UCE BIOLOGY 553/2 & 553/3 PRACTICAL WORK BOOK 2026 EDITION

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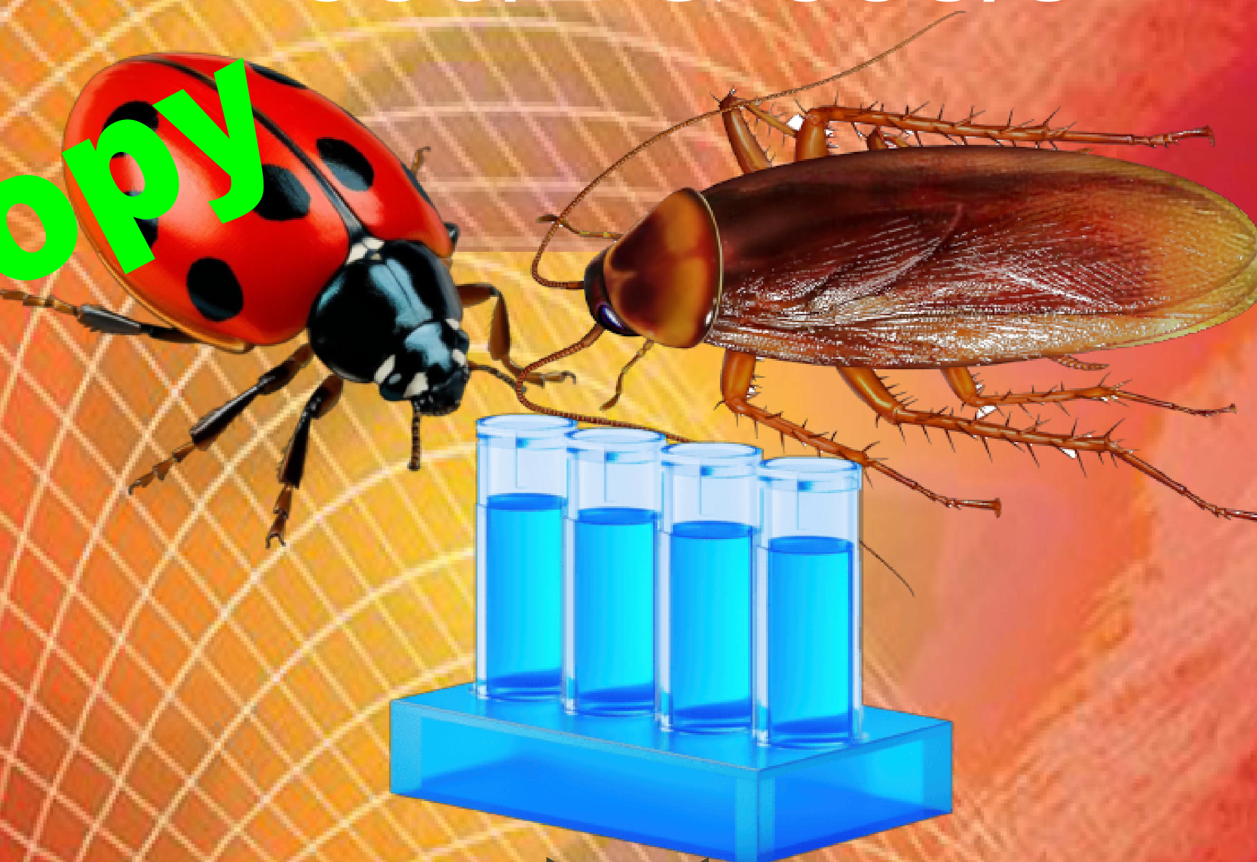
UCE

Biology

553/2 & 553/3



Practical Workbook

2026 Edition by WAKATA

UCE

Biology

553/2 & 553/3

Practical Workbook

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Edition 2026

Contents page

Paper format (553/2 or 553/3)

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

Item 1 (Physiology and Physical experiments in biology)

1. **Nutrition**
   - Food tests
   - Enzyme activity

2. **Transport**
   - Osmosis
   - Diffusion

3. **Soil Science**
   - Capillarity
   - Retention
   - Drainage
   - Soil pH

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

1. **Plants and their structures**
   - Leaves
   - Flowers
   - Fruits
   - Stems
   - Seeds
   - Roots

2. **Animals and their structures**
   - Arthropods mainly insects such as cockroaches, houseflies, termites, bees etc
   - Fish
   - Teeth
   - Vertebrae bones
   - Parasites such as ticks

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

Nature of practical items

- Item 1 in the paper may include a scenario or real-life situation on scientific investigation in Biology.
- Item 2 in the paper may include a scenario or real life situation on structure and function in living organisms.

Expected candidate's Report / Response

1. Scientific investigation in Biology.

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

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

Aim of the Investigation

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

Examples

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

A good aim:

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

Hypothesis

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

- Cause and effect
- The expected trend or relationship

Examples

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

A hypothesis must be:

- Testable
- Logical
- Scientifically based

Variables

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

1. **Independent Variable**

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

   Examples

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

2. **Dependent Variable**

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

   Examples

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

3. **Controlled Variables**

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

   Examples

   - Size and thickness of potato strips
   - Same volume and type of solution
   - Same plant species
   - Same duration of experiment

   Failing to control variables leads to unreliable results.

Results / Observations

Results are what you see, measure, or record during the experiment.
They may be presented as:

- Tables
- Drawings
- Graphs
- Written observations

Example Table (Osmosis)

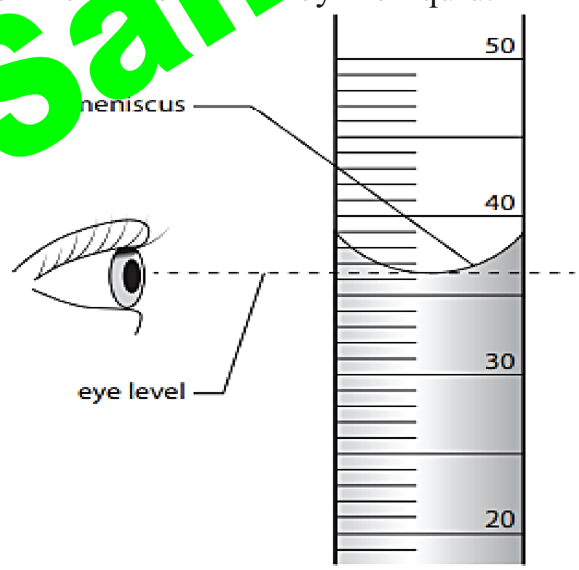
Solution	Initial Length (cm)	Final Length (cm)	Change in Length (cm)
Distilled water	4.0	4.5	+0.5
10% salt	4.0	3.2	–0.8

Observation Statements

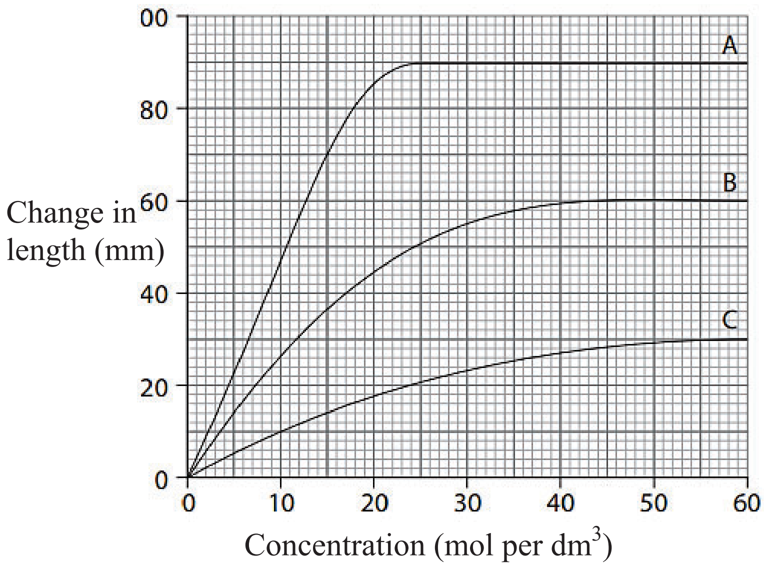
- Potato in distilled water became firm and swollen
- Potato in salt solution became soft and shrunk

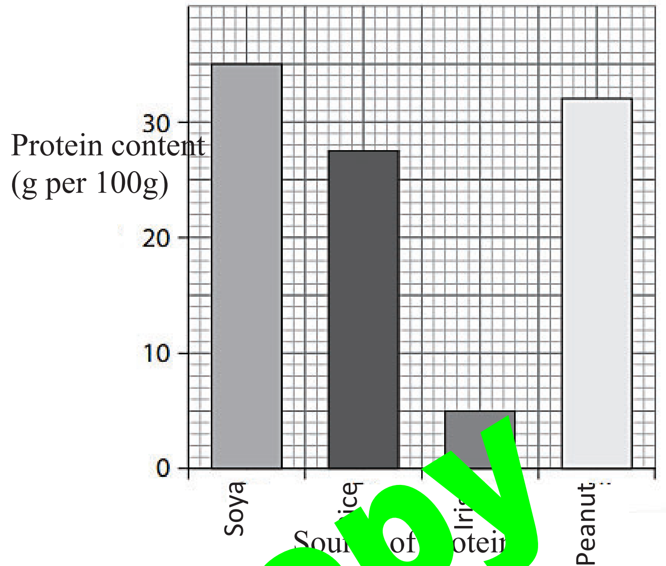
Observations must be objective (what you see), not opinions.

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



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

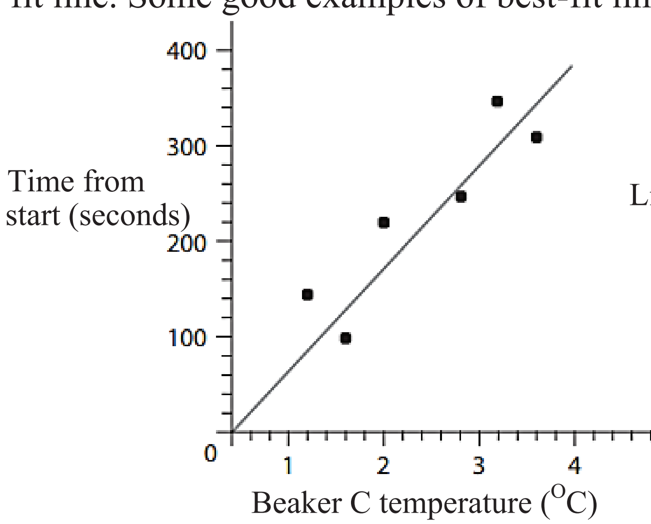


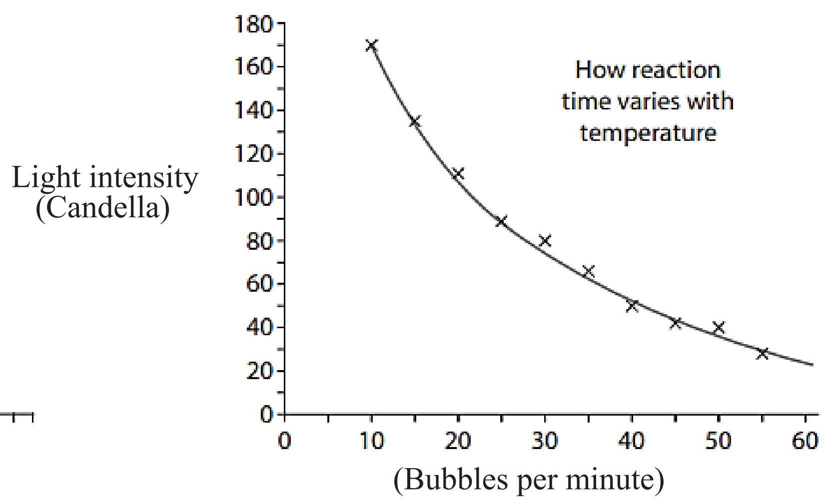


Tip: At the top of any table of data you have to use write the letter X and Y next to the independent and dependent variable to remind you which axis each goes on.

The second stage of drawing a graph is adding a scale. You must select a scale that allows you to use more than half of the graph grid in both directions. Choose a sensible ratio to allow you to easily plot your points (e.g. each 1cm on the graph grid represents 1, 2, 5, 10, 50 or 100 units of the variable). If you choose to use other numbers for your scale it becomes much more difficult to plot your graph.

Now you are ready to plot the points of data on the graph grid. You can use either crosses (×) or a point enclosed inside a circle ⊙ to plot your points but take your time to make sure these are plotted accurately. Remember to use a sharp pencil as large dots make it difficult to see the place the point is plotted and may make it difficult for the accuracy of the plot to be decided.
Finally a best-fit line needs to be added. This must be a single thin line or smooth curve. It does not need to go through all of the points but it should have roughly half the number of points on each side of the line or curve. Remember to ignore any anomalous data when you draw your best-fit line. Some good examples of best-fit lines that you should use are shown below:





Conclusion and Advice

The conclusion is a summary of findings, showing whether the hypothesis was supported or rejected.

It should:

- Answer the aim of the investigation
- Refer to the evidence from results

Example Conclusion

- The experiment showed that osmosis causes water to move from dilute to concentrated solutions through a semi-permeable membrane.
- The hypothesis was supported.

Advice / Application

This section explains:

- The importance of findings in real-life situations
- How the knowledge can be applied

Examples

- Farmers should avoid storing vegetables in salty water because they lose water and become soft.
- Food should be preserved using salt to remove water from microorganisms.

Food tests in biology

Food tests are carried out to find out the **types of food nutrients present in a sample**. These include tests for:

- Starch
- Reducing sugars
- Non-reducing sugars
- Proteins
- Lipids (fats and oils)
- Vitamin C (Ascorbic acid)

Summary of Food Tests

Food Nutrient	Name of the Test	Reagent(s) Used
Starch	Iodine Test	Iodine solution
Reducing sugars	Benedict's Test	Benedict's solution
Non-reducing sugars	Hydrolysis + Benedict's Test	Dilute hydrochloric acid (HCl), Sodium hydrogen carbonate, Benedict's solution
Proteins	Biuret Test	Biuret solution *(or Sodium hydroxide + Copper(II) sulphate)*
Lipids (fats & oils)	Ethanol Emulsion Test	Ethanol, Distilled water
Vitamin C (Ascorbic acid)	DCPIP Test	DCPIP solution

Procedure

1. To 1 cm³ of test solution, add 1 cm³ of ethanol and shake to dissolve lipids.
2. Add 1 cm³ of distilled water.

Expected result

- Milky-white emulsion forms → lipid present
- Solution remains clear → lipid absent

B. Grease-Spot (Paper Translucency) Test

Procedure

- Rub a small portion of the sample on brown paper and hold it to light.

Expected result

- Translucent spot → lipid present
- No translucent spot → lipid absent

6. **Test for Vitamin C (DCPIP Test)**

Procedure

To 1 cm³ of DCPIP solution in a test tube, add the test solution drop by drop, shaking after each drop until a change occurs.

Expected result

- Blue colour disappears → vitamin C present
- Blue colour persists → vitamin C absent

Enzyme Activities in Biology

Enzymes are biological catalysts that speed up the rate of chemical reactions in living organisms without being used up. Each enzyme works on a specific substrate and produces specific products.

Enzyme activity is affected by:

- Temperature
- pH
- Enzyme concentration
- Substrate concentration

1. **Amylase (Enzyme for Starch Breakdown)**

Function / Role

Amylase breaks down **starch into maltose (a reducing sugar).**

Source

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

Osmosis

Meaning of Osmosis

Osmosis is the movement of water molecules from a region of higher water concentration to a region of lower water concentration through a selectively (partially) permeable membrane.

A selectively permeable membrane allows small water molecules to pass through, but prevents larger solute molecules from passing.

Examples of selectively permeable membranes include:

- Cell membranes
- Dialysis tubing / Visking tubing
- Egg membrane

Key Terms in Osmosis

- **Hypotonic solution.** This is a solution with higher water concentration / lower solute concentration
- **Hypertonic solution.** This is a solution with lower water concentration / higher solute concentration
- **Isotonic solution** – both sides have equal water concentration

Effects of Osmosis in Plant Cells

When plant cells are placed in different solutions:

In a Hypotonic Solution (e.g., distilled water)

- Water enters the cell by osmosis
- Vacuole swells
- Cell becomes turgid
- Cell wall prevents bursting

Importance of turgidity

- Maintains shape of plant organs (leaves, stems)
- Supports young herbaceous plants
- Keeps leaves firm and upright

In a Hypertonic Solution (e.g., concentrated salt/sugar solution)

- Water leaves the cell
- Cytoplasm and vacuole shrink
- Cell membrane pulls away from the cell wall
- Cell becomes plasmolysed

In an Isotonic Solution

- No net movement of water
- Cell remains **flaccid (normal)**

2. Anatomy / Structure and function in living organisms

A candidate is expected to:

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

1. Identification of the Specimen(s)

When identifying a specimen, always follow a systematic approach:

(a) Observe General Features First

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

(b) Observe Detailed / Diagnostic Features

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

(c) Use Biological Terms

Avoid common words like *"legs like a stick"*.

Use proper terms such as:

- Jointed appendages
- Compound eyes
- Tap root system
- Parallel venation
- Thorax, abdomen, cephalothorax

(d) State the Likely Name

Give:

1. Common name

2. Where possible, the biological group

Example:

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

Flowering plants

Plant organs perform specific functions that support growth, transport, reproduction, and survival. In practical work, candidates are often required to observe, draw, label, compare, and state functions of these structures.

(a) Leaves

Structure

A typical leaf has:

- Lamina (leaf blade)
- Midrib and veins
- Petiole (stalk) — in petiolate leaves
- Leaf margin and apex

Internal structures include:

- Upper epidermis
- Palisade mesophyll (many chloroplasts)
- Spongy mesophyll
- Vascular bundles (xylem & phloem)
- Stomata (mainly lower surface)

Functions

- Photosynthesis
- Transpiration
- Gaseous exchange
- Storage (in some leaves e.g., onions, succulents)

Practical Skills

- Drawing and labelling a leaf
- Distinguishing **monocot vs dicot leaves**
- Observing stomata using a peel/ impression

(b) Flowers

Parts of a Typical Flower

- Calyx (sepals) — protection
- Corolla (petals) — attract pollinators
- Androecium (stamens) — male part
  — *anther, filament*
- Gynoecium (carpel/pistil) — female part
  — *stigma, style, ovary, ovule*

Functions

- Sexual reproduction
- Formation of fruits and seeds

Worked out examples

Example 1

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

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

Two foods commonly served to pupils were sampled from the school kitchen, labelled Sample **A** and Sample **B**, and taken to the science laboratory for nutrient investigation.

Task:

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

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

You are provided with the following by your teacher:

- 25 cm³ of Sample **A**
  (prepared by boiling 125 g of white rice, mashing it while warm, adding 500 ml of distilled water, mixing thoroughly into slurry, allowing solids to settle, decanting the liquid, and diluting the decanted solution to 1000 ml using distilled water).

- 25 cm³ of Sample **B**
  (prepared by soaking 125 g of dry beans in water for 24 hours, boiling until soft, pounding into paste, mixing with 500 ml of distilled water, decanting the solution, and diluting the filtrate to 1000 ml using distilled water).

Access to:

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

Student X's Expected Response

1. Aim
To investigate the nutrients present in food samples A and B and advise the mother on the adequacy of the child's diet.

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

3. Variables

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

4. Materials / Apparatus

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

5. Procedure / Observations / Data Presentation

Procedure	Sample	Observations	Deductions
To 1 cm^3 of food sample add 2 drops of Iodine solution	A	Cloudy/turbid/milky solution turns black/blue-black	Starch present
	B	Cloudy/turbid/milky solution turns black/blue-black	Starch present
To 1 cm^3 of food sample add 1 cm^3 of Benedict's solution and boil	A	Cloudy/turbid/milky solution turns blue and the blue colour persists	Reducing sugars absent
	B	Cloudy/turbid/milky solution turns blue and	Reducing sugars absent

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

Example 2

In a rural daycare, the caretaker observed that some children complained of feeling hungry soon after meals, while others occasionally experienced low energy. The nutrition assistant suspects that although the meals are filling, some food components may not be easily digested.

To investigate this, the assistant has provided two types of solutions to the pupils: Solution **P**, which is a liquid extract from a food, and Solutions **Q, R,** and **S**, which are enzyme solutions suspected to act on Solution **P** at different concentrations.

Task:

Design and carry out a scientific investigation to determine the food substances present in Solution **P** and the effect of different concentrations of the enzyme solutions on Solution **P**.

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

You are provided with the following by your teacher:

- 10 cm^3 of Solution **P** (*prepared by crushing 125 g of peeled cassava into paste, adding 500 ml distilled water, mixing thoroughly, decanting the liquid, and diluting the filtrate to 1000 ml with distilled water*)
- 5 cm^3 of 0.5% amylase solution, labelled **Q**
- 5 cm^3 of 1.0% amylase solution, labelled **R**
- 5 cm^3 of 5% amylase solution, labelled **S**
- 6 test tubes, hand lens, labels
- Access to: source of heat, iodine solution, Benedict's solution, dilute NaOH, $CuSO_4$, ethanol + water (for fats test)

Student X Expected Response

Aim

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

Hypothesis

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

Variables

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

Materials / Apparatus

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

Procedure / Observations / Data Presentation

To 1 cm³ of Solution P add 2 drops of iodine solution	P	Turbid solution turns blue-black	Starch present
To 1 cm³ of Solution P add 1 cm³ dilute NaOH followed by 3 drops $CuSO_4$	P	Turbid solution turns blue	Proteins absent
To 1 cm³ of Solution P add 1 cm³ Benedict's solution and boil	P	Turbid solution turns blue	Reducing sugars absent
Label three test tubes 1, 2, 3; put 1 cm³ of Solution P in each	1,2,3	—	—

Example 3

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

To help learners study this change, the teacher prepared four liquid extracts from seeds at different stages of germination, labelled Solutions **A**, **B**, **C**, and **D**. The number of days of germination for each solution is not disclosed to the students.

Task:

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

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

You are provided with the following by your teacher:

- Solution **A** *(made by crushing 7 days germinating maize/sorghum seeds)*
- Solution **B** *(made by crushing 4 days germinating maize/sorghum seeds)*
- Solution **C** *(made by crushing 2 days germinating maize/sorghum seeds)*
- Solution **D** *(made by crushing 1 day germinating /fresh dried maize/sorghum seeds)*
- Access to: source of heat, reagents for food tests.

Student X — Expected Response

Aim

To identify the food substances present in Solutions A, B, C and D and compare their sugar content in order to arrange the solutions in the order of increasing days of germination.

Hypothesis

If seeds germinate for a longer time, then the amount of reducing sugars increases while the amount of starch decreases, because starch is hydrolysed to sugars during germination.

Variables

- Independent variable: Stage (time) of germination of the seeds used to prepare the solutions
- Dependent variable: Amount of starch and reducing sugars present

Data Analysis / Interpretation

- Solution **A** has very high reducing sugar and little starch → most hydrolysis has occurred
- Solution **B** has moderate sugar and little/moderate starch → some hydrolysis has occurred
- Solution **C** has little sugar and much starch → early stage of hydrolysis
- Solution **D** has no sugar and much starch → least or no germination change

Therefore, the greater the sugar content, the longer the seeds have been germinating.

Conclusion

Order of solutions in increasing days of germination

D < C < B < A

- **D** → least germinated (much starch, no sugar)
- **C** → slightly germinated (much starch, little sugar)
- **B** → more germinated (moderate sugar, less starch)
- **A** → most germinated (much sugar, little starch)

This supports the principle that during germination starch is hydrolysed to reducing sugars and sugar content increases with time.

Example 4

A small food-processing company produces a natural onion extract that is sold as a health supplement. The company claims that the extract provides important nutrients such as reducing sugars and vitamin **C**, which can help to improve body energy and immunity.

However, nutrition inspectors have raised concerns that some batches of the extract may lose important nutrients during processing and heating. The company wants to confirm which key food substances are present in the extract and whether heating affects vitamin **C** content.

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

Task:

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

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

You are provided with the following by your teacher:

- Extract **B1**
- 6 test tubes
- A 10 mL measuring cylinder
- Access to a source of heat
- Reagents commonly used in food tests

Student X — Expected Response

Aim

To test Extract **B1** for the presence of starch, reducing sugars, proteins, lipids, vitamin **C**, and enzyme activity, and to determine the effect of heating on vitamin **C**.

Hypothesis

Extract **B1** contains reducing sugars and vitamin **C**, but vitamin C decreases when the extract is heated.

Variables

- **Independent variable:**
  Heating of Extract **B1** (heated vs unheated)
- **Dependent variables:**
  - ✓ Colour changes in food tests
  - ✓ Number of drops needed to decolorise DCPIP
  - ✓ Amount of bubbles produced in the enzyme test
- **Controlled variables:**
  - ✓ Volume of extract and reagents
  - ✓ Temperature and duration of heating
  - ✓ Type of reagents used

Materials

- Extract **B1**
- Benedict's solution
- Iodine solution
- Dilute sodium hydroxide
- Copper(II) sulphate solution
- DCPIP solution
- Ethanol
- Hydrogen peroxide
- Test tubes, test tube holder, source of heat
- Measuring cylinder, dropper

Conclusion & Recommendation

Extract B1 contains high reducing sugars and vitamin **C**, but heating significantly reduces vitamin **C** content. The company should:

- ✓ Avoid excessive heating during processing
- ✓ Label the product as a source of energy and vitamin **C**
- ✓ Store and transport under cool conditions

Therefore, the extract may be approved only if processed under conditions that preserve vitamin **C**.

Example 5

A biotechnology company is researching ways to reduce the build-up of hydrogen peroxide (H_2O_2) in plant waste during processing. Hydrogen peroxide is harmful to cells, so the company wants to identify plant tissues that contain an active substance that can break down H_2O_2 efficiently.

The company has obtained a plant tissue sample labelled **P**. The researchers suspect that the tissue contains an enzyme that decomposes H_2O_2 into harmless substances. They want to investigate how different treatments of the tissue affect the activity of the enzyme.

Task:

Design and carry out a scientific investigation to determine the effect of different treatments on the enzyme activity in **P** by observing its ability to break down hydrogen peroxide.

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

You are provided with the following by your teacher:

- Medium-sized potato tuber, labelled **P**
- 12 cm^3 of hydrogen peroxide solution (*prepared by diluting 100 cm^3 of concentrated H_2O_2 to 1 litre with water*)
- 5 cm^3 distilled water
- 3 cm^3 of 2 M HCl
- 5 test tubes
- Thermometer, hand lens, knife/razor blade, small measuring cylinder (10 mL)
- Access to a source of heat and reagents for carrying out food tests

Student X's Expected Response

Aim:

To investigate the enzyme activity in Specimen **P** by observing its ability to decompose hydrogen peroxide and to determine the effect of different treatments on the enzyme.

Hypothesis:

The plant tissue (Specimen **P**) contains an enzyme that decomposes hydrogen peroxide, and its activity will vary with treatment; boiling and acid will reduce or stop the activity, while increasing surface area will increase the rate of reaction.

Variables:

Independent variable:

- Treatment of the plant tissue (whole cuboid, cut into small pieces, boiled, treated with acid, control).

Dependent variable:

- Rate of decomposition of hydrogen peroxide (observed as bubble formation).

Controlled variables:

- Volume of hydrogen peroxide used (3 cm³)
- Volume of plant tissue used (1 cuboid or 10 pieces)
- Temperature (room temperature, except boiled cuboid)
- Time of reaction observation
- Test tube size and type

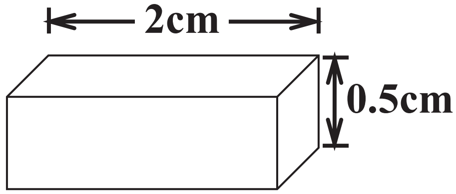
Materials / Apparatus:

- Specimen **P** (medium-sized potato tuber)
- Hydrogen peroxide solution (12 cm³, diluted to 1 litre)
- Distilled water (5 cm³)
- 2 M HCl (3 cm³)
- 5 test tubes
- Thermometer
- Hand lens

- Knife/razor blade
- Small measuring cylinder (10 mL)
- Source of heat

Procedure / Observations / Data Presentation

(a) Cut out 5 cuboids from specimen **P** each 2cm long (Breadth) and width of 0.5cm respectively.



(b) Put one cylinder of **P** in a boiling tube with water and boil for 5 minutes and cut one cuboid into 10 pieces.
(c) Label 5 test tubes **1**, **2**, **3**, **4** and **5**.
(d) Put 3cm^3 of hydrogen peroxide solution in each of the test tubes **1**, **2**, **3**, and **4**.
(e) Put 3cm^3 of distilled water in test tubes.
(f) Carryout the following tests on specimen **P** using the solutions provided.
(g) Record your observations and deductions in the table below.

TESTS		OSERVATIONS	DEDUCTIONS
(h)	To test tube **1**, add one cuboid from specimen **P**.	Few bubbles of a colourless gas given off slowly	Hydrogen peroxide decomposed / broken down at slow rate
(i)	To test tube **2**, add the 10 pieces cut from one cuboid from specimen **P**.	Very many bubbles of a colourless gas given off very fast / vigorously	Hydrogen peroxide decomposed / broken down at very fast rate
(j)	To test tube **3**, add the boiled cuboid from specimen **P**.	No bubbles of a colourless gas given off	Hydrogen peroxide not decomposed / broken down
(k)	To test tube **4**, add of 2cm^3 Hydrochloric acid followed by one of the remaining cuboid of specimen **P**.	Few bubbles of a colourless gas given off slowly	Hydrogen peroxide brown down slowly
(l)	To test tube **5**, add one of the remaining cuboid of **P**.	No bubbles of gas given off	Water molecules not broken down

Data Analysis / Explanation:

- Test tube 2 shows more bubbles than tube 1 because cutting the tissue into smaller pieces increases the surface area, allowing more enzyme molecules to contact H_2O_2.
- Test tube 3 shows no reaction because boiling denatures the enzyme, altering its active site.
- Test tube 4 shows no reaction because acid changes the enzyme's shape, inactivating it.
- Test tube 5 serves as a control to confirm that bubbles are produced by enzyme activity, not spontaneously.

Conclusion:

- Solution **P** contains the enzyme catalase which decomposes hydrogen peroxide into water and oxygen.
- The enzyme activity is affected by surface area, heat, and pH.
- Increasing surface area increases the rate of reaction, while heat and acid inactivate the enzyme.

Recommendation:

- For maximum enzyme activity, plant tissues should be used fresh, at room temperature, and without exposure to extreme pH.

Example 6

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

Task:
Design and carry out a scientific investigation to compare the water retention capacities of the soil samples and recommend the best soil for planting crops in dry conditions.

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

Example 7

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

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

Task:

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

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

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

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

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

NB: Your teacher has provided you with the following

- A fleshly killed Soldier termite labelled **A**
- A fleshly killed worker termite labelled **B**
- A fleshly killed housefly labelled **C**
- Hand lens (×10 or ×8, preferably).

Student X's Expected Response

(a) (i) Phylum

Phylum: Arthropoda

Reason(s):

- The specimens have a segmented body divided into head, thorax and abdomen.
- They have jointed appendages (legs).
- Their bodies are covered by a chitinous exoskeleton.

(a) (ii)

Description of how structures on one specimen increased damage to stored grain

I chose specimen **B** (worker termite).

- It has chewing mouthparts (mandibles) which enable it to bite and feed on the grains.
- It has a small soft body, allowing it to enter small cracks in the store and reach the grains easily.
- It is the one responsible for feeding the colony, therefore it causes continuous loss of grain.

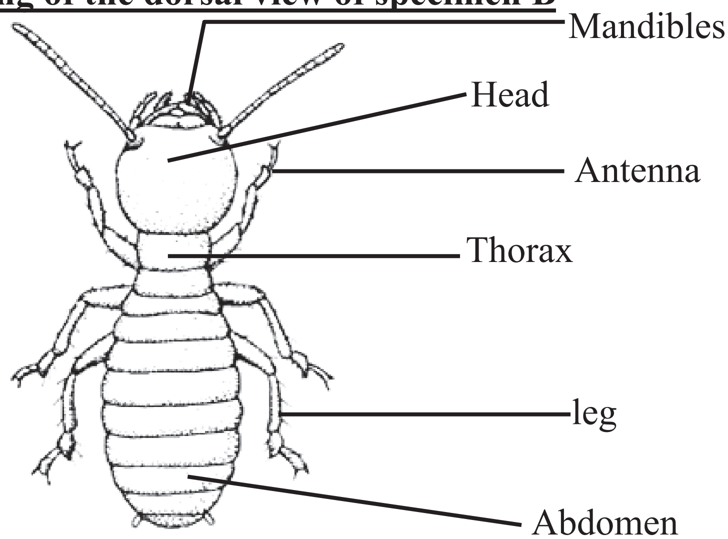
(b) Description of mouth part, head and leg

Specimen	Mouth part	Head	Leg
A (Soldier termite)	Chewing mandibles for cutting and defence	Large head to support strong jaws	Walking legs for movement
B (Worker termite)	Chewing mouthparts for feeding on grains	Small head for handling food	Walking legs for movement in tunnels
C (Housefly)	Sponging/sucking mouthpart for feeding on liquids	Broad head with compound eyes for vision	Long slender legs with claws and pads for perching

(c) (i) Adaptations of legs of specimen C

- The legs have pads and claws which help it to grip and perch on different surfaces.
- The pads pick up dirt and microorganisms, which can be transferred to food.
- The legs are long and slender, helping the fly to move and land quickly on food surfaces.
- This helps the insect to survive in its habitat and spread contamination.

(c) (ii) <u>A drawing of the dorsal view of specimen B</u>



Magnification: ×

Example 8

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

Unlike other workers, Sarah followed the advice by keeping food waste properly covered and cleaning the working surfaces regularly. Over time, the rate of food spoilage in her section reduced.

Meanwhile, workers in the neighbouring section continued leaving food remains uncovered. Their food products became increasingly contaminated.

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

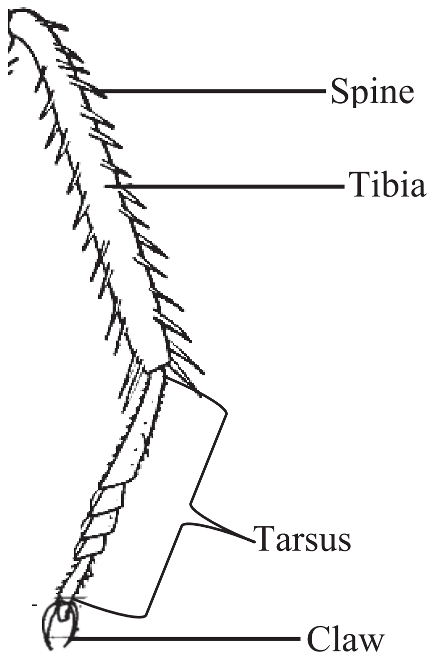
Task:

(a)

(i) With reason(s), identify the smallest taxonomic group to which both specimens **J** and **K** belong.
Taxonomic group: ___
Reason(s): ___

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

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



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Example 9

In a school botanical garden, the Headteacher observed that certain plants were producing more fruits and seeds than others, while some plants were wilting faster and losing water more quickly. The teacher wanted the students to investigate how the structure of different plant parts affects pollination, growth, and water conservation, which ultimately influences plant productivity.
To help the students, the teacher collected different leaves and flowers the garden:

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

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

Task:

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

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

(ii) Explain how:

Reason;

- ✓ Its dull coloured
- ✓ Pollen grains are dusty to be blown/ rain fall

(b) (ii) How the specimens encourage self- or cross-pollination

Specimen M

- ✓ M - has both male and female parts which mature at the same time can pollinate on the same flower hence self pollination

Specimen N

- ✓ Specimen **N** has only one part and can get female part from a different plant hence cross pollination

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

G
- Has germinating birds
- It is smooth
- Has notches
- Has crenate margin
- Has net work venation

H
- Has white like polythene substance (cuticle)
- It is hairy
- Has hollow leaf stalk
- It has simple entire margin

F
- It is hairy
- It has parallel veins
- It has a sheath
- It has simple entire margin

(d) (i) How specimen F minimizes transpiration

Specimen **F** has cuticle that minimize transpiration

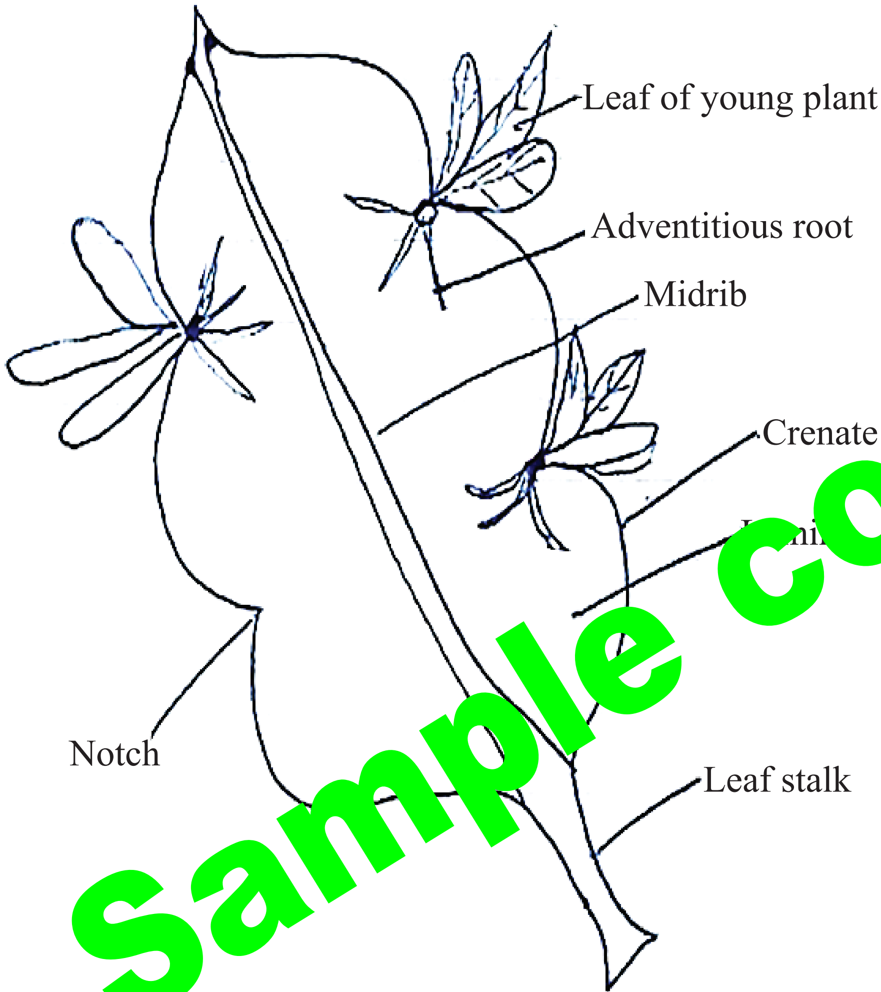
Specimen **F** has hairy lamina, that trap a film of water that may cover the stomata to prevent further escape of water from the plant / leaf

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

1 **a)** Specimen with net work venation…………**2**
  b) Specimen with parallel venation…………..**F**

2 **a)** Specimen with crenate margin……………....**G**
  b) Specimen with simple entire margin……….**H**

(e) **A drawing showing specimen G**



Magnification: × 2

Example 10

In a village, children often complained of difficulty in chewing certain foods. A local dentist observed that some children were having trouble grinding hard foods like cassava and maize, while others had difficulty biting softer foods such as fruits.

To investigate, the dentist collected two different teeth from children during routine check-ups. You are provided with specimens ***Q*** and **R**.

The dentist used these specimens to demonstrate how different teeth are adapted to perform specific functions in the human mouth.

You are provided with specimens ***Q*** and **R**.

(a) (ii) Observable features enabling the teeth to perform their functions

Tooth	Observable features	Function
Q (Molar)	Broad, flat crown; multiple cusps; thick enamel	Grinds and crushes hard foods into smaller particles for swallowing and digestion
R (Incisor)	Sharp, thin edge; single root; flat surface	Bites and cuts soft foods easily

(a) (iii) Effect on digestion if the teeth are damaged or missing

- Tooth **Q** missing or damaged: Hard food will not be crushed properly, leading to difficulty chewing and slower digestion, possibly causing stomach upset.
- Tooth **R** missing or damaged: Soft food cannot be bitten or cut efficiently, leading to difficulty in eating, taking large bites and increased risk of choking.
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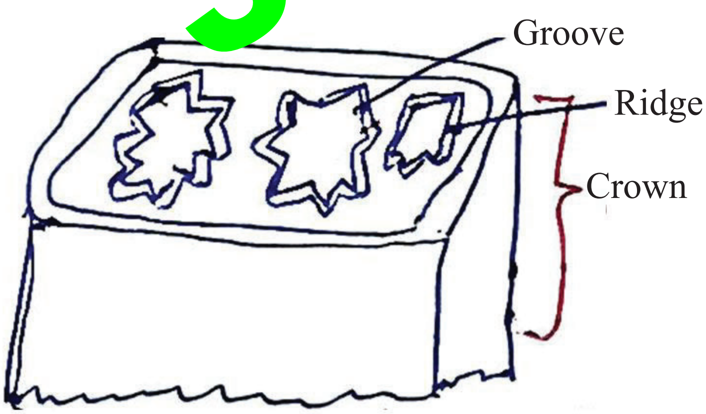
(b) **A drawing showing upper surface of the crown of specimen *Q*.**



We hope you have now gained confidence. You are encouraged to try the items below. All the requirements for each item are listed at the end of this book. We wish you every success.

Self-trial Experiments

Practical 1

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

Task:
Design and carry out an investigation on the food samples **A** and **B** and use your findings to advise Anita accordingly.

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

(a) Aim, hypothesis, variables and materials

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Practical 3

A secondary school athletics team is preparing for an inter-school sports competition. The coach wants to provide the athletes with food that can give them more energy during training and competitions. Two food samples eaten regularly by students are labelled Food **E** and Food **F**.

The school laboratory technician wants students to help determine which food provides more energy-giving nutrients.

Task:

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

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

(a) Aim, hypothesis, variables and materials

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Practical 6

A biscuit company in Kampala is developing a new type of nutritious biscuit for school children. The nutrition team wants to ensure that the ingredients used in the biscuits can supply the right nutrients needed for growth and energy.

Two of the main ingredients used in the biscuit mixture are provided as Solution **M** and **Solution N**. The company wants to know the types of food nutrients present in each of these ingredients so that they can decide how best to use them in biscuit production.

Task:

Design and carry out an investigation on Solution **M** and Solution **N** to identify the food nutrients present in each ingredient and use your findings to advise the biscuit company on how each solution contributes to nutrition.

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

(a) Aim, hypothesis, variables and materials

Practical 8

A food-processing company is developing a process in which an active substance reacts with Liquid **S** during production. However, the reaction is slow and delays the process. The company believes that the reaction may proceed faster when the liquid is placed in a suitable medium.

Three different solutions, **P, Q** and **R** are available on the market, but it is not known which one provides the most suitable medium for the reaction. The medium that allows the reaction to occur faster and more effectively is considered the best.

Task:
Design and carry out a scientific investigation to determine which solution **P**, **Q** or **R** provides the most suitable medium for the reaction between Liquid **S** and the active substance. Provide an appropriate recommendation to the company.

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

(a) Aim, hypothesis, variables and materials

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Practical 11

In a farming community in eastern Uganda, most families depend on maize as their major food and income crop. Recently, the farmers have observed that maize plants grown in some gardens are weak, yellowish, and produce very small cobs, while maize in nearby gardens appears dark green, healthy, and produces better yields. This difference in growth has caused concern because the affected farmers are losing income and food supply.

An agricultural extension worker visited the area to investigate the problem. After observing the maize fields, she suspected that the differences in plant performance may be related to variations in soil pH, which can affect the availability of nutrients such as nitrogen, phosphorus, and magnesium in the soil. The worker explained to the farmers that when soils become too acidic or too alkaline, crops like maize may fail to grow well even if the soil contains nutrients.

To confirm this, she collected three soil samples **A, B** and **C** from different gardens in the village.

The samples were taken to the school laboratory so learners could help investigate the soil pH levels and determine which soil was most suitable for maize growing. The extension worker hopes that the results of the investigation will help farmers understand their soils better and guide them in improving crop production.

Task:

Design and carry out a scientific investigation to compare the pH of soils **A**, **B**, and **C** and determine which soil is most suitable for growing maize.

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

(a) Aim, hypothesis, variables and materials

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Practical 18

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

Task:
Design and carry out a scientific investigation to determine the effect of temperature on the movement of water across the cells of tissue **T** when placed in the same solution.

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

(a) Aim, hypothesis, variables and materials

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Practical 23

In a rural village, farmers storing grains in different granaries noticed significant differences in spoilage. While most farmers lost large quantities of maize and beans to pests, one farmer reported minimal losses despite having visible insects.

A science teacher collected two specimens from the granaries to explain the variation, specimen **A** and specimen **B**. The teacher suspected that structural differences between these insects affected their ability to damage grains**.**

Task:

(a) (i) Identify the phylum of each specimen.

Phylum:

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Reason(s):

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

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

(c) Draw a labelled dorsal view of specimen **B**

Practical 31

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

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

To deepen understanding, the teacher collected several specimens from the garden. The flowers differed in petal arrangement, colour, and position of reproductive organs while the leaves showed variations in size, texture, and thickness.

Students were required to investigate how these structural differences affect reproduction, survival, and plant productivity in the moist environment.

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

Task:

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

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

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Practical 32

In a community located near a seasonal wetland, farmers noticed that some weeds were rapidly spreading across their gardens and footpaths, even in areas where crops had not been planted before. During the rainy season, plants such as Bidens pilosa and Tridax procumbens were commonly seen growing along grazing routes and around homesteads. Meanwhile, plants like Desmodium and beans were mostly found in crop fields.

To help students understand how different plants spread from one place to another, a science teacher collected mature fruits **H**, **I**, **J** and **K** from various flowering plants found in the area. The fruits were carefully selected because they showed special features that help them move and colonise new habitats.

The teacher wants learners to observe, compare and relate the structural features of the fruits to the methods by which they are dispersed in nature. A hand lens has been provided to enable you to examine fine details that cannot be seen clearly with the naked eye.

Task:

(a) What plant parts are the specimens? Give a reason for your answer.

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(b) Using a hand lens where necessary, examine the specimens and describe the structural features on each of them.

(i) **H**

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(ii) **I**

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Practical Requirements (Practical Instructions)

Each candidate will require the following materials and apparatus.

Practical 1

- 25 cm^3 of solution **A** (*is prepared by crushing* 125 g *of peeled fresh cassava, into paste, add* 500 ml *of water, mix and decant the solution then dilute it to* 1000 ml *using distilled water*).
- 25 cm^3 of solution **B** (*is prepared by soaking* 125 g *of beans in water for* 24 *hours, pound the beans into paste and mix with* 500 ml *of distilled water. Decant the solution and dilute to* 1000 ml *using distilled water*).

Access to:

- Reagents for food tests.
- 2 Beakers.
- Source of heat.
- 6 Test tubes.
- Test tube holder.
- Test tube rack.
- Droppers.
- **A t**hermometer.

Practical 2

- 25 cm^3 of solution **C** (*prepared by grinding 100 g of groundnuts, mixing with 400 ml water, filtering and diluting to 1000 ml)*
- 25 cm^3 of solution **D** (*prepared by boiling 100 g of Irish potatoes in 400 ml water, mashing, filtering and diluting to 1000 ml*)

Access to:

- Reagents for food tests
- 2 beakers
- Source of heat
- 6 test tubes
- Test tube holder
- Test tube rack
- Droppers
- A thermometer

Practical 3

- 25 cm^3 of **solution E** (*prepared by boiling 100 g of maize flour in 400 ml water, cooling, filtering and diluting to 1000 ml*)

  25 cm^3 of **solution F** (*prepared by crushing 100 g of ripe bananas, mixing with 400 ml water, filtering and diluting to 1000 ml*)
- **Access** to heat and reagents for food tests.

Practical 4

- 25 cm^3 of **solution G** (*prepared by blending 100 g of fresh tomatoes with 400 ml water, filtering and diluting to 1000 ml*)

  25 cm^3 of **solution H** (*prepared by crushing 100 g of pawpaw, mixing with 400 ml water, filtering and diluting to 1000 ml*)
- **Access:** to heat and reagents for food tests.

Practical 5

- 25 cm^3 of **solution J** (*prepared by grinding 100 g of sim-sim seeds, mixing with 400 ml water, filtering and diluting to 1000 ml*)
- 25 cm^3 of **solution K** (*prepared by boiling 100 g of rice in 400 ml water, filtering and diluting to 1000 ml)*
- **Access:** to heat and reagents for food tests.

Practical 6

- 25 cm^3 of **Solution M** (*prepared from egg albumen mixed with distilled water and filtered*)
- 25 cm^3 of **Solution N** (*prepared from egg yolk mixed with distilled water and filtered*)
- **Access to**: heat and reagents for food tests.

Practical 7

- 10cm^3 of Liquid **S** (Starch solution)
- 6cm^3 of active substance (Amylase)
- Solution **P** (0.1M NaOH)
- Solution **Q**(distilled water)
- Solution **R** (0.1M HCl)
- Iodine solution
- 6 test tubes