, yellow then moderate reducing sugars present.
- (iii) Benedict's blue turns to green, yellow, orange or red, then much reducing sugars present.
- (iv) Iodine brown colour to black then much starch present.
- (v) Traces of purple or violet then little proteins present
- (vi) Purple or violet observed then much proteins present.

Activity 30

Requirements

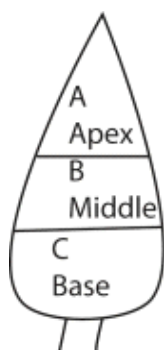
M – pineapple ripe at the bottom only

N1 – raw banana

N2 – ripe banana

You are provided with specimen M (pineapple slice), N1 and N2 which are plant parts

- (a) Peel specimen M and cut it into three parts namely, apex, middle and base as shown in the figure below



Put apex in a mortar and grind using a pestle. Decant at least 4cm³ of the juice into a test tube, add an equal amount of water and label extract S

Clean the mortar and pestle and repeat the procedure to obtain extracts B and C from middle and base of M respectively.

Carry out a DCPIP test, Benedict's test and biuret test on each extract and record your observation and deductions in the table below. For DCPIP test, record the number of drops of extracts required to decolorize DCPIP.

Test	Observations/number of drops	deductions
DCPIP test To 2cm ³ of DCPIP solution add extracts A/B/C drop wise until in excess	A: 4-6 drops	Much vitamin C present
	B: 6-7 drops	Moderate vitamin C present
	C: 10- 18	Little vitamin C present
Biuret test To 1cm ³ of solutions A/B/C add 1cm ³ of sodium hydroxide solution, followed by 2/3/4 drops of CuSO ₄ solution	A: turbid/colourless/ yellow solution turned to blue; then to pale purple	No/little protein present
	B: turbid/colourless/ yellow solution turned to blue; then to pale purple	No/little protein present
	C: turbid/colourless/ yellow solution turned to blue; then to pale purple	No/little protein present
Benedict's test To 1cm ³ of extract A/B/C add 1cm ³ of Benedict's solution and boil for 1 minute	A: turbid/colourless/ yellow solution turned to blue, to green then to yellow	Moderate reducing sugar present
	B: turbid/colourless/ yellow solution turned to blue, to green then to yellow to orange ppt.	Much reducing sugar present
	A: turbid/colourless/ yellow solution turned to blue, to green then to yellow, to orange to red ppt.	Very much reducing sugar present

(b) Describe the pattern of distribution of food substances in specimen M

- (i) The amount of vitamin C decreases from apex to base
- (ii) The amount of reducing sugars increases from apex to base
- (iii) The amount of proteins decrease from apex to base/accept remain the same.

- (c) Specimen N1 (raw banana) and N2 (ripe banana) are parts of a fruit at different stages of development. Peel and cut from each specimen, a piece measuring 3cm x 3cm x 3cm. Using a mortar and pestle, grind the pieces of N1 into paste, and 10cm³ of water, stir well and leave to settle. After settling decant of the solution and label it E. Repeat the procedure using the piece from N2 and label it F. Carry out an iodine test, a Benedict's test and Biuret test on each solution. Record your observations and deductions in Table 2.

Iodine test To 1cm ³ of solutions E/F add 2/3/4 drops of iodine solution	E: turbid/colourless solution/suspension turned to black	Much starch present
	F: turbid/colourless solution/suspension formed blue specs	little starch present
Benedict's test To 1cm ³ of extract E/F add 1cm ³ of Benedict's solution and boil for 1 minute	E: turbid/colourless solution/suspension turned to blue, to green then to yellow	Moderate reducing sugar present
	F: turbid/colourless solution/suspension turned to blue, to green then to yellow to orange ppt.	Much reducing sugar present
Biuret test To 1cm ³ of solutions E/F add 1cm ³ of sodium hydroxide solution, followed by 2/3/4 drops of CuSO ₄ solution	E: turbid/colourless solution/suspension turned to blue; then to pale purple	No/little protein present
	F: turbid/colourless solution/suspension turned to blue; then to pale purple	No/little protein present

- (d) (i) Describe the relationship between the distribution of food substances and the development of the fruit from which N1 and N2 were obtained

As the fruit ripens, the amount of starch decreases, the amount of reducing sugars increases while the amount of proteins does not change.

- (ii) From your results in table 2, comment on the suitability of the specimens N1 and N2 as the main diet for young child.

N1 and N2 are not suitable as main diet for your child because they contain trace proteins.

Activity 31

You are provided with solutions A (1% starch solution) and B (1% sucrose solution).

You are to investigate the action of saliva and dilute hydrochloric acid on these solutions

Procedure

- (a) (i) Test Put 1cm^3 of solution A and 1cm^3 of benedict's solution in a test tube and boil. Allow it to cool. Record your observation and conclusions in table 1 below. Repeat the same procedure with solution B.

Table 1.

Test	Observation	Conclusion
solution A + Benedict's solution, boil and cool	The solution turns blue and remains blue	Reducing sugars absent
Solution B + benedicts solution, boil and cool	The solution turns blue and remains blue	Reducing sugars absent

- (ii) Put 1cm^3 of solution A into each of the two test tubes labelled 1 and 2. Put 1cm^3 of solution B into each of other two test tubes labelled 3 and 4. Put all the four test tubes in a water bath maintained at $35 - 40^\circ\text{C}$. Rinse your mouth with warm water to remove any food particles and then collect 2cm^3 of saliva in a test tube. Dilute the saliva with an equal volume of distilled water, mix well. Put 1cm^3 of the diluted saliva into each of the test tubes 1 and 3. Put 1cm^3 of dilute HCl into each of the test tubes 2 and 4 and ensure thorough mixing. Leave the test tubes in the bath, shaking them well at regular intervals.

- (iii) After 5 minutes take a sample from each of the test tubes 1 and 3 add 5 drops of Benedict's solution and boil. To each of the test tubes 2 and 4, add 1cm^3 of sodium hydroxide followed by 5 drops of Benedict's solution and boil. Record your observations in the table below. Repeat stage (iii) with the remaining contents in test tubes 1 -4 after 30 minutes.

	Tests	After 5 minutes	After 30 minutes
1	Solution A + saliva	Blue solution turns green	Blue solution turns green then yellow
2	Solution A + dilute HCl	Blue solution remains blue	Blue solution remains blue
3	Solution B + saliva	Blue solution remains blue	Blue solution remains blue
4	Solution B + dilute HCl	Blue solution turns green then yellow and then brown ppt.	Blue solution turns green then yellow and then brown ppt.

- (b) From the results above, explain your observation for

Solution A: Solution A contains starch that was broken down to reducing sugars by amylase enzyme in saliva. However, hydrochloric acid provided unfavorable medium for amylase to act.

Solution B: Solution B contains non-reducing sugars that was broken down/hydrolysed to reducing sugars by HCl.

- (vii) What was the use of adding dilute sodium hydroxide solution to the test tubes 2 and 4 before carrying out Benedict's test? Sodium hydroxide neutralizes excess HCl because Benedict's solution does not work in acidic medium
- (viii) suggest with reason (s) what solution A and B are:
- (i) Solution A: Starch
Reason: It was hydrolyzed by amylase enzyme to reducing sugars
 - (ii) (ii) Solution B Non reducing sugars.
 - (iii) Reason
It was hydrolysed by HCl to reducing sugars

Activity 32

Requirements

B1 – 1% glucose +1% egg albumen

B2 – 1% sucrose + 1% starch

NaHCO₃ solution

Dil. HCl

Benedict's solution

Heat source

Copper sulphate solution

DCPIP Solution

You are provided with solutions B1 and B2 both of which are food mixture.

- (a) Using the reagents provided carry out tests on B1 and B2 for the food substances specified in the table below. Record your tests, observations and inferences in the table below.

Experiment	Solutions	Observations	inferences
Proteins Test To 1cm ³ of food mixture add 1cm ³ of NaOH solution followed by 2/3/4 drops of copper sulphate solution	B1	Turbid solution turns to intense/deep purple/violet solution	Much proteins present
	B2	Turbid solution turns to pale blue solution	Proteins absent

Starch test To 1cm ³ of solution in a test tube add ½ drops of iodine solution	B1	Turbid solution turns to brown	Starch absent
	B2	Turbid solution turns to black/deep blue	Much starch present
Reducing sugar test To 1cm ³ of solution add 1cm ³ of Benedict's solution and boil for 1 minute	B1	Turbid solution turns to blue which on boiling turns green solution, then yellow to red ppt.	Much reducing sugars
	B2	Turbid solution turns to blue solution and remains blue on heating	Reducing sugars absent
Non-reducing sugar test To 1cm ³ of solution add 3 drops of HCl, boil for 1 minute, cool, add 1cm ³ of NaOH solution, followed by 1 cm ³ of benedict's solution and boil for 1 minute	B1	Non applicable because it contained reducing sugars	
	B2	Turbid solution turns to blue which on boiling turns green solution, then yellow to red ppt.	Much non-reducing sugars present

- (b) (i) Obtain 6cm³ of the food mixture which you found to contain starch. Label 3 test tubes 1, 2, and 3 and add 2 cm³ of the mixture to each test tube.

Rinse your mouth with water and spit out 2 cm³ of saliva into a test tube. Dilute with an equal volume of water.

To test tube 1 add 1 cm³ of saliva.

To test tube 2 add 1 cm³ of saliva and 5 drops of sodium hydrogen carbonate.

To test tube 3 add 1 cm³ of saliva and 4 drops of hydrochloric acid.

Incubate all three test tubes in a water bath maintained at 37⁰C- 40⁰C for 20 minutes.

- (iv) Carry out tests for starch in all the 3 test tubes 1,2, and 3.

Test tube	Observations	Inferences
1	A purple solution on addition of iodine	moderate starch
2	A light purple solution on addition of iodine	little starch
3	Dark purple suspension	much starch

- (v) Give reasons for the results obtained in the test in (b) (i) above
- Test tube 2 contained least starch content because sodium bicarbonate provided a buffered favourable pH for the enzyme amylase to work faster and longer while test tube 3 had much starch because the action of amylase enzyme was inhibited by low pH provided by an acid.

Enzymes

Enzymes are biological catalysts that control the direction and rate of chemical reactions in and out of cells. Properties or characteristics of enzymes

Demonstrable properties of enzymes

- (i) They are specific in action
- (ii) Their activity increases with increase in concentration
- (iii) They work at an optimum PH range. pH may adjusted by adding either an acid or a base to the mixture

The optimum pH for common laboratory enzymes is given in the table below

Enzymes	Optimum PH
Pepsin	Acidic
Lipase	Alkaline
Salivary amylase	Neutral or slightly alkaline
Catalase	Neutral or slightly alkaline
Trypsin	Neutral or slightly alkaline

- (iv) They are denatured (destroyed) at high temperatures ($>60^{\circ}\text{C}$) and inactivated (slowed down) at low temperatures (ice cold) work best at optimum temperature, (usually $35^{\circ} - 37^{\circ}$).

A constant temperature is obtained using a water bath/plastic cup by adding hot or cold water and monitored by a thermometer.

Amylase enzyme

- (i) It digests starch to reducing sugars reducing sugar
- (ii) The test is carried out by putting Saliva or salivary amylase into the starch solution and incubate or put the test tube in a water bath at $35^{\circ} - 40^{\circ}\text{C}$ for about 30 – 60 minutes.

Positive results

Digestion of starch is indicated by

- Clearing of turbid suspension (insoluble starch being digest to soluble reducing sugars)

- Formation of reducing sugars/ positive Benedict's/Fehling's solution test
- Absence of starch by iodine test (though this is unlikely because the time for incubation may not be enough to digest all the starch).

Investigating the properties of amylase

Demonstrating the specificity of amylase enzyme

- (a) An unknown solution is added to a starch suspension and the mixture incubated at $35^{\circ}\text{C} - 40^{\circ}\text{C}$ for 1 hour. After 1 hour the mixture is tested for reducing sugar. Presence of reducing sugars shows that the unknown solution contained amylase enzyme.
- (b) When unknown solution that previously found to contain no reducing sugars is added to an amylase solution and a positive test for reducing sugars obtained after incubating the mixture at $35^{\circ}\text{C} - 40^{\circ}\text{C}$ for about 30 minutes; then the unknown solution contains starch. Hence we can use starch solution to identify amylase enzyme or amylase enzyme solution to identify starch solution.

Demonstration of effect of pH on action of amylase solution

- (a) Three test tubes are prepared as follows

Test tubes	content
T1	1cm^3 of starch solution + 1cm^3 of water + 1cm^3 of amylase solution
T2	1cm^3 of starch solution + 1cm^3 of 1M HCl + 1cm^3 of amylase solution
T3	1cm^3 of starch solution + 1cm^3 of 1M NaOH + 1cm^3 of amylase solution

- (b) The three test tube and their contents are incubated at $35^{\circ} - 40^{\circ}$ for 30 minutes
Results of Benedict's solution

Test tubes	Results of Benedict's solution
T1	Reducing sugars present
T2	No reducing sugars
T3	No or traces of reducing sugars

Explanation of results

Test tubes	Explanation of results
T1	Reducing sugars present because amylase enzyme works best at neutral or slightly alkaline pH.
T2	No reducing sugars because amylase enzyme is inhibited by acidic pH
T3	No or traces of reducing sugars because amylase enzyme works in slight alkaline but inhibited by strong alkaline solutions.

Hence the results of incubation may be used to identify the pH of the solutions added.

Demonstrating the effect of temperature on amylase enzyme

(a) Two test tubes are prepared as follows

Test tubes	content
T1	1cm ³ of 1% starch solution + 1cm ³ of amylase solution
T2	1cm ³ of 1% starch solution + 1cm ³ of boiled and cold amylase solution

(b) The two test tube and their contents are incubated at 35⁰ – 40⁰ for about 30 minutes and test for presence of reducing sugars

Results of Benedict's solution

Test tubes	Results of Benedict's solution
T1	Reducing sugars present
T2	No reducing sugars

Explanation of results

Test tubes	Explanation of results
T1	Reducing sugars present because amylase enzyme was active
T2	No reducing sugars because amylase enzyme was denatured

Hence the high temperature denatures amylase enzyme

Demonstrating the effect of concentration of amylase enzyme

(a) Two test tubes are prepared as follows

Test tubes	content
T1	1cm ³ of 1% starch solution + 1cm ³ of water + 1cm ³ of amylase solution
T2	1cm ³ of 1% starch solution + 2cm ³ of amylase solution

(b) The three test tube and their contents are incubated at 35⁰ – 40⁰. Test for absence of starch in each mixture every after 1 minute by adding a drop of iodine solution to a drop of each mixture on a white tile

Results of iodine test

Test tubes	Results of Benedict's solution
T1	Absence starch is detected after absence of starch in T2
T2	Absence of starch detected earlier.

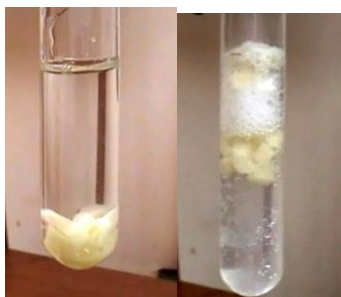
- Explanation of results

Test tubes	Explanation of results
T1	Digestion of starch took longer because the enzyme was dilute
T2	Digestion of starch was fast because the enzyme was concentrated

Alternatively, equal volumes of enzyme solutions of different concentration may be used

Catalyse enzyme

- It is found in most of living tissues including pieces of Iris potatoes, onions and raw paw paws, liver, muscle, lungs etc.
- It hydrolyses/ breaks down hydrogen peroxide(H_2O_2) solution to oxygen leading to evolution of a gas.



Negative test Positive test

Recording and interpretation of results

1. The observations are recorded indicating the rate of evolution of a gas i.e. Rapid/ slow/ moderate effervescence; many/ few bubbles; Rapid/ slow bubbling or no effervescence. Don't record no observable change/ reaction
2. Deduction is recorded as H_2O_2 decomposed/ broken down rapidly/ slowly/ moderately but NOT H_2O_2 hydrolysed.
3. The rate of effervescence/reaction can also be measured the height of the foam or height of the mixture provided equal volumes of hydrogen peroxide solutions are used. The longer the foam the faster the rate of reaction

Activity 33

Requirements

Solution X = extract from 120g of Irish potatoes in a litre

Solution Y = extract from 300g of Irish potatoes in a litre

Solution Z = extract from 600g of Irish potatoes in a litre

Solution Q = 10 Vol of hydrogen peroxide

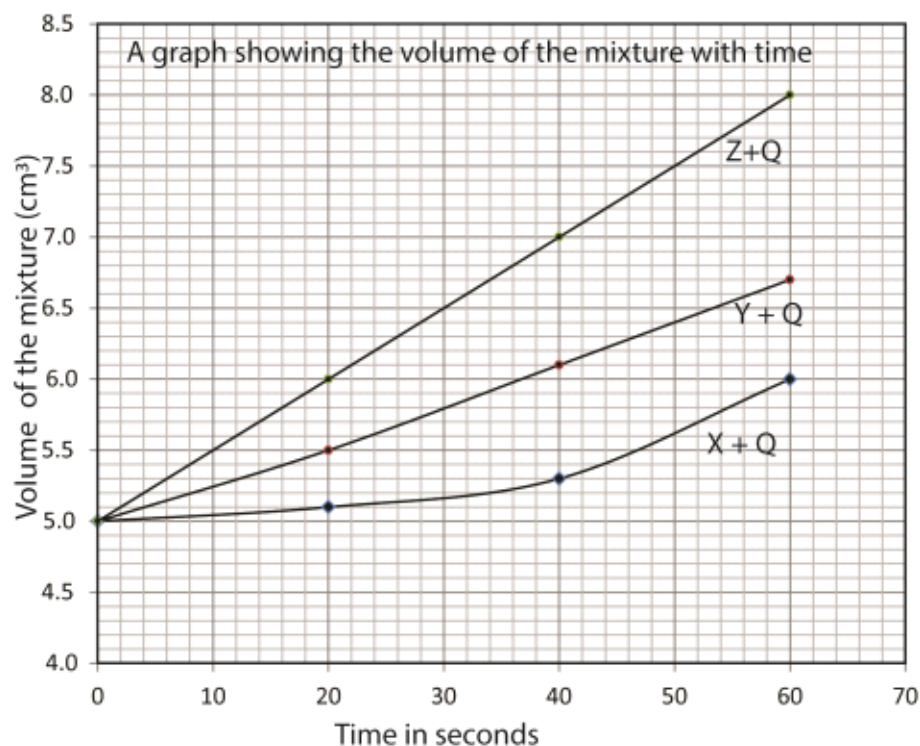
You are provided with solution X, Y, and Z which are extracts of plant tissue at different concentration and solution Q. You are to carry out test using the solutions and answer the questions that follow.

- (a) In a 10ml measuring cylinder, add 3cm^3 of solution X followed by 2cm^3 of Solution Q and at the same time start a stop clock. Observe the reaction and record the volume of the contents including the bubbles/froth, every 20 seconds for 60 seconds, record your results in table 1. Repeat the procedure with solution Y and Z.

Table 1

Time	Volume mixture of (X+Q)cm ³	Volume mixture of (Y+Q)cm ³	Volume mixture of (Z+Q)cm ³
0	5.0	5.0	5.0
20	5.1	5.5	6.0
40	5.3	6.1	7.0
60	6.0	6.7	8.0

(b) (i) Using same axis, represent your results in a graphical form in the space provided



(ii) Using the graph in (b)(i), calculate the average rate of reaction (increase in volume of the mixture per second) for each mixture. Show your working.

$$\text{Average rate} = \frac{\text{Final volume} - \text{Initial volume}}{\text{time}}$$

$$\text{Rate of X + Q} = \frac{6.0 - 5.0}{60} = 0.02 \text{ cm}^3/\text{s}$$

$$\text{Rate of Y + Q} = \frac{6.7 - 5.0}{60} = 0.03 \text{ cm}^3/\text{s}$$

$$\text{Rate of Z + Q} = \frac{8.0 - 5.0}{60} = 0.05 \text{ cm}^3/\text{s}$$

(c) (i) State what is being investigated

Effect of enzyme/catalyse **concentration** on the rate of reaction/decomposition of hydrogen peroxide

(ii) Explain the results

The rate of reaction increased with the concentration of enzymes. The concentration of catalyse enzyme increased from $X < Y < Z$.

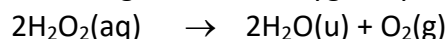
4. When a piece of living tissue is added to a liquid and causes effervescence, then the liquid is hydrogen peroxide or when a hydrogen peroxide is added to a tissue and results in effervescence, then the tissue contains catalyse enzyme. (specificity)
5. When a potato is boiled first no gas will be given off because catalyse is denatured. (effect of heat on enzyme)
6. Low pH or adding HCl to the mixture denatures the enzyme so there will be no effervescence. (effect of pH on enzyme)
7. High pH or adding NaOH solution, favor catalyse enzyme leading to faster evolution of a gas. (effect of pH on enzyme)
8. When two equal cubes of potatoes/liver are used; the one that is crushed or cut into smaller pieces will give faster evolution of gases due to bigger surface area. (effect of concentration of enzyme)
9. When two equal crushed cubes are used, the big one will give faster evolution of a gas due higher concentration of the enzyme. (effect of concentration of enzyme)
10. Liver contains higher concentration of catalyse enzyme than the lung or muscle. Hence large effervescence is observed when a piece of liver is added to hydrogen peroxide solution than with equal pieces of lung or muscle.
11. When pieces of a liver of equal sizes are added to equal volumes of hydrogen peroxide of different concentrations. The solution with higher concentration gives higher rate of effervescence.
12. The rate of reaction can also be measured by timing how long it takes for a piece of filter paper, soaked in tissue extract and dropped into a fixed volume of hydrogen peroxide, to rise to the surface. The faster the piece rises to the top indicates faster evolution of a gas. It is used to compare the concentration/behaviour of catalyse enzyme in different extracts or the concentration of the substrate (H_2O_2) solution or the effect of pH of a solution that may be added to hydrogen peroxide/extract solution before the filter paper test. The rationale is that, when a filter paper wetted by a extract containing catalyse enzyme is dipped in hydrogen peroxide, hydrogen peroxide decomposes to form bubbles thereby making the filter paper less dense hence rising to float.

Difference between enzyme and catalysts.

	Enzymes	Catalysts
1.	proteins in nature	inorganic chemicals e.g. Pt
2.	catalyze specific reactions Such as hydrolysis of starch	may catalyze more than one reaction e.g. platinum catalyze decomposition of H_2O_2 and reduction of benzene
3.	Denatured by heat above 45°C	Usually are not affected by heat
4.	Very sensitive to pH	Not sensitive to pH
5.	Initiate reaction	Do not initiate reaction

Activity 34

In the presence of certain chemical substances, hydrogen peroxide decomposes easily, liberating water and oxygen by effervescence according to the equation.



You are provided with soaked bean seeds for 24 hours and manganese dioxide. Carry out the following experiments to investigate the effect of soaked bean seeds and manganese dioxide on hydrogen peroxide.

Procedure:

- (i) Label four test tubes 1, 2, 3 and 4.
- (ii) To test tube 1 add a spatula end full of manganese dioxide
- (iii) To test tube 2 add a spatula end-full of manganese dioxide and heat for about 3 minutes. Leave to cool.
- (iv) Choose 2 – 3 soaked bean seeds, crush and place in test tube 3.
- (v) Boil 2 -3 soaked bean seeds for 5 minutes, crush them and place in test tube 4.
- (vi) To test tube 1 add a few drops of hydrogen peroxide and record your observation in the table below.
- (vii) Repeat (vi) for test tubes 2, 3 and 4. Record your results in the table below.

Test tube	Observations
1	Effervescence
2	Effervescence
3	Effervescence
4	No effervescence

- (viii) Suggest the name of the chemical substance that produced the changes in test tube 3. Enzyme catalyze
- (ix) Interpret your observations and comment on the biological principles underlying the experiment

Test tube 1: there was effervescence because manganese dioxide catalyses the breakdown of hydrogen peroxide into oxygen.

Test tube 2: there was effervescence because manganese dioxide is not denatured by heat

Test tube 3: there was effervescence because catalyze enzyme catalyses the breakdown of hydrogen peroxide into oxygen

Test tube 4: there was no effervescence because catalyze enzyme was denatured by heat.

Activity 35

Materials

80cm³ of 3% hydrogen peroxide, labeled X

10cm³ of Irish potato extract, labeled Y (to prepare Y, peel and weigh 30g of fresh Irish potato tuber, crush it into fine paste, add 100cm³ of distilled water, stir and decant)

You are required to carry out tests on solution using filter paper, following the following procedure

Procedure

- Using a ruler measure out 1cm x 1cm square grids on the filter paper provided, then cut them using a pair of scissor or razor blade.
- Pour 10cm³ of solution Y in a petri dish and immerse the seven pieces of filter paper into it.
- Label seven test tubes as 25°C, 35°C, 45°C, 65°C, HCl and NaOH and add 10cm³ of solution X into each.
- In a plastic beaker provided, create a water bath maintained at 25°C by mixing hot and cold water where necessary, while monitoring the temperature with a thermometer.
- Place the test tube containing solution X labeled 25°C into the water bath and leave it for 2 minutes.
- Pick up one piece of the filter paper from the petri dish with a pair of forceps and drop it into the test tube in the water bath. Allow it to sink and immediately start a clock.
- Stop the clock when the piece of the paper floats at the surface and record the time taken for the paper to float, in Table 1.
- Repeat steps (iv) to (vii) using water bath at 35°C, 45°C, 55°C and 65°C.

Table 1

Temperature ($^{\circ}\text{C}$)	Time taken (s)
25	19
35	11
45	16
55	35
65	50
Optimum temperature can be 35 or 45°C (shortest time taken)	
Accept: correct trend with values between 5 and 100s	

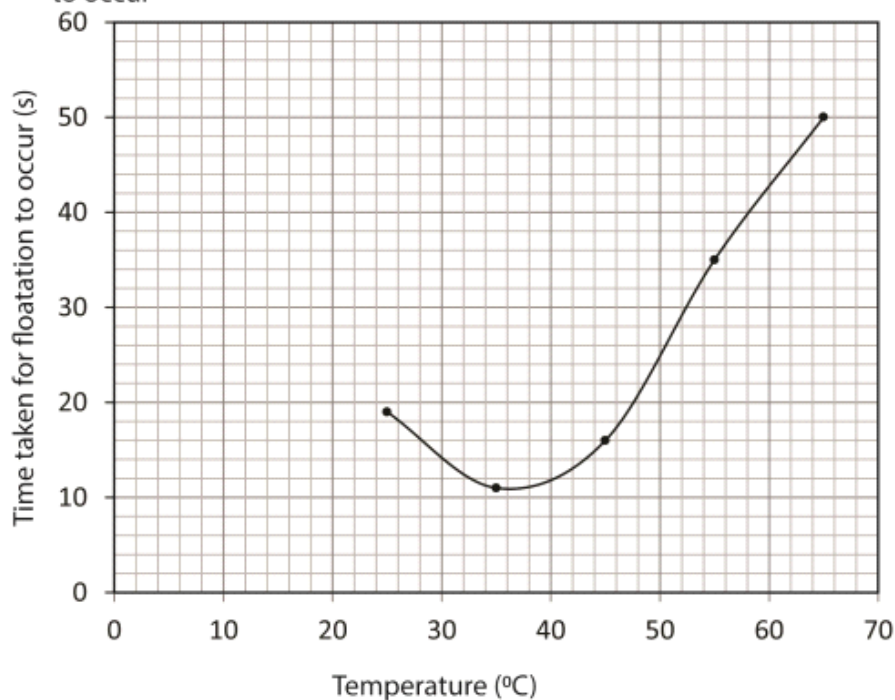
- (i) Add 2 drops of 2M hydrochloric acid to the test tube labeled HCl and 2 drops of 2M sodium hydroxide solution to the test tube labeled NaOH. Place both test tube in a water bath at 35°C for 2 minutes. Drop a piece of filter paper from solution Y on a petri dish, one at a time and record the time taken for floatation to occur.

HCl: 13s (accept btn 10 – 120)

NaOH: 5s (accept between 5 and 100s)

- (j) Draw a graph in the space provided of the time taken for floatation to occur against temperature. (07marks)

A graph showing the effect of temperature on the time taken for floatation to occur



(k) Explain the time taken for flotation to occur at different temperatures (12marks)

- At 25°C, low rate of decomposition because the substrate and enzyme have low kinetic energy and hence low rate of collision for the reaction to occur
- At 35°C, is the optimum temperature for the enzyme that caused the highest rate of decomposition hence it took the shortest time for the filter paper to float.
- From 45°C – 65°C, the rate of reaction decreased because the enzyme was progressively denatured as the temperature increased.

(l) From your results

- State the range of temperatures with the fastest rate of flotation. Give a reason for your answer.

35°C – 45°C reason: least/shortest time taken for flotation to occur

- State the effect of hydrochloric acid and sodium hydroxide on the rate of flotation. Give reason for your answer.

HCl increased the time for flotation to occur because it inhibits/denatures/provides unfavorable medium to the enzyme activity.

NaOH decreased the time for flotation to occur because it provided favorable medium to the enzyme activity.

Activity 36

Materials

20cm³ of Solution Q (20 volumes of hydrogen peroxide)

Solution P (2M HCl)

Solution R (2M NaOH)

Specimen S (medium sized Irish potato)

Experiment

You are provided with solutions P, Q, R and specimen S. Solution P and R provide different pH media

- (a)(i) Label four beakers, A1, A2, A3 and A4, prepare their corresponding solutions as shown in table 1

Solution/cm ³	Volume of solution Q/cm ³	Volume of water added/cm ³
A1	7	7
A2	4	8
A3	5	30
A4	1	11

- (ii) Cut a cube from specimen S measuring 3cm x 3cm x 3cm. Chop the cube into small pieces and crush them into a paste using motor and pestle. Add 10cm³ of distilled water and decant into a petri dish labeled extract S.
- (iii) Obtain and label six test tubes A1, A2, A3, A4, A5 and A6. Pour 10cm³ of each of solutions A1, A2, A3 and A4 into the corresponding test tubes.

- (iv) Pour 10cm³ of solution A3 into each of the test tubes A5 and A6. Add five drops of solution P to the content of A5 and 5 drops of solution R to contents of A6.
- (v) Cut six pieces of filter paper each 0.5cm x 0.5cm. Dip the filter papers into extract S and leave to stay in extract for 5 minutes.
- (vi) Pick one filter paper from extract S and gently place at the bottom of the solution in test tube A1 using a forceps and immediately start the clock. Note the time taken for the filter paper to reach the surface
- (vii) Repeat procedure (vi) using solutions in test tube A2, A3, A4, A5 and A6. Record your observations in table 2

Test tube	Content	Observation	Time taken for filter paper to return to surface/seconds
A1	Solution A1 + filter paper	Very rapid/very fast/very many bubbles/effervescence Filter paper rose rapidly/fast	3 – 15
A2	Solution A2 + filter paper	Rapid/fast/many bubbles/effervescence Filter paper rose rapidly/fast	4 – 16
A3	Solution A3 + filter paper	Moderately slow bubbles/effervescence Filter paper rose slowly	7 – 24
A4	Solution A4 + filter paper	Slow effervescence Filter paper rose slowly	13 – 35
A5	Solution A5 + filter paper	Few bubbles Filter paper did not rise	infinitely
A6	Solution A6 + filter paper	Moderately slow bubbles/effervescence Filter paper rose moderately slow	10 - 26

Note: Rate of reaction should decrease from A1 to A4.

- (b) Explain the results in the following test tubes.
 - (i) A1 (03marks)
Extract S contains enzyme catalyse/active substance/catalyse, A1 contained highest concentration of the substrate resulting into high chances of collision between the enzyme and the substrate, hence very fast rate of breakdown/decomposition of the substrate/rate of reaction.
 - (ii) A3 (03marks)
Extract S contains enzyme catalyse/active substance/catalyse, A3 contained moderate concentration of the substrate resulting into moderate chances of collision between the enzyme and the substrate, hence moderate rate of breakdown/decomposition of the substrate/rate of reaction.

- (iii) A4 (03marks)
Extract S contains enzyme catalyse/active substance/catalyse, A5 contained low concentration of the substrate resulting into low chances of collision between the enzyme and the substrate, hence low rate of breakdown/decomposition of the substrate/rate of reaction.
- (iv) A5 (03marks)
Very low/no enzyme activity because solution P inhibited/provided unfavourable conditions for the action of the enzyme/active substances to decompose the substrate.
- (iv) A6 (03marks)
Moderate enzyme activity because solution R provided moderately favourable conditions for the action of the enzyme/active substances to decompose the substrate.
- (c)(i) Explain the significance of the reactions in the experiment multicellular organism (05marks)
Hydrogen peroxide is toxic/poisonous by product of metabolism in cells/tissues is decomposed by catalyse enzyme into harmless products (water and oxygen)
- (ii) How are sources of errors minimized during experiment? (03marks)
- Cutting filter paper pieces from the same filter paper
 - Soaking the filter paper pieces for the same period of time
 - Cutting filter paper pieces of the same size
 - Using test tubes of the same diameters/size to ensure same height of the solutions or equal distances to be travelled by the filter paper
 - Using the same stock of hydrogen peroxide.

Pepsin and trypsin

- Pepsin (from the stomach) and trypsin (from duodenum, pancreas) digest insoluble protein particles such as crushed muscles and boiled white egg suspension to soluble products. NB. The pancreas also contains amylase enzyme that can digest starch.
- Enzyme pepsin hydrolyses proteins in an acidic PH (medium) while Trypsin does so in a neutral or alkaline PH.
- Most proteins due to their structure form suspensions not solutions.
- Hydrolysis is confirmed by the appearance of the suspension. If the suspension remains turbid (milky) then hydrolysis has not taken place and if the suspension clears to form a colourless solution then hydrolysis has taken place.

Activity 37

You should read these instructions carefully before you start work.

Investigating the effect of temperature on the rate of the reaction catalyzed by trypsin

Theory of experiment

Casein is a protein found in milk. Trypsin is an enzyme that digests casein. When trypsin is added to a dilute suspension of milk powder, the casein is digested and the solution goes clear.

Method

You are provided with the following:

- 0.5% trypsin solution
- 3% solution of milk powder
- pH 7 buffer solution
- a large beaker to use as a water bath
- test tubes
- bungs or cork for test tubes
- test-tube rack
- stopwatch
- marker pen
- pipettes or syringes
- thermometer.

You are required to find the rate of reaction at five different temperatures.

- Using a marker pen write an 'X' on the glass halfway down one side of each of three test tubes.
- Add 10cm^3 of the solution of milk powder to each of these three test tubes.
- Add 2cm^3 of trypsin solution to 2cm^3 of pH 7 buffer in another set of three test tubes.
- Stand the three test tubes containing the solution of milk powder and the three test tubes containing trypsin and buffer in a water bath at 20°C .
- Leave all six tubes in the water bath for 10 minutes.
- Add the trypsin and buffer solution from one test tube to the solution of milk powder in another test tube.
- Put a bung or cork in the test tube and invert about 5 times to mix thoroughly.

- Put the test tube back into the water bath.
- Repeat steps 6 and 7 using the other test tubes you set up.
- Time how long it takes for the milk to go clear. Do this by measuring the time taken to first see the 'X' through the solution.
- Record the time for each of the three experiments.
- Using the same method, find out how long it takes the trypsin to digest the protein in the solution of milk powder at 30°C, 40°C, 50°C, 60°C.
- Record your data in a suitable table.
- Process your data and draw a graph of your processed data.

Activity 38

Materials

Solution A- 1% starch solution

Solution B-mixture of 20g sucrose + 10cm³ of egg white in one litre

P – 1% yeast solution

Q – 1% pepsin;

R – 0.2M HCl

S – Cockroaches

You are provided with solutions A, B P, Q and R.

- (a)(i) Carry out tests in table 1 on the solution A and B, record your tests and observation in the table.

Table 1

Test	Solution	observations
<u>Benedict's test</u> To 1cm ³ of solution in a test tube add 1cm ³ of Benedict's solution and boil	A	Milky solution turns to pale blue solution
	B	Milky/turbid solution/suspension turns to pale blue/ purple solution
<u>Buired test</u> To 1cm ³ of solution in test tube add 1cm ³ of sodium hydroxide followed by 1/2/3 drops of copper (II) sulphate	A	Milky solution turns to pale blue solution
	B	Milky/turbid solution/suspension turns to pale purple solution

- (ii) Test solution R with litmus paper and state your observations and deductions
Blue litmus paper turned red, red litmus paper remained red. Hence R is acidic.

- (b)(i) Cut the midguts from two specimens labeled S. Grind the midguts in a mortar with pestle, and add 5cm³ of distilled water, stir, leave to settle and decant. Label the extract C.
- (ii) Label eight test tubes (i) to(viii) and carry out the following procedures as summarized in table 2 below

Table 2

Test tube	Contents
(i)	1cm ³ of solution A + 1cm ³ of solution Q + 1cm ³ of solution R
(ii)	1cm ³ of solution A + 1cm ³ of solution Q + 1cm ³ of distilled water
(iii)	1cm ³ of solution B + 1cm ³ of solution Q + 1cm ³ of solution R
(iv)	1cm ³ of solution B + 1cm ³ of solution Q + 1cm ³ of distilled water
(v)	1cm ³ of solution A + 1cm ³ of solution P
(vi)	1cm ³ of solution B + 1cm ³ of solution P
(vii)	1cm ³ of solution A + 1cm ³ of solution C
(viii)	1cm ³ of solution B + 1cm ³ of solution C

- (ii) Observe and describe the appearance of the mixtures in each of the test tubes (i) – (iv) before incubation. Fill in table 3 and complete the table after incubation.
- (c)(i) Incubate all eight test tubes (i) – (vii) between 35⁰C – 40⁰C for 30 minutes (meanwhile you may continue with other work). After 30 minutes of incubation, remove the test tubes and allow the contents of test tube (i) – (iv) to settle for 10 minutes. Record your observations on the appearance of the mixture in each test tube in table 3 and complete the table.

Table 3 (12marks)

Test tube	Observation before incubation	Observation after incubation	Deduction
(i)	Milky/cloudy/turbid solution/suspension	Milky/cloudy/turbid solution persisted	Solution A not hydrolyzed/broken down
(ii)	Milky/ turbid solution	Milky/ turbid solution persisted	Solution A not hydrolyzed/broken down
(iii)	Milky/ turbid solution	Milky/ turbid solution partially/completely cleared	Solution B hydrolyzed/partially broken down
(iv)	Milky/cloudy/turbid solution	Milky/cloudy/turbid solution persisted	Solution B not hydrolyzed/broken down

- (iii) Carry out Benedict's test on the respective contents of the incubated test tubes (v) – (vii). Record your observations and deductions in table 4.

Table 4 (07marks)

Test tube	Observations	Deduction
(v)	Milky/pale yellow solution/suspension turns to pale blue	Reducing sugars absent
(vi)	Milky/turbid/pale yellow solution/suspension turns from blue to green to yellow to red/orange ppt.	Moderate/much reducing sugars present
(vii)	Milky/turbid/pale yellow solution/suspension turns from blue to green to yellow to red/orange ppt.	Moderate/much reducing sugars present
(viii)	Milky/turbid/pale yellow solution/suspension turns from blue to green to yellow to red/orange ppt.	Moderate/much reducing sugars present

- (d) From your results, explain the effect of the following solutions on solution A.
- Solution Q
Solution Q has no effect on solution A because it lacked an active substance or favorable conditions to act.
 - Solution P
Solution P broke down/hydrolysed contents of A to reducing sugars because it contained an active substance/enzyme or favorable condition for action.
 - Extract C
Extract broke down/hydrolysed contents of A to reducing sugars because it contained an active substance/enzyme or favorable conditions to act.
- (e) From your results, explain the effect of the following solutions on solution B.
- Solution Q
Solution Q broke down/hydrolysed contents of B because it contained an active substance/enzyme that works in acidic media.
 - Solution P
Solution P broke down/hydrolysed contents of B to reducing sugars because it contained an active substance/enzyme and favorable conditions.
 - Extract C
Extract C broke down/hydrolysed contents of B to reducing sugars because it contained an active substance/enzyme and favorable conditions.
- (f) From your results of the experiments, suggest with reasons, the nature of solutions A and B
- Solution A contains complex carbohydrate/non reducing sugar/starch because it was hydrolysed to reducing sugars by enzymes in extract C.
 - Solution B contains complex carbohydrate/non reducing sugar/starch because it was hydrolysed to reducing sugars by enzymes in extract C. It also contains proteins because it was hydrolysed by solution Q in acidic medium.

Enzymes in Yeast and their functions

Enzyme	Function
Zymase	A complex of enzymes that converts sugars (glucose) into ethanol and CO ₂ during fermentation.
Invertase	Breaks down sucrose into glucose and fructose, making sugars more accessible for fermentation.
Maltase	Hydrolyzes maltose into two glucose molecules, aiding in carbohydrate metabolism.
Amylase	Converts starch into simpler sugars like maltose and glucose, crucial in baking and brewing.
Protease	Breaks down proteins into peptides and amino acids, used in nutrient recycling and industrial processes.
Lipase	Catalyzes the breakdown of lipids into fatty acids and glycerol.
Phosphatase	Removes phosphate groups from molecules, involved in energy regulation and signal transduction.

Use of methylene blue in yeast experiments

- Methylene blue turns colourless in presence of carbon dioxide solution. This is used to determine the rate of fermentation of glucose by zymase enzyme in yeast since it occurs with production of carbon dioxide.
- If equal concentration of glucose, starch and sucrose are mixed with equal amounts of yeast and methylene blue solution; the glucose mixture decolourize earlier before the sucrose or starch mixture because sucrose or starch have to be hydrolysed first to provide glucose.

Activity 39

An investigation of the effect of temperature on respiration in yeast

Theory of experiment

Yeast is a single-celled fungus. It can respire aerobically and anaerobically. During aerobic respiration, the transport of electrons is linked to the synthesis of ATP. In this investigation, these electrons will be taken up by a substance called methylene blue. When methylene blue is reduced, it changes from blue to colourless.

Method

You are provided with the following:

- yeast mixture (5%)
- glucose solution (5%)
- methylene blue (prepared by diluting 1cm³ of 0.1% methylene blue solution to 100cm³)
- test tubes
- test-tube rack
- beaker to act as water bath

- a way of changing the temperature of the water bath
- graduated pipettes or syringes
- marker pen
- thermometer
- timer.

You should read these instructions carefully before you start your investigation.

- (i) Use the beaker to set up a water bath at 30°C.
- (ii) Label two test tubes 1 and 2
- (iii) To each test tube add 1cm³ of glucose solution and 1 cm³ of yeast mixture after stirring and shake to mix.
- (iv) Place the tubes in the water bath and leave them until their contents reach 30°C. the temperature of the water bath may slightly higher.
- (v) Add 2cm³ methylene blue to test tube 1.
- (vi) Immediately shake this tube for 10 seconds and replace the tube in the water bath.
- (vii) Note the time and do not shake this tube again.
- (viii) Record how long it takes for the blue color to disappear in the tube.
- (ix) Repeat steps six to eight for tube 2. Record the average time taken
- (x) Repeat steps (i) to (ix) at 35°C, 40°C, 50°C, 60°C.
- (xi) Record your data in a suitable table.
- (xii) Process your data and draw a graph of your processed data.

Diffusion

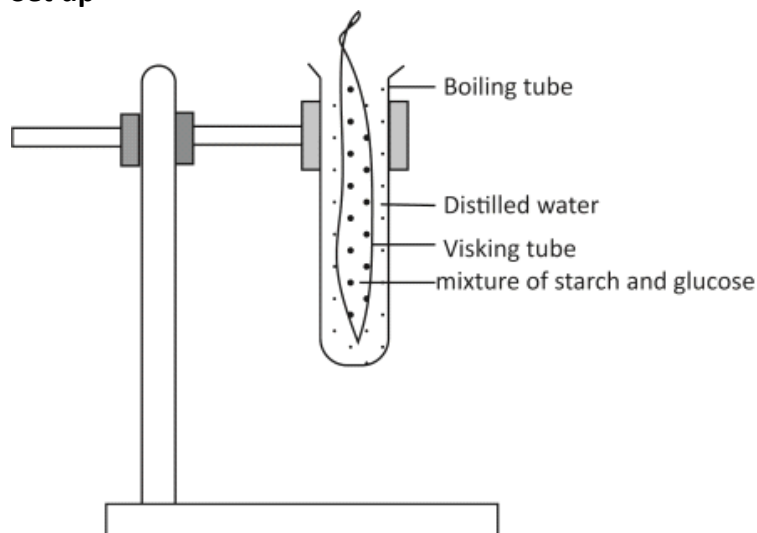
It is the movement of particles (molecules or ions) from a region where they are comparatively concentrated to a region where they are at lower concentration. The difference in the concentration between two regions is called concentration gradient or diffusion gradient. Diffusion will always take place whenever such a gradient exist; and it will continue until eventually the particles are uniformly distributed throughout the system. It is a passive process which takes place by random thermal motion.

During biology experiments we can investigate the factors affecting the rate of diffusion by comparing the distances penetrated by a dye into equal cubes in a given time. Bigger distances indicate faster rate of diffusion.

Activity 40

Using visking tube to demonstrate a semi-permeable membrane.

Set up



- Place a solution containing starch and glucose in a visking tube as shown in the set up above and leave for 30 minutes
- After 30 minutes remove the visking tube and transfer its contents into a separate test tube.
- Test for the presence of starch and glucose in content of the boiling tube and visking tube

Questions

- Explain how presence of starch and glucose were determined?
- State your finding
Starch was identified only in the visking tube but absent in boiling tube content.
Glucose was identified in both the visking and boiling tube contents
- Explain your findings in (ii)
Glucose was present in both visking and boiling tube content because it has small molecules that allowed some to diffuse/pass through the pore of the visking tube into the boiling tube.
Starch with big molecules/molecular mass was unable to pass through the pores of the visking tube into the boiling tube; the reason why it was not present in the boiling tube contents.
- Giving reasons, state the nature of the visking tube.

Semi- permeable/selectively permeable because it allowed glucose molecules to pass through but not starch molecules.

Activity 41

An experiment to investigate the effect of concentration gradient on the rate of diffusion

- Make two cubes each of 2cm x 2cm x 2cm of Irish potatoes.
- Place one cube in a beaker containing 25cm³ of 1% potassium permanganate solution and another in a similar beaker containing 5% potassium permanganate solution and leave for 5 minutes.
- Remove the cubes from the solutions, blot off excess solution using filter papers.
- Cut and measure the distances penetrated by the dye in cube.

Findings

The cube from a 5% solution showed a bigger part colored purple than the one from a 1% solution due to higher concentration gradient.

Activity 42

You are provided with specimen **P** (Irish Potato)

- Using a scalpel, peel the specimen **P** then cut out two cubes from it. Cube **B1** measuring 1cm x 1cm x 1cm and cube **B2** measuring 2cm x 2cm x 2cm.
- Calculate the surface area, the volume and the surface area to volume ratio of each cube in table 1. Show your working. (03 mark)

	Surface area	volume	Surface area : volume
B1	$6(l \times w)$ $6(1 \times 1) = 6$	$L \times w \times h = 1 \times 1 \times 1 = 1$	$\frac{6}{1} = 6$
B2	$6(l \times w)$ $6(2 \times 2) = 24$	$L \times w \times h = 2 \times 2 \times 2 = 8$	$\frac{24}{8} = 3$

- Immerse each cube completely in a beaker containing potassium permanganate (10%) solution and leave for 15 minutes. After 15 minutes remove the cube from the solution and wipe them using blotting paper.
- Using a razor blade, cut each cube into two halves. Using half of each cube, measure the distance, *d*, in mm, across the uncoloured portion as indicated in

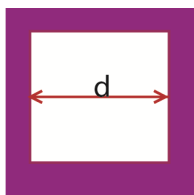


Fig. 1

Record your results

B1 = 5 – 9 mm

B2 = 16 - 19 mm

- (e) What physiological process is observed in (b.)

Diffusion

- (f) How do the results in (b.) relate to the physiological process named in (c.) above, in living organisms?

The smaller organism has the larger the surface area to volume ratio and faster rate of diffusion when acquiring necessities from their environment. The bigger/larger the organism have smaller the surface area to volume ratio and hence slower the rate of diffusion when acquiring necessities from their environment.

Osmosis

This is the passage of solvent molecules from a region of their high concentration to a region of their low concentration through a partially permeable membrane. The solvent in biological system is water. In living tissues the semipermeable membrane is their cell wall and cell membranes and water can enter or leave the cell through the cell membrane and/ or cell wall by osmosis.

Terminologies

- (i) **Semipermeable membrane:** it one that allows passage of small particles/molecules while retaining big molecules
- (ii) **Osmotic pressure:** The ability of plant/living tissue or solution to take in water molecules. It's usually positive and a cell / solution which is highly concentrated has the highest osmotic potential.
- (iii) **Osmotic Potential:** It's always negative and is similar in definition as above or the reduction in water potential as a result of adding solute molecules to solution. A

solution with lower water potential has more solutes and hence high osmotic pressure such that it takes in much water by osmosis. Conversely a solution with higher osmotic potential (less negative) has less ability to gain water by osmosis.

- (iv) **Solute potential:** This is similar to osmotic potential, a solution with the lowest solute potential is more negative and has great tendency to take in water by osmosis.
- (v) **Water potential:** This is the ability of a plant/living tissue to lose water. It is always negative. A solution with a less negative water potential higher water potential or is more dilute and hence it easily loses water. A solution with the lowest water potential has a lower ability to lose water.
- (vi) **Hypotonic solution:** This is a solution which is more dilute and can easily lose water to a concentrated plant tissue.
- (vii) **Isotonic solution:** This is the solution which has a concentration similar to that of the plant tissue or to the other solution.
- (viii) **Hypertonic solution:** This is a highly concentrated solution which can easily gain water from dilute solution or dilute plant tissue.

Ways of showing that osmosis has taken place

Effect of osmosis on the length of plant tissue and volume of solution

Theory

- 0.3M sucrose solution is isotonic to most plant cells/tissue.
- Plant tissues placed in isotonic solution neither loss or gain water by osmosis
- Plant tissues placed in hypotonic solution (<0.3M sucrose solution) absorb water by osmosis and increase in size/length
- Plant tissues placed in hypertonic solutions lose water by osmosis and decrease in length

Activity 43

- (i) 6 cylinders of same size (1cm in diameter and 6cm long) are made.
- (ii) Prepare 6 test tubes and put 10cm³ of 0.0, 0.1, 0.2, 0.3, 0.4, 0.5M sucrose solutions.
- (iii) Put one cylinder in each of the solution in (ii) and wait for 60 minutes. (always be doing other parts of the practical paper)
- (iv) Remove the cylinders without losing any drop of the solution.
- (v) Then measure and record the final volume of the solution and length of each cylinder.

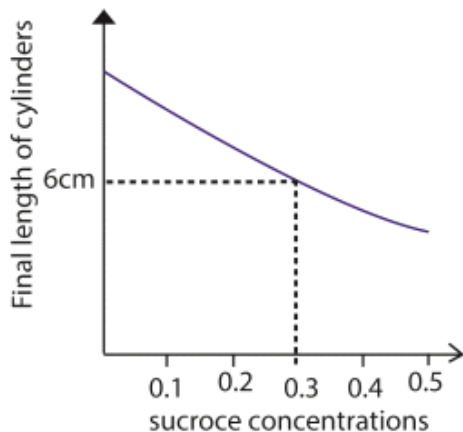
Findings

- (i) There was no change in length of the cylinder and the residual volume of solution of 0.3M sucrose solution. Hence 0.3M sucrose solution is isotonic solution
- (ii) Lengths of the cylinders increased from 0.3M to 0.0M sucrose solution and decreased from 0.3M to 0.5M sucrose solution

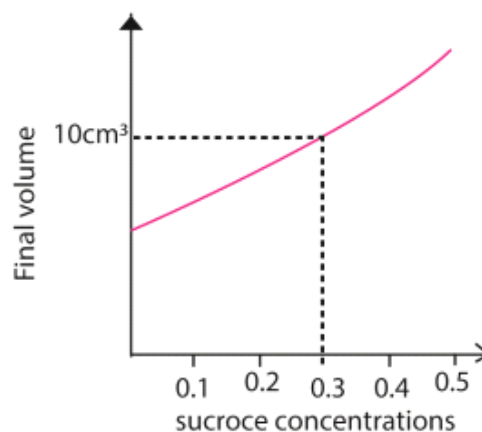
- (iii) The volumes of the residual solutions decreased from 0.3M to 0.0M sucrose solution and increased from 0.3M to 0.5M sucrose solution. 0.0M – 0.3M sucrose solutions are hypotonic while 0.3M – 0.5M sucrose solutions are hypertonic
- (iv) The cylinders in solution 0.0M -0.3M were stiffer compared to that in 0.3M sucrose solution due to intake water by osmosis while those in 0.4M and 0.5M sucrose solution were flabbier/softer due to loss of water by osmosis.
- (v) The importance of the above characteristics of the cylinders in different concentrations are;
 - The herbaceous plant takes in water by osmosis to become turgid and gain support to stand upright
 - Turgidity enables plants to store water.
 - Flabby nature leads to wilting of plant leaves to reduce water loss.

Graphical representations of the findings

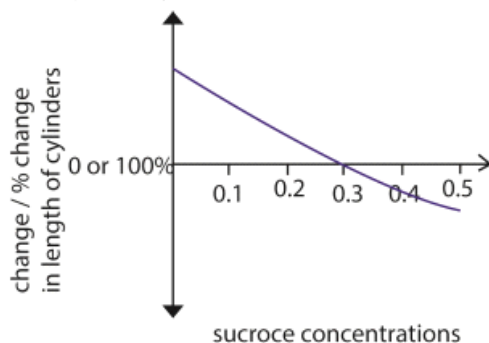
A graph of final length of potato cylinders in sucrose solutions



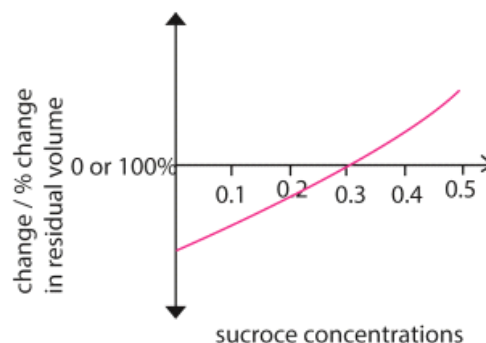
A graph of final volume of sucrose solutions



A graph of change /% change in length of potato cylinders in sucrose solutions



A graph of change /% change in residual volume of sucrose solutions



Alternatively, the initial and final masses of the cylinder may be used as illustrated by the sample results below:

Sample results for sucrose

Sucrose concentration/ mol dm ⁻³	Initial mass/g	Final mass/g	Change in mass/g	Percentage change
0.0	6.54	6.81	0.27	4.13
0.2	6.57	6.63	0.06	0.91
0.4	6.46	6.17	-0.35	-5.42
0.6	6.41	5.96	-0.45	-7.02
0.8	6.21	5.57	-0.64	-10.30
1.0	6.33	5.53	-0.80	-12.60

Use the above sample results to

- Plot a graph of final mass against sucrose concentration; from your graph determine the concentration of the cell sap.
- Plot a graph of change in mass against sucrose concentration; from your graph determine the concentration of the cell sap.
- Plot a graph of percentage change in mass against sucrose concentration; from your graph determine the concentration of the cell sap.

Effect of osmosis volume of residual solution

Theory

- 0.3M sucrose solution is isotonic to most plant cells/tissue.
- Plant tissues placed in isotonic solution neither loss or gain water by osmosis, hence the volume of residual solution neither increase or decrease
- Plant tissues placed in hypotonic solution (<0.3M sucrose solution) absorb water from the solution by osmosis and the volume of residual solution reduces.
- Plant tissues placed in hypertonic solutions lose water by osmosis to external solution and the volume of residual solution increase

Activity 44

Requirements

Sucrose solution: A(1M), B(0.8M), C(0.5M), D(0.3M), E(0.1M) and F (0.0M/distilled water)

P – Large Irish potato tuber

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

- Measure 8.0cm³ of each of the solution and transfer the solutions into tubes labeled correspondingly. Using a cork borer; obtain six equal sized cylinders of 1cm in diameter and 6.0cm in height. Immerse a cylinder into each of the solution in the test tubes and leave for 1 ½ hours.

- (b) After 1 ½ hour, transfer solution A into a 10cm³ measuring cylinder and record the final volume in the table below. Repeat the procedure for the remaining solutions. Record your results in the table below
- (c) Calculate the initial to final volume ratio of the solutions and record your results in table below (06marks)

Solution	Final volume/cm ³	Initial volume : final volume ratio
A	8.5 – 9.0	0.89 – 0.94
B	8.4 – 8.8	0.91 – 0.95
C	8.1 – 8.5	0.93 – 0.99
D	7.8 – 8.2	0.96 – 1.03
E	7.4 – 7.9	1.01 – 1.08
F	7.0 – 7.6	1.05 – 1.14

- (d) (i) Suggest the solution with concentration nearest to that of the cell sap of specimen P; explain your answer (06marks)
- Solution D, because its volume remained close to the initial volume, hence there was no net movement of water into and out of the plant tissue
- (ii) Arrange solutions A to F in order of decreasing osmotic potential. Explain your answer. (06marks)

F, E, D, C, B, A / $F > E > D > C > B > A$

Reason: The tendency of water to move out of the plant tissue increase from F to A while the tendency of water to move into the plant tissue increased from A to F

- (e) Explain the results obtained in test tubes A, D and E (09marks)

Test tube A

Solution A is hypertonic/more concentrated than the cell sap; water was lost by osmosis from plant cells and gained by external solution causing greatest increase in volume.

Test tube D

Solution D is isotonic/same concentration as cell sap; there was no net movement of water into and out of the plant cells, hence the volume of external solution did not change.

Test tube E

Solution E is hypotonic/less concentrated than the cell sap; water was absorbed by osmosis by plant cells and lost from external solution causing greatest *decrease* in volume.

- (f) Examine the cylinder placed in solution B and F

- (i) Compare the physical conditions of the cylinders from solution B and F

From solution B	From solution F
Shorter/narrower/decreased length	Longer/broader/increased length
Shrunk/decreased volume	Swollen/bigger/increased volume
Flabby/soft	Turgid/hard/stiff/firm
Smooth texture	Rough/coarse texture

Rej: flexible/flaccid/spongy

(ii) Suggest the ecological significance of your observation in (d)(i) in the life of specimen P

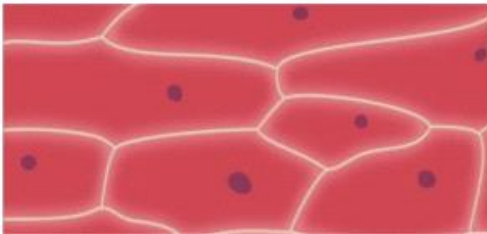
- Turgidity provides support to herbaceous plant/causes them to be upright for photosynthesis
- Turgidity enables plant to store water/open stomata for gaseous exchange
- Flabby nature causes wilting of plant to reduce water loss.

Osmosis and Plasmolysis

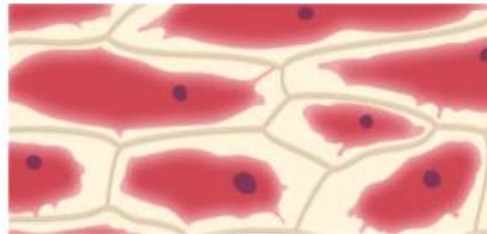
Theory

- ✚ 0.3M sucrose solution is isotonic to most plant cells/tissue.
- ✚ Plant tissues placed in isotonic solution neither loss or gain water by osmosis
- ✚ Plant tissues placed in hypotonic solution ($<0.3M$ sucrose solution) absorb water by osmosis and increase in size/length; the cells' cell membranes fuse with cell wall and the cells are said to be turgid.
- ✚ Plant tissues placed in hypertonic solutions lose water by osmosis, their cytoplasm shrink and their cytoplasm separate from the cell wall leaving perceptible gap. Plasmolysis is the shrinking of plant cell cytoplasm due to water loss caused by osmosis.
- ✚ The percentage of plasmolysed cell and extent of plasmolysis increases with concentration of external solution

Unplasmolysed onion epidermal cells



Plasmolysed onion epidermal cells



Activity 45

Materials

Specimen V – leaf of purple commelina plant

Solution H1 – 5% sodium chloride

Solution H2 – distilled water

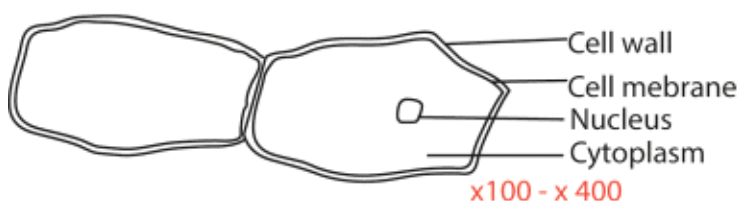
You are provided with specimen V from open space and solutions H1 and H2.

(a) Examine specimen V and state how it is adapted to its function (05marks)

- Broad/long to provide large surface area for absorption of sunlight for photosynthesis.
- Hairy lamina traps a layer of moist air and reduces water loss/transpiration.
- Shiny lamina reflects excess heat to reduce transpiration
- Thick/fleshy for water storage
- Purple/green pigment to trap light for photosynthesis
- Parallel veins for support

- (b) Obtain four strips from the upper of specimen V and place them in a petri dish containing water
- (c) Label two petri dishes as H1 and H2 and pour corresponding solutions H1 and H2 to each
- (d) Transfer two strips of V into solution H1 in the petri dish
- (e) Transfer two strips of V into solution H2 in the petri dish
- (f) Leave the set-up to stand for at least 5 minutes. After 5 minutes
 - (i) Remove one strip from solution H2, and mount in a drop of solution H2 on a microscope slide. Observe under medium power of microscope. Draw and label any two adjacent cells (06½ marks)

A drawing of two adjacent cell of the upper epidermis of specimn V in solution H2 under medium power of microscope



NB: H2 is hypotonic and hence the cells are turgid

- (g) Remove one strip from solution H1, and mount in a drop of solution H1 on a microscope slide. Observe under medium power of microscope. Describe the appearance of the cell parts

Thin cell membrane enclosing a shrinking cytoplasm drawn inwards from the cell wall leaving a space between the cell wall and cell membrane
- (h) Explain the effect of ach of the solutions H1 and H2 on the cells of specimen V.

Solution H1

Cytoplasm shrunk implying that the cells are plasmolysed in solution H1; Hence H1 is hypertonic/more concentrated than the cell sap and draw draws water from the cells by osmosis.

Solution H2

Cell wall fused with cell membrane implying that the cells are turgid; hence solution H2 is hypotonic/dilute compared to the cell sap; thus supplies water to the cells by osmosis.

- (i) From your observation what is the significance of the effects of solutions H1 and H2 to the plant from which specimen V was obtained

Solution H1

- plasmolysis results into wilting/dropping/infolding of leaves to reduce surface area and closure stomata to reduce the rate of transpiration.

Solution H2

- turgidity provides support to herbaceous plants;
- turgidity leads to opening of the stomata and facilitates gaseous exchange.
- turgidity causes opening of flower and make them more conspicuous to promote pollination
- turgidity allows water storage.

Effect of osmosis on the opening and closure of stomata

Theory

- ▽ In isotonic (0.3M sucrose solution) solution there is no net movement of water in and out of the guard cells. Without an increase in turgor pressure, the guard cells do not swell or change shape, and the stomata remain in their default state, which is often closed or partially closed.
- ▽ In hypotonic solutions (<0.3M sucrose solution), guard cells absorb water by osmosis and swell leading to opening of the stomata widely.
- ▽ In hypertonic solutions (>0.3M sucrose solution), guard cells lose water by osmosis and shrink, leading to closure of the stomata.

Activity 46

Requirements

S – commelina plant from open space

T – commelina plant from the shaded area

A – water

B – 0.3M sucrose solution

C – 0.7M sucrose solution

Specimens S and T are from plants of the same species but grown under different habitats.

Solutions A, B and C are sucrose solutions of different concentrations.

- ◇ Examine specimen S and T using a hand lens where necessary and state one difference between the specimens. (01marks)

S- open sun	T – shade/dim light
Pale green	Dark green
Narrow lamina	Broad lamina
More hairs	Few hair

- ◇ Label four microscope slides at their edges as S – upper epidermis, S lower epidermis, T – upper epidermis and S lower epidermis. From each specimen peel a small piece of the upper and lower epidermis, one at a time and mount in a drop of water on the corresponding microscope slide. Cover with a cover slip and view them one at a time under low power of microscope. For each piece of epidermis viewed, count the number of stomata visible in a field of view and record them in table 2

Table 2

Specimen	N0. of stomata on upper epidermis	N0. of stomata on lower epidermis
S	20 – 70	80 – 200
T	40 – 45	60 - 350

- ◇ From your observation in (a) and (b) suggest the type of habitat from which each specimen was obtained giving two reasons
S – sunny/open terrestrial habitat

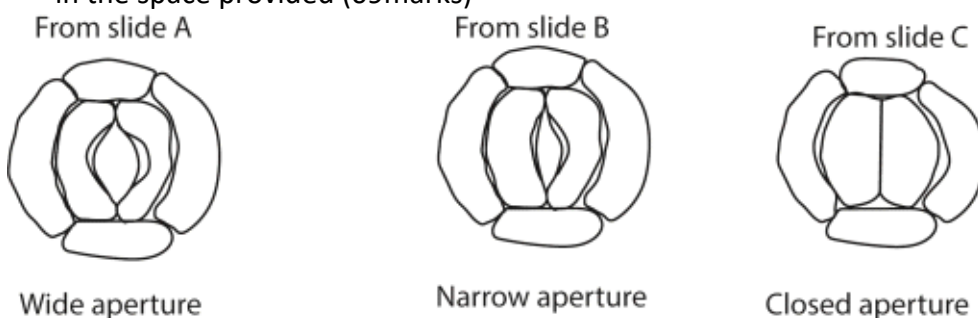
Reasons

- Very few stomata on upper epidermis compared to the lower epidermis to reduce water loss through transpiration
- Many hairs to trap a zone of high humidity around the stomata to reduce water loss through transpiration
- Narrower leaf surface area to minimize water loss

T- shady/damp terrestrial habitat

- More number stomata on the lower than upper to minimize water loss
- Deep green and hence more chlorophyll concentration to trap light
- Less hairy to enhance transpiration
- Broad leaves to increase surface area for light absorption.

- ◇ Label three microscope slides at their edges as A, B and C and on each slide, add a drop of corresponding solution. Peel three small pieces of the lower epidermis from S and mount a piece with outer side uppermost in each solution on the slides. Leave the set up for 5 minutes. After 5 minutes cover each mounted piece with a cover and observe under low power of microscope. Draw one stoma with its adjacent cells from each slide, in the space provided (09marks)



- ◇ Explain what is observed from each slide

From slide A

Solution A was hypotonic with lowest concentration; guard cells took in water by osmosis, expanded leading the widest opening of the stomata

From slide B

Solution B was slightly less concentrated than guard cell sap; guard cells slightly took in water by osmosis, expanded leading to partial opening of the stomata

From slide C

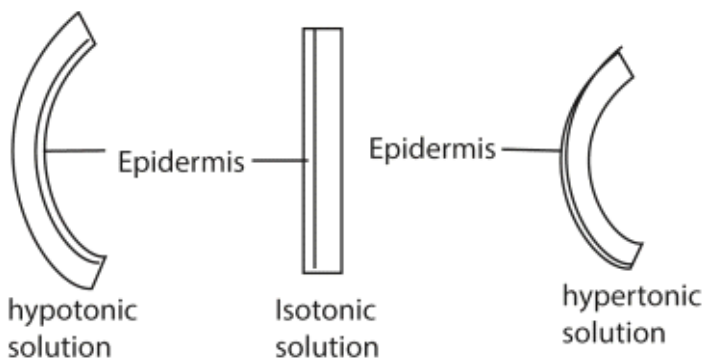
Solution C was hypertonic with higher concentration; guard cells lost water by osmosis, resulting guard cells becoming plasmolysed/flaccid causing closure of the stomata

Effect of osmosis on stem strip curvature (such as a quarter longitudinal section of commelina stem piece)

Theory

- ▽ 0.3M sucrose solution is isotonic to most plant cells/tissue.
- ▽ The cells of a longitudinal stem strip placed in isotonic solution neither loss or gain water by osmosis; hence the stem strip will neither increase nor decrease in length and it will not bend.

- ▽ The cells of a longitudinal stem strip placed in hypotonic solution ($<0.3\text{M}$ sucrose solution) absorb water by osmosis and increase in size/length; however, the inner parenchymal cells increase in length more than the outer epidermal cells and thus the stem strip bends outwards
- ▽ The cells of a longitudinal stem strip placed in hypertonic solution ($>0.3\text{M}$ sucrose solution) lose water by osmosis and decrease in size/length; however, the inner parenchymal cells decrease in length more than the outer epidermal cells and thus the stem strip bends inwards.



Activity 46

Materials

Sucrose solutions of the following molarities A (0.6M), B (0.45M), C (0.3M), D (0.2M) and E (0.1M)
 Specimen P - (commelina plant (rheoes color))

You are provided with specimen P and different solutions of different sucrose concentrations labeled A, B, C, D and E.

You are to carry out tests on the specimen using the solutions

Label 5 petri dishes as A, B, C, D and E and put 10cm^3 of the corresponding solutions in each. Cut two pieces of stem from specimen P, each measuring 3cm long preferably from the same internode or from internodes next to each other. Cut each piece longitudinally into four equal pieces. Put a piece into each petri dishes containing sucrose solutions and leave for 40 minutes

Meanwhile, peel off strips of the lower epidermis from a leaf of specimen P. Put a strip in each of the petri-dishes containing solutions A, B, C, D and E and leave for 10 minutes.

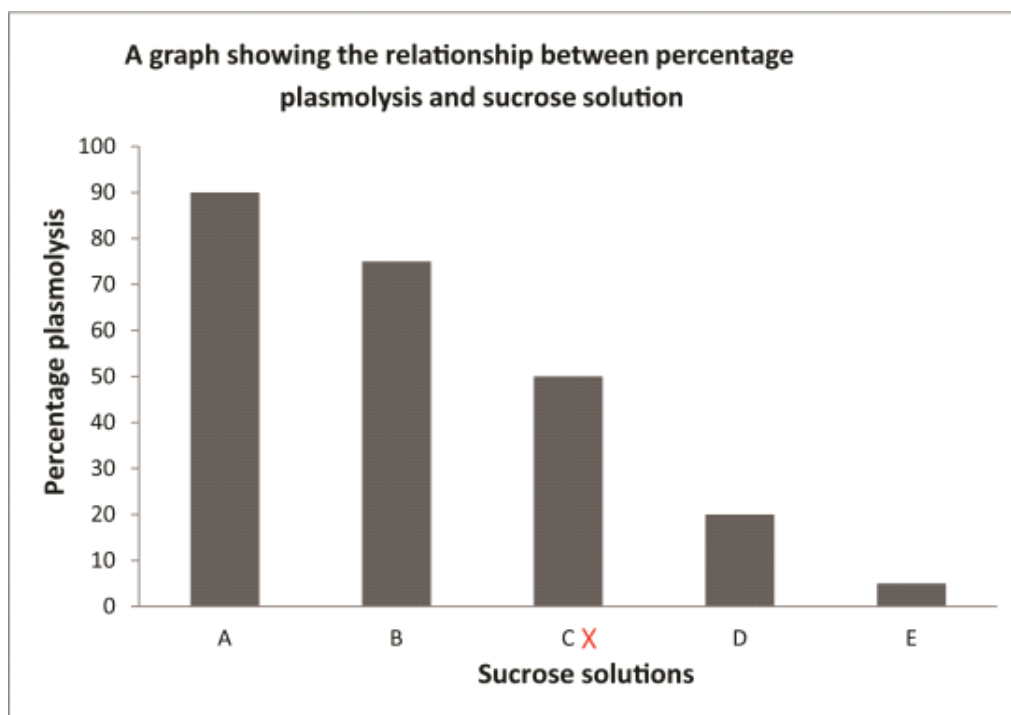
After 10 minutes mount the epidermal strip from each solution onto a slide in a drop of its corresponding solution and view it under medium power of microscope. Count 20 purple coloured cells, and count the number of cells that are plasmolysed out of 20 cells.

- (a)(i) Compute the percentage of cells plasmolysed in each solution and record your values in table 1

Table 1

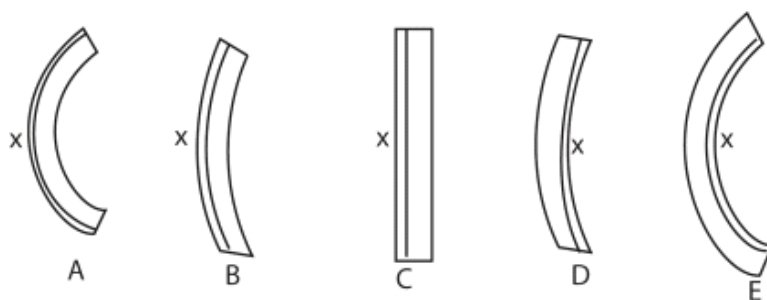
Sucrose solution/15cm ³ each	Number of plasmolysed cells	Percentage plasmolysis
A(0.6M)	17 – 20	85 – 100
B (0.45)	14 – 17	70 – 85
C (0.3M)	08 – 12	40 – 60
B(0.2M)	0.2 -05	10 – 20
A(0.1)	0 – 02	0 – 10

- (ii) Plot a graph to show the relationship between percentage plasmolysis with sucrose solution (07½ marks)
- (iii) On your graph mark point X to show the solution with the concentration that would have 50%



- (b) After 40 minutes observe the pieces of the stem of P from the solutions in the petri dishes. Draw the shapes of each piece in the space below:

Shapes of the stem after 40 minutes



x - for epidermal side

- (c) From your results
- Suggest the solution with the concentration nearest to that of the cell sap of specimen P. explain your answer.
Solution C: it causes 50% plasmolysis/has value close to 50% plasmolysis/piece of the stem placed in it remained straight/slightly curved; which implies little/no net loss/gain of by the tissue placed in it.
 - Arrange eth sucrose solutions starting with the most concentrated. Explain your answer. (5 ½ marks)
A, B, C, D, E or $A > B > C > D > E$; percentage plasmolysis decrease in that order

Effect of osmosis on density of residual solution

- ◇ 0.3M sucrose solution is isotonic to most plant cells/tissue.
- ◇ The plant tissue placed in isotonic solution ($=0.3\text{M}$ sucrose solution) neither loss or gain water by osmosis; the external solution will not change in density. A drop of coloured isotonic solution introduced in the centre of the residual solution after the experiment neither rises nor sinks but spreads uniformly.
- ◇ The plant tissue placed in hypotonic solution ($<0.3\text{M}$ sucrose solution) absorb water from the external solution. The external solution becomes more concentrated and denser. When a drop of coloured solution of same concentration is introduced in the centre of the residual solution after the experiment; it rises because the residual solution is denser.
- ◇ The plant tissue placed in hypertonic solution ($>0.3\text{M}$ sucrose solution) loses water to the external solution by osmosis. The external solution becomes dilute and less dense. When a drop of coloured solution of same concentration is introduced in the centre of the residual solution after the experiment; it sinks because the residual solution is less dense.
- ◇ The change in the density of residual solution depends on the concentration of the initial solution. The bigger the change in density, the faster the coloured solution rises or sinks.

Activity 47

Requirement

Solution A: (0.1M sucrose solution)

Solution B: (0.2M Sucrose solution)

Solution C: (0.3M sucrose solution)

Solution D: (0.5M sucrose solution)

Solution E: (0.7M sucrose solution)

Specimen **T** – Fresh medium sized Irish potato.

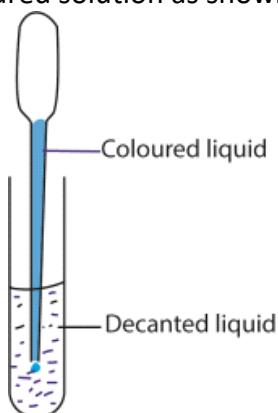
Carry out tests on **T** and the solution using the procedure provided

- Label 10 test tubes in two sets A1, A2, B1, B2, C1, C2, D1, D2, E1, E2 and put the solutions into corresponding sets of test tubes in the quantities shown in table 1.

Table 1

Test tube	Solutions added
A1	3cm ³ of A
A2	2cm ³ of A
B1	3cm ³ of B
B2	2cm ³ of B
C1	3cm ³ of C
C2	2cm ³ of C
D1	3cm ³ of D
D2	2cm ³ of D
E1	3cm ³ of E
E2	2cm ³ of E

- (ii) Arrange test tube A1, B1, C1, D1, E1 in the front row and A2, B2, C2, D2, and E2 in the back row of the test tube rack.
- (iii) Add a small drop of 1% methylene blue solution to each test tube in the back row
- (iv) Using a cork borer, prepare 5 cylinders from specimen **T** measuring 1cm in diameter and 5cm in length
- (v) Add one cylinder to each of the test tubes in the front row (uncoloured solution) and leave for 30 minutes.
- (vi) After 30 minutes, decant the liquid in the test tube A1 into another test tube
- (vii) Using a dropper, obtain a coloured solution from test tube A2 and carefully, lower the tip of the dropper into the centre of the decanted liquid, and release one drop of the coloured solution as shown in the figure below



- (viii) Observe the behaviour of the coloured drop and record your observation in table 2. Clean the dropper and repeat procedure (vi) – (vii) the liquids of the remaining sets of test tubes by decanting solutions from test tubes with potato cylinder and adding coloured solution from corresponding test tubes from back row. (14marks)

Table 2

Test tubes from which liquids were decanted	Behaviour of coloured drops
A1	Rises fast
B1	Rise slowly
C1	Spread horizontally
D1	Sink slowly
E1	Sink fast

(ix) (i) Explain the behaviour of the coloured drop in each decanted liquid

A1	A1 was hypotonic, water was absorbed by the cylinder and the decanted solution became concentrated and denser than the coloured solution A2. The big difference in density causes fast rising of coloured solution B2
B1	B1 was slightly hypotonic, little water absorbed by the cylinder and the decanted solution became slightly concentrated and denser than B2. The small difference in density cause slow rising of coloured solution B2
C1	C1 was isotonic, no net movement of water between the solution and the cylinder and the decanted solution had same concentration and same density as the coloured solution C2. With no difference in density, the coloured solution C2 spread rather sinking or rising.
D1	D1 was slightly hypertonic, the cylinder lost little water to the solution and the decanted solution became slightly dilute and slightly less dense than D2. The small difference in density cause slow sinking of coloured solution D2
E1	E1 was hypertonic, the cylinder lost water to the solution and the decanted solution became dilute and greatly less dense than E2. The big difference in density cause fast rate of sinking of coloured solution E2

(ii) From your results, estimate the water potential of the cells of specimen T. Give a reason for your answer

Water potential of cells of cylinder is equivalent to that of solution C: because it showed no net movement of water between the cylinder and solution or no change in density of the solution.

Activity 48

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

(a) Using the clear sucrose solution (1.0m) and distilled water, prepare 10cm^3 each of solution A₁ – F₁ with concentrations corresponding to that of solution A – F above.

(b) Record the amount of the clear solution and distilled water used in the table below: (06 marks)

Solutions	A1	B1	C1	D1	E1	F1
Volume of clear solution used (cm ³)						
Volume of distilled water used (cm ³)						

- (c) Using a cork borer (1cm), cut six plant tissues of length 6 cm each from specimen Q (Irish potato). Transfer one plant tissue into each of the coloured solutions and leave the stand for one hour.

After one hour:-

- (d) Suck a little of the coloured solution A into a dropper and insert the tip of the dropper halfway into the corresponding clear locution A1. Carefully release one drop of the coloured solution and withdraw the dropper.
- (e) Observe the movement of the coloured drop and note the time taken for the drop to either rise to the top of the clear solution or sink to the bottom.
- (f) Repeat procedures (i) and (ii) using a drop from the remaining solution B – f. Record your results as following:-
- - ve values for time taken if drop sinks
 - + ve values if drop rises. A B
 - Zero if drop spreads out or remains stationary where it was released.

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

- (g) Plot a graph to show the relationship between time taken and the original molarities of solution A – F. (11 marks)
- (h) Explain the observed behaviour of a drop of coloured solution:
- ◇ **Solution C** (01½marks)
Drop spread rather than rising or sinking because C1 was isotonic it neither gained or lost water, hence, its density did not change
 - ◇ **Solution E** (01½marks)
Drop rose fairly rapidly because E1 was hypertonic; hence it drained water from the tissue cylinder, became dilute and less dense than E.
- (i) Suggest how you would experimentally verify the explanations given in (c) (i) and (ii) above (01½marks)
- (j) Compare the masses of equal volumes of C and C1 and E and E1 after 1hour.
- ◇ (i) Compare the physical condition of the plant tissues immersed in solution B and F.

From section B	From section F
Rigid	Soft/flabby
Longer	short
Bigger	smaller

(ii) Explain how the physical condition of the plant materials from the two solutions (B to F) may be used to establish their osmotic potentials. (02 marks)

For B: external solution was hypotonic, the cylinder took in water by osmosis becoming turgid, longer and bigger

For F: external solution was hypertonic, the cylinder lost water by osmosis becoming flabby, short and small

(iii) Suggest one advantage of the observed physical condition of plant material from solution B has over than from solution F in non-woody plants. (1 mark)

Non – woody plant in B attains support

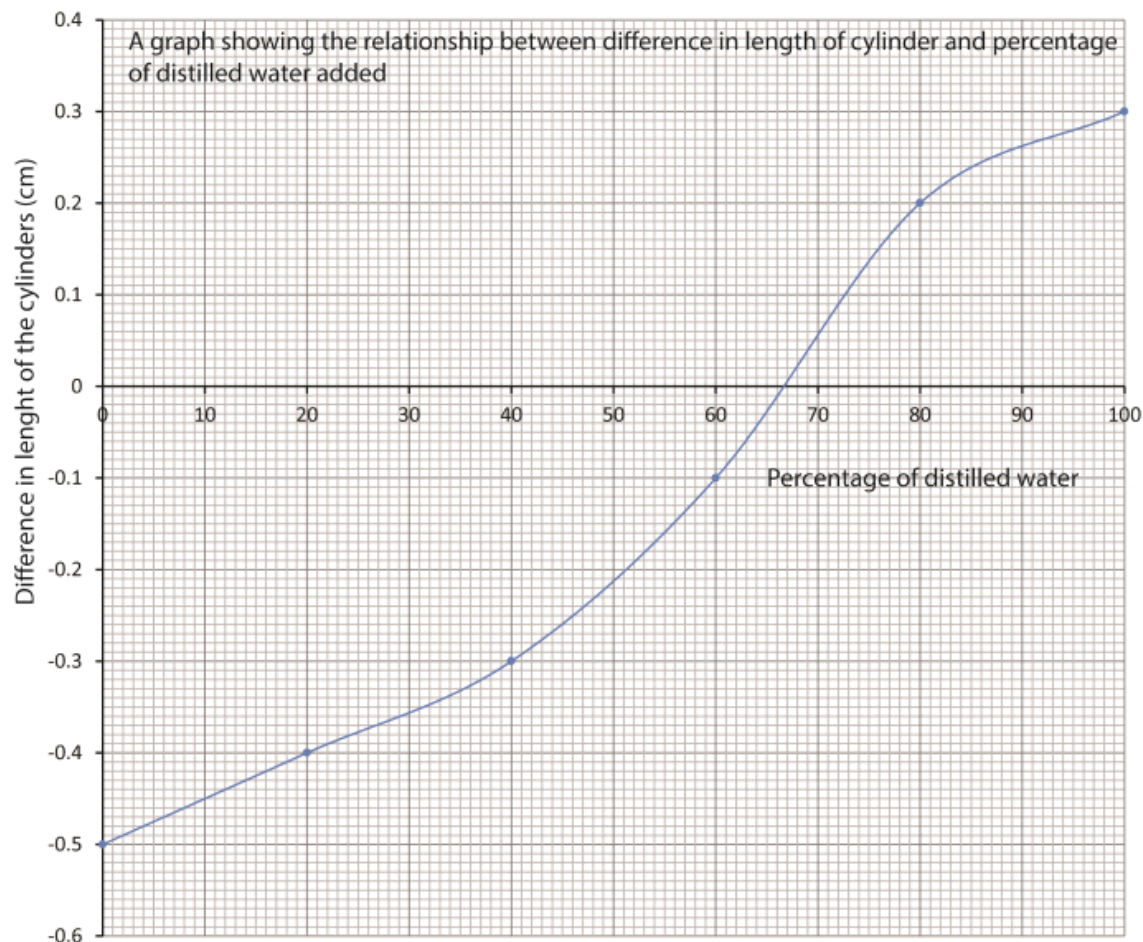
Activity 49

You are provided with specimen P (Irish potato), Solution Q (1M sucrose solution) and distilled water

- ◇ Using a cork borer (1cm) provided, prepare six solid cylinders of P each 5.0cm.
- ◇ Label six test tubes A, B, C, D and F in each pour a mixture of distilled water and solution Q in proportions shown in the table below
- ◇ Place one cylinder (a) in each of the test tubes, ensuring that it is fully immersed in the solution
- ◇ Leave the test tube and the cylinders to stand for one hour. (meanwhile proceed with other work)
- ◇ After one hour, remove and measure the lengths of each cylinder from the test tubes. Record the new length and complete the table below

Test tube	Volume of distilled water added (cm ³)	Volume of solution Q added (cm ³)	Length after one hour (NL) (cm)	Difference in length $L = NL - IL$	Percentage of distilled water added
A	10	0	5.2 – 5.4	0.3	100
B	8	2	5.1 – 5.3	0.2	80
C	6	4	4.8 – 4.9	-0.1	60
D	4	6	4.6 – 4.8	-0.3	40
E	2	8	4.5 – 4.7	- 0.4	20
F	0	10	4.4 – 4.6	-0.5	0

- (i) Plot a suitable graph showing the relationship between the difference in length with the percentage of distilled water



- (ii) Using the graph, determine the percentage of solution Q by volume with the same concentration as the cell sap of specimen P. Explain your answer.

Percentage of solution Q = $100 - 67 = 33\%$ because it caused no change in length or there was no net uptake or loss of water from the cylinder of P by osmosis.

- (iii) From 67% to 0% of distilled water added the cylinders decreased in length because the solutions formed were hypertonic to the cell sap and caused loss of water from P by osmosis. Hence the cylinders shortened

From 67% to 100% of distilled water added the cylinders increased in length because the solutions formed were hypotonic to the cell sap and caused uptake of water by osmosis into the cylinder. Hence the cylinders lengthened.

- (b) (i) Explain why the new length of the cylinder in test tube A could not go beyond the length of the cylinder (1 hour is sufficient for the physiological process being investigated in this experiment) (05 marks)

The cells cannot elongate/expand further or reached full turgor. The rigid/inelastic/fir/tough cell wall has developed pressure potential/wall pressure to prevent/resist further expansion of the cells by net gain/intake/absorption of water

- (ii) Explain the ecological significance of the experimental results of the plant from which specimen P was obtained, if the soil is 37% water

The solution would be hypertonic to the cell sap; the plant cells would lose water by osmosis become plasmolysed resulting into stomata closure/wilting thus reducing the rate of transpiration/water loss by transpiration.

Germination

Germination experiments are meant to investigate the changes that occur on food reserves during germination with time.

Note that during germination

- ◇ Starch is broken down to reducing sugars to provide energy.
Hence
- ◇ non germinating seeds contain starch but no reducing sugars. The extract looks milky.
- ◇ germinating seeds may contain starch and or reducing sugars depending on the duration of germination. Milkyness of the extract fades
- ◇ Late stages of germination seeds do no starch nor reducing sugars because these have been used up. The reduces are fibrous
- ◇ Lipids are degraded into fatty acids and glycerol. Making the extrat during germination acidic
- ◇ Proteins: Broken down into amino acids, providing building blocks for new proteins and energy.
- ◇ Proteins and lipids make the extract colloid while there degradation during germinations makes the extracts clearer, there reduced viscosity with visible fibres.

Activity 50

You are provided with seeds and seedlings of Ground nuts, which have been under germination for 3 hours, 48 hours, and 96 hours.

Pick 20 seed or seedlings and pound them with a mortar and pestle to form a paste; add 30 ml of water grind for sometime and decant off 15 cm³ into a test tube or flask. Allow to stand as you make similar extracts for the remaining seedling.

Take note of the appearance of the extract and the residue.

Divide each extract into five approximately equal parts (no need to measure exactly) in test tube labelled 1, 2, 3, 4, and 5 you will end up with a total of 15 test tubes of the extract portions.

- (a) For test tubes labelled (1) (they are three) add to each test tube 2cm³ of yeast solution, shake to mix and leave to stand for 40 minutes. After 40 minutes, to 2 cm³ of the extract

add equal amount of Benedict's solution and heat in a water bath for 3 minutes. Record your observation in the table provided.

- (b) For test tubes labelled (2), to each add 1cm³ of sodium hydroxide, shake and add 2 drops of copper sulphate solution shake and leave to stand for 5 minutes before making observation.
- (c) For test tube labelled (3) to each add 5 drops of iodine solution shake and leave to stand for 15 minutes. Examine and record your observation
- (d) For test tube labelled (4) to each tube add equal amount of Benedict's solution and heat in a water bath for 3 minutes.
- (e) For test tube labelled (5) add 2cm³ of Litmus solution to each. DO NOT SHAKE but leave to stand for 10 minutes. Record your observations.

Table

Record your observation in the appropriate spaces

Test	3 hour	48 hours	96 hours
1. Extract + yeast solution + Benedict's solution + heat			
2. Extract + sodium hydroxide + copper sulphate	Purple colour develops	Dark purple colour	Pale purple color
3. Extract + Iodine solution	Color remain brown Starch absent	Iodine colour persist Starch absent	Color changes black Starch present
4. Extract + Benedict's solution + heat	Blue color persist Reducing sugar absent	Color changed from blue to green to yellow Reducing sugars present	Blue color persisted Reducing sugar absent

5. extract + Litmus solution	Litmus retains original color and remain floating above the solution	Litmus diffuse slightly into the extract and turns pink	Litmus solution diffuse through the extract and turns pink
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Using only the information obtained from this experiment, answers the following questions.

- (i) List the organic composition of dry ground nuts starting with “lipids”

Lipids and proteins

- (ii) Give a concise outline of the changes, which occurred to the organic compounds in the seeds of groundnuts during germination as revealed by this experiment. Attempt to show how you arrived at your conclusions.

Lipids are changed fatty acid and reducing sugar and the starch because in test tube labelled (2) reducing sugars appeared only after 48hrs and were not there at 3 hours and 96 hours, In test tube 3 starch was available only in test tube of 96 hours showing that it probably formed from reducing sugars of lipids. In test (5) extract of 48 and 96 hours, litmus solution turned pink indicating that lipids had been hydrolysed into fatty acids

Proteins were hydrolyses into amino acid at 48 hour (the reason for dark purple) and probably amino acid built into proteins at 96 hours (the purple color at 96 was less than that at 48)

- (iii) Attempt to explain the differences (if any) in the three test tubes labelled (5) at 3 hours, 48 hours, and 96 hours.

The g. nuts at 3 hours contained un-hydrolysed lipid that made the extract more colloidal and viscous that litmus solution floated. At 48 and 96 hours, lipids were partially hydrolysed into fatty acid that turned Litmus solution pink make made the extract less viscous that Litmus solution diffused easily

- (iv) Which category of ground nuts yielded?
a. Light and less milky water extract what this suggests to you

That at 96 because it contained least food reserve

b. More fibrous residue? What does this indicate?

That at 96 because its food reserves had been removed

Activity 51

Requirement

P – big Irish potato

X – NaOH

Y – HCl

Z – Hydrogen peroxide

You are provided with Specimen **P (big Irish potato)** and solution **X, Y and Z**.

Using the solutions you are to carry out tests on the specimens. Peel specimen **Q**, then cut it into four cubes of measurement and label as indicated below

0.5cm x 0.5cm x 0.5cm, label **K**

1.0cm x 1.0cm x 1.0cm, label **L**

1.5cm x 1.5cm x 1.5cm, label **M**

2.0cm x 2.0cm x 2.0cm, label **K**

Prepare an extract from each cube as follows:

Grind the cube in a mortar and pestle the add 10cm³ of distilled water, stir leave to settle and decant. Label each extract correspondingly.

(a) Label four test tubes as 1, 2, 3 and 4 and add contents to each as shown in table 1.

Record your observation and deduction in the table

(06 marks)

Table 1

Test tube	Contents	Observation	Deduction
1	2 cm ³ of Z and 2 cm ³ of K	Bubbles given off at very slow rate 1	Hydrogen peroxide in Z slowly decomposed to oxygen ½

2	2 cm ³ of Z and 2 cm ³ of L	Bubbles given off at a rate higher than in test tube 1 1	Hydrogen peroxide in Z decomposed to oxygen at a rate higher than in 1 ½
3	2 cm ³ of Z and 2 cm ³ of M	Bubbles given off at a rate higher than in test tube 2 1	Hydrogen peroxide in Z decomposed to oxygen at a rate higher than in 2 ½
4	2 cm ³ of Z and 2 cm ³ of N	Bubbles given off at a rate higher than in test tube 3 1	Hydrogen peroxide in Z decomposed to oxygen at a rate higher than in 3 ½

Reject: “reaction” instead of ‘effervescence’ or ‘bubble’

(b) Use extract N to carry out further tests in table 2. Record your observation and deduction in table 2 (4 ½ marks)

Table 2

EXP. No.	Test	Observations	Deduction
1	To 2cm ³ of Z add 2 cm ³ of N that had been boiled for 5 minutes and cooled	No bubbles given off /no effervescence 1	Z /H₂O₂ not decomposed ½
2	To 2cm ³ of Z add 2 cm ³ of N followed by 2cm ³ of X	Bubbles given off at a very slow rate 1	Z / H₂O₂ decomposed at a slow rate ½
3	To 2cm ³ of Z add 2 cm ³ of N followed by 2cm ³ of Y	No bubbles given off 1	Z /H₂O₂ not decomposed ½

(c) Explain your results:

(i) Table 1 (8lines) (03 marks)

The rate at which bubbles are given out increased for K, to L, to M, to N (1) because The concentration of catalyse enzyme that decomposed hydrogen peroxide in Z increased from K, to L, to M, to N with the increase in the size of the cube (2)

(ii) In table 2 (03 marks) (6 lines)

- ◇ No bubbles were given out in experiment b(1) because the enzyme catalyse was denatured on heating (1)
- ◇ Bubbles were given out at a slow rate in (b)(2) because X provided a less favourable medium for the enzyme (1)
- ◇ No bubbles were given off in (b) (3) because Y provided unfavourable medium for the enzyme catalyse (1)

(iii) From the test in Table 1 and 2, state the factors that were being investigate (03)

In table 1: concentration (1)

Table 2 is the effect of temperature (1) and the effects of media X and Y (probably pH) (1) on the rate of action of enzyme amylase

Reject if the table is not specified

(d) Peel specimen P and from it cut a cube 1.0cm x 1.0cm x 1.0cm and make an extract from it in the same way you prepared the earlier extracts. Label P.

(i) Carry out the following tests to determine the relative abundance of starch, Reducing sugars and proteins in extracts P and L prepared in 2(a)

Record your tests, observations and deductions for each extract in the table 3 (12 marks)

Test	Observations	Deductions
Starch	P Light blue solution obtained	Traces of starch ½

To 1 cm³ of the extract, 3 drops of iodine were added 2	$\frac{1}{2}$ L: dark blue solution obtained $\frac{1}{2}$	Abundant starch present $\frac{1}{2}$
Reducing sugars To 1 cm³ of the extract, equal volume of Benedict's solution add and boiled for 1 minute 2	P: Extract turns from blue to green to yellow $\frac{1}{2}$ L: the blue color persists $\frac{1}{2}$	Reducing sugars present $\frac{1}{2}$ Reducing sugars absent $\frac{1}{2}$
Proteins To 1 cm³ of the extract, equal amount of sodium hydroxide added followed by 2 drops of copper sulphate 2	P: A deep purple solution forms $\frac{1}{2}$ L: Light purple solution formed $\frac{1}{2}$	Abundant proteins present $\frac{1}{2}$ Less proteins than in P are present $\frac{1}{2}$

Reject the entire row if the test is not written correctly, if the observation is not written in comparative form

(ii) Explain any difference between the contents of P and L in the table 3 (05 marks)

P had less starch (**1**) and more proteins (**1**) and reducing sugar than L probably because starch is being changed to reducing sugar (**1**) and proteins (**1**) during germination in P. or P had more proteins than L probably because insoluble proteins are being hydrolysed to soluble proteins (**1**) during germination

Activity 52

Requirement

Solution A = 1-day germinated sorghum

Solution B = 3-day germinated sorghum

Solution C = 5-day germinated sorghum

Solution D = 7- day germinated sorghum

Solution E = one day germinated bean seeds

Solution F= five day germinated bean seeds

You are provided with solution A, B, C, D which are extracts from seedlings of the same type of seed at different stages of germination

- (a) Carry out an iodine test on each solution. Record your tests, observation and deduction in table 1

Table 1

Test	Solutions	Observation	Deduction
To 1 cm ³ of solution add 2/3/4 drops of iodine solution	A	Turbid solution turned black	Much starch present
	B	Turbid solution turned blue	Moderate starch present
	C	Turbid solution formed black specks	Little starch present
	D	Turbid solution turned yellow/brown	No starch/starch absent

- (b) Carry out Benedict's test on each solution. Record your tests, observation and deduction in table 2

Table 2

Test	Solutions	Observation	Deduction
To 1 cm ³ of solution add 1cm ³ of Benedict's solution and boil for 1 minute	A	Turbid solution turned pale blue solution	Reducing sugars absent
	B	Turbid solution turned green	Moderate reducing sugars present
	C	Turbid solution turned green to yellow to brown	Much reducing sugars present

		ppt.	
	D	Turbid solution turned blue/green	Reducing sugars absent/little reducing sugars present

- (c) Solutions E and F are extracts of same type of seed, but different from seed type from which extract A, B, C and D were obtained. Solution E is from seedlings of the same age as those from which extract A was obtained, while F is from seedlings of the same age as those from which extract C was obtained
- (d) Carry out Biuret's test on solutions A, C, E and F. record your tests observation and deductions in table 3

Table 3

Test	Solutions	Observation	Deduction
To 1 cm ³ of solution add 1cm ³ of NaOH followed by 1/2/3 of CuSO ₄ solution	A	Turbid solution turned pale blue solution	Protein absent
	B	Turbid solution turned pale blue solution	Proteins absent
	C	Turbid solution turned purple/violet	Much protein present
	D	Turbid solution turned pale purple	Trace proteins present

- (e) Carry out Benedict's test on solutions E and F

Table 4

Test	Solutions	Observation	Deduction
To 1 cm ³ of solution add 1cm ³ of Benedict's solution and boil for 1 minute	E	Turbid solution turned pale blue solution	Reducing sugars absent
	F	Turbid solution turned green	Little reducing sugars present

- (f) (i) From your results in table 1 and 2, arrange the solution A, B, C and D in order, starting with solution from the youngest seedlings and ending with that from the oldest seedlings. (01 marks)

A, B, and C

Reason

The amount of starch decrease from A to C while the amount of reducing sugars increased from A to C due to the conversion of starch to reducing sugars during germination.

(ii) From your results in Table 3 and 4, compare the contents in solution A and E and contents in solutions C and F

A and C have no proteins

E and F have proteins and some reducing sugars

(iii) Explain your results in table 3 and 4

Seed from which extract A and C were obtained do not store protein

Seed from which extract E and F were obtained store protein and carbohydrates

During germination carbohydrates in the seed from which extract E and F were obtained are converted to reducing sugars and proteins are used up.

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Thanks

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