

BIOLOGY LABORATORY EQUIPMENTS AND CHEMICALS

Conducting experiments in biology requires the use of several scientific apparatuses. It is therefore necessary to **know** the frequently used apparatus in biology experiments. Some materials are easier to procure while others might be difficult or simply too expensive to afford especially when required in large quantities. This booklet has suggested alternatives you can use if the standard apparatus have not been procured. It also provides useful tips on how you can make them by using locally available materials.

Beakers

Use: To hold liquids

Alternative Materials: Water bottles, juice containers, lids for bottles or jars, and a knife.

Procedure: Take empty plastic bottles of different sizes. Cut them in half.

The base can be used as a beaker.

Blotting/Filter Paper

Use: To use remove/wipe excess water.

Materials: Tissue paper.

Cages

Use: To capture different small animals.

Alternative Materials: Cardboard box, wire mesh, string, and bottles.

Procedure: Make a cut in the bottle without cutting completely through the bottle.

Get an empty box and cut it on top. Cover the top with wire mesh and use it as a cage

Dissection Needles

Use: To hold a specimen in place while performing a dissection.

Alternative Materials: pins, needles from syringes, or acacia thorns.

Dissection Trays

Use: To hold a specimen in place while performing a dissection.

Alternative Materials: Take away food container, candles.

Procedure: Melt the candle wax in a take away container to create a dissection tray.

Droppers

Use: To add liquids in drops.

Alternative Materials: 2 mL syringes.

Procedure: Take a syringe. Remove the needle.

Hazard: Remove the needle from the syringe. Never use syringes with the needles. Never provide needles to the students.

Funnel

Use: To guide liquid or powder into a small opening.

Alternative Materials: Empty water bottles, knife.

Procedure: Take an empty water bottle and remove the cap. Cut them in half. The upper part of the bottle can be used as a funnel

Petri Dishes

Use: To grow cultures or display small specimens.

Alternative Materials: Water bottle and scissors.

Procedure: Take empty plastic bottles of different sizes. Cut about 1 inch up from the bottom of the bottle. Lids of different containers can also be used as petri dishes.

Scalpels

Use: To dissect different organisms.

Alternative Materials: Knife, box cutter, or razor blades.

Spatula

Use: To transfer small amounts of a solid substance.

Alternative Materials: Wooden, plastic, or metal spoon, a knife and plastic bottle.

Procedure: Cut a thin rectangle from plastic water bottle half way so that it resembles a spatula.

Stopper

Use: To close a bottle or make an airtight seal.

Alternative Materials: Bottle caps, Sandals (ndala), and a knife.

Procedure: Cut a spherical piece of a sandal according to the size of the stopper you need.

Test Tubes

Use: To hold a small amount of liquid for examination or testing.

Alternative Materials: Syringe, candle or heat source, and a hard surface.

Procedure: Buy syringes of different volume from a pharmacy. Remove the plunger and the needle. Burn the bottom with a candle till the plastic begins to melt, then press the melted bottom against a hard surface to close.

Test Tube Holders

Use: To hold test tubes while heating.

Alternative Materials: A small piece of wood and a rubber band.

Procedure: Tie a rubber band to a piece of dry wood, then wrap the rubber band around the test tube.

Watch Glass

Use: To display small specimens.

Alternative Materials: Water bottles and scissors.

Procedure: Take empty plastic bottles of different sizes. Cut about 1 inch up from the bottom of the bottle. Lids of different containers can also be used as watch glasses.

Water Bath

Use: To heat substances without using a direct flame.

Alternative Materials: Heat source, water, and a cooking pot.

Procedure: Bring water to a boil in a pot or metal basin, then place the test tubes in the water to heat the substance inside the test tube.

White Tile

Use: To easily observe colour changes in leaves.

Alternative Materials: Glue or cellotape, wood block, white paper, and plastic sheeting

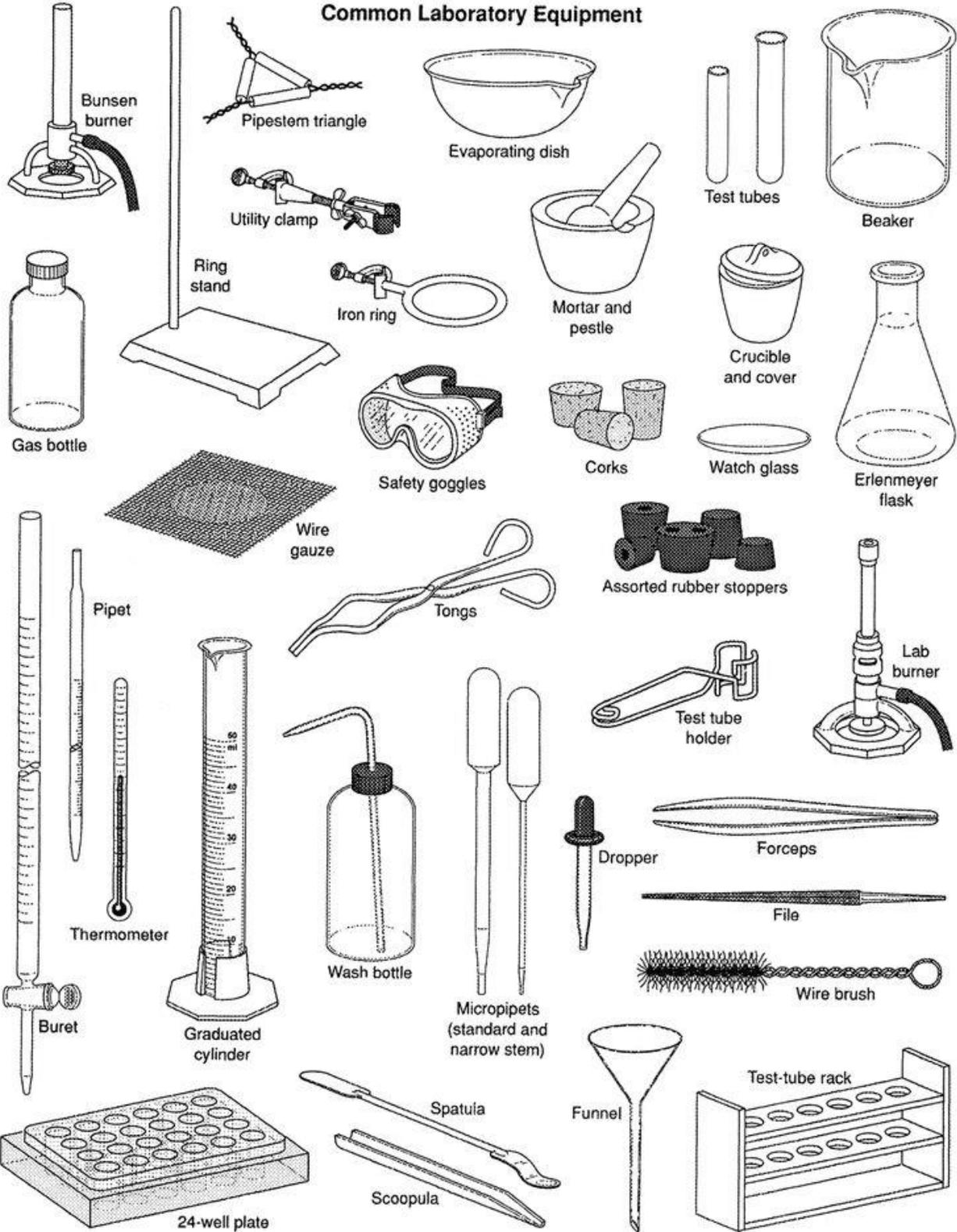
Making Procedure: Using cellotape or glue, cover a wood block with white paper. Then cover the white paper with a plastic sheet to prevent water from wetting the paper.

laboratory equipment



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Common Laboratory Equipment



Biology laboratory Chemicals

The following is a list of chemicals you will need in the biology laboratory.

For each we note IUPAC name, description of the chemicals, uses of these chemicals at your school, and/or functional alternatives to these chemicals and their hazards. Chemicals are generally listed alphabetically by IUPAC name.

Citric Acid

IUPAC Name: 2-hydroxypropane-1, 2, 3-tricarboxylic acid

Formula: $C_6H_8O_7 = CH_2(COOH)COH(CHOOH)CH_2COOH$

Description: White crystals soluble in water

Use: All purpose weak acid, manufacture of Benedict's solution

Hazard: Keep out of eyes

Source: Markets, Supermarkets

Copper Sulfate

IUPAC Name: Copper (II) Sulphate pentahydrate

Formula: $CuSO_4$

Description: white (anhydrous) or blue (pentahydrate) crystals

Use: Manufacture of Benedict's solution, test for Proteins

Description: Purple Liquid

Uses: Staining xylem cells

Glucose

Formula: $C_6H_{12}O_6$

Description: White powder

Uses: Food test

Note: For food tests, the vitamins added to most glucose products will not cause a problem.

Iodine

Formula: $I_{2(s)}$

Description: Brown liquid

Uses: Food test for starch and lipids

Sodium Carbonate

Formula: Na_2CO_3

Local name: Soda ash, washing soda

Description: White powder completely soluble in water

Use: Manufacturing Benedict's solution

Hazard: Caustic, corrosive

Sodium Hydroxide

Formula: NaOH

Local name: Caustic soda

Description: White deliquescent crystals

Uses: Food tests for protein, absorbs carbon dioxide in photosynthesis experiments

Hazard: Corrodes metal, burns skin, and can blind if it gets in to the eyes

Note: Biuret reagent is now commonly used instead of Copper(ii) sulphate and sodium hydroxide solution.

Sodium Hydrogen Carbonate

Formula: NaHCO₃

Local name: Baking soda

Description: White powder

Uses: To add CO₂ in photosynthesis experiments

Hazard: Corrodes metal, burns skin, and can blind if it gets in to the eyes

Making Biology Solutions

Standard chemicals and solutions for use in biology experiments may be procured from commercial suppliers of school and industrial laboratory chemicals. However, most of these chemicals/solutions can also be prepared from the school laboratories if certain materials are available. Here are the materials you will need and instructions on how to prepare common solutions for the Biology laboratory.

Benedict's Solution

Description: Bright blue solution

Use: To test for reducing and non-reducing sugars

Result: Gives orange precipitate when boiled with reducing sugar

Hazard: Copper ions are poisonous if they enter the body. Use tools to avoid contact between copper (II) sulphate and skin. Wash hands after using this chemical.

Preparation Procedure

- ❖ Dissolve 5 teaspoons of sodium carbonate.
- ❖ 3 teaspoons of citric acid, and
- ❖ one teaspoon of copper sulphate in half a litre of water.
- ❖ Shake until everything is fully dissolved.

NB: The addition of the citric acid and sodium carbonate should be done slowly as they cause effervescence when mixed quickly.

Calcium Hydroxide Solution (Lime Water)

Description: Opaque white liquid

Use: To test for CO₂

Result: This liquid will change from clear to cloudy if CO₂ is present.

Procedure: Add 3 spoonfuls of white cement into about half a litre of water.

Stir the solution and let it settle. Decant the clear solution and transfer it to a reagent bottle.

Citric Acid Solution

Description: Colourless solution

Use: To hydrolyse non-reducing sugars to reducing sugars

Procedure: Dissolve 2 1/2 spoonfuls of citric acid in half a litre of water.

Copper Sulphate Solution

Description: Light blue solution

Use: To test for proteins, to prepare Benedict's Solution

Result: Gives a purple colour when combined with NaOH in protein solution

Hazard: Copper ions are poisonous if they enter the body. Use tools to avoid contact between copper (II) sulphate and skin. Wash hands after using this chemical.

Procedure: Dissolve 1 spoonful of CuSO_4 crystals in 1/2 litre of water. Dissolve the CuSO_4 completely.

Iodine Solution

Description: Light brown solution

Use: To test for starch and lipids

Result: Gives a red ring with lipids and a black-blue with starch

Procedure: Dilute 1 part concentrated iodine tincture with 9 parts water.

Keep the solution in a labelled reagent bottle.

Sodium Hydroxide Solution

Description: Slightly cloudy white solution

Use: To test for proteins

Result: Gives a purple colour when combined with CuSO_4 in protein solution

Hazard: Corrodes metal, burns skin, and can blind if it gets into the eyes

Procedure: Combine 1 spoon of NaOH with 1/2 litre of water.

Topic: 10.1 Living Organisms and life processes

Subtopic: 10.1.1 Characteristics of living organisms

Title: characteristics of living organisms

There are 7 characteristics of living things; respiration, reproduction, excretion, irritability, movement, nutrition, and growth. The following activity can be done by learners in small groups to show the characteristics of living things and enforce observation skills.

Learning Objectives

- ❖ To outline the characteristics of living things.
- ❖ To differentiate between living and non-living things.

Materials

❖ Plastic water bottles, traps, plastic cups, non-living things like a pen and a rock, and a cardboard box.

Specimens

- ❖ Grasshopper, lizard, ant, or any other living things

Precautions

- ❖ Some organisms may be poisonous and should be avoided.

Preparation Procedure

1. Prepare cages and traps from the plastic water bottles. Purchase rat traps from the market.
2. Collect living things by using the traps and cages.
3. Collect non-living things to observe.
4. Put the collected organisms in cages, petri dishes, and plastic cups for students to observe.

Activity Procedure

1. Observe the specimens, draw and label each.
2. Record the characteristics of life you have observed in each specimen.
3. Categorize the specimens as living or non-living using your observations.

Results and Conclusion

Using the seven characteristics of life and observation skills, you should be able to determine which specimens are living and which are non-living.

Discussion Questions

1. How can you determine if a specimen is a living organism?
2. What are the differences between plants and animals?

Notes

The collection of the specimens and thorough observation is very important. You may not see all of the characteristics in one day, but through observation students will have a general understanding of the characteristics of life.

Topic: 10.2 Cell Structure and Organization

Subtopic: 10.2.2 Cell Structure and Function

Title: Examining Animal and Plant Cells

Plant and animal cells have similarities and differences. Plant cells have a cell wall which gives it a definite shape. Animal cells only have a cell membrane and thus a less rigid structure. Both types of cells have a nucleus which controls the function of the cell. Cells have different types of structures depending on their function in the organism.

Learning Objectives

- ❖ To differentiate various types of cells.

Materials

- ❖ Compound microscope, plastic slides, cover slips, needle, iodine solution, white tiles, beaker, petri dish, onion, soft tissues from plants, blotting paper, permanent blood cell slide, and razor blade/sharp knife.

Precautions

- ❖ Use the razor blade and knife carefully as you may cut yourself.

Activity Procedure

1. Collect all materials
2. Peel a thin layer of epidermal cells from the onion and stain them using a few drops of iodine solution.
3. Cut a few thin cross sections from the stem and root using a sharp razor blade and place the specimens into a petri dish with water and a few drops of Gentian Violet.
4. Select the thinnest section of a stem and root and place the specimens on a slide.
5. Observe each specimen with the microscope and draw what you see.

Results and Conclusion

The activity is intended to enable you to observe the structure of different plant cells.

Discussion Questions

1. What is the function of epidermal cells of plants?

2. What differences did you observe between the plant and animal cells?

NB: While observing the animal and plant cells under a microscope, you will only see the layout of the cells but not the details of different organelles as with a light microscope.

Introduction to Classification

Based on the fact there are so many different living things in the world, biologists put these organisms into groups to make it easier to study and identify them. This process is called classification. Classification enables scientists to make predictions. When we know the characteristics of a group we can predict the features of an organism in that group. For example, an owl and chicken are both birds. If we know what the heart of a chicken looks like we can predict what the heart of an owl will look like even if we haven't seen it.

Learning Objectives

- ❖ To group living things according to their similarities and differences.

Materials

Marker pen, cardboard, bread, and a tomato.

Specimens

- ❖ Rat, ants, hibiscus or another type of flower, beetle, fungi, worm.

Hazards and Safety

❖ When collecting and observing specimens, avoid dangerous animals like snakes, black ants, wasps, and bees. Stay away from poisonous plants like deadly nightshade and poisonous fungi.

Preparation Procedure

1. Collect different living things like fungi, plants of different shapes and sizes, and animals.
2. Place a piece of moist bread near a window to culture bread mould.
3. Cut a tomato in half and leave it overnight to prepare mucor.
4. Mount the different specimens on a piece of cardboard box and label each specimen with a single letter.

Activity Procedure

1. Display the specimens for observation.
2. Group the organisms based on their similarities and differences.
3. Classify the organisms, naming their Kingdom, Phylum/Division, and Class.

Results and Conclusion

Students are expected to observe and group living things according to their similarities and differences.

Discussion Questions

1. Why do you think it is important to classify living things?
2. Draw and label a specimen from each Phylum.

Topic: 11.9 Growth and development

Subtopic: 11.9.2 Germination and development

Title: Examination of Structures of Representative Dicotyledonous and Monocotyledonous plants

Monocot and dicot plants are flowering plants and are found in division Angiospermatophyta. They differ in morphological structures from roots, stems, leaves, and flowers, e.g. root size, leaf shape, floral parts, arrangement of vascular bundles and number of cotyledons in their seeds.

Learning Objectives

- ❖ To describe the structures of representative dicotyledons and monocotyledons.

Materials

Razor blade, maize grain, bean seed, petri dishes, cardboard boxes, microscope, scalpel, monocot and dicot plants.

Precautions

Care must be taken when cutting the specimens as you may cut yourself.

Preparation Procedure

1. From a nearby field or garden, collect dicotyledonous plants (hibiscus plant, bean plants, black jack plant) and monocotyledonous plants (grasses, maize plants.).
2. Place the plants into a beaker.

Activity Procedure

1. Observe the dicot and monocot plants from the external appearance by considering roots, leaves and flowers.
2. Record the features seen from each plant.
3. Cut a transverse section of a stem and roots of monocot and dicot that can be mounted on a slide and observe the arrangement of the vascular bundles on a compound microscope.
4. Draw the vascular bundles as seen under a compound microscope (for monocot and dicot roots and stem).

5. Cut maize grain and bean seeds longitudinally to see how many cotyledons are in each specimen and draw them.

Results and Conclusions

All of the common features of each class should be easily observed.

Discussion Questions

1. With the aid of diagrams, differentiate monocots from dicots.
2. What is the economic importance of monocots and dicots?
3. Classify maize and bean plants as either dicotyledonous or monocotyledon

Nutrition

Nutrition is the way organisms obtain materials they need to live. There are two types of nutrition, autotrophic nutrition and heterotrophic nutrition. Autotrophic nutrition is how plants get their food. Plants use energy from sunlight to convert raw materials into food. This process is called photosynthesis. Heterotrophic nutrition is how animals get food. Animal food may be plants or other animals, alive or dead. Food is anything that provides the body with a source of energy, material for growth and repair, or other factors for good health. Nutrients are food substances necessary for healthy growth. Humans eat foods containing the following nutrients: carbohydrates, fats, proteins, vitamins, and mineral elements. Nutrition is important because it allows us to move, grow, keep our bodies warm, repair damaged tissue and fight diseases.

Food Test for Lipids (Grease spot test)

Lipids are an organic food substance made of carbon, oxygen, and hydrogen. Lipids occur in two forms: fats and oils. Oils are liquid at room temperature whereas fats are solid. Lipids provide the body with energy and create a layer of insulation to help keep the body warm. The main sources of lipids are milk, animal fats, groundnuts, coconuts, and avocado.

Learning Objectives

- ❖ To carry out a test for lipids in a given food sample.

Materials

Filter paper or brown paper, distilled water, source of light, test tubes, droppers, and a cooking oil that is liquid at room temperature, e.g. sunower oil.

Activity Procedure

1. Place a sample of cooking oil on a filter paper.
2. place a drop of distilled water next to the drop of the same food sample.
3. hold the paper against light until the drop of water disappears; then observe and record what happens.

Results and Conclusions

You should see the formation of a red ring at the top of the sample solution.

This indicates the presence of lipids.

Observation	conclusion
Sample spot disappears	Fats/oils absent
Permanent spot formed	Fats/oils present

Discussion Questions

1. In which part of the digestive system is the identified food substance digested?
2. Name the enzyme responsible for its digestion.

3. When the identified food substance is digested, what is the end product?

Notes

Food Test for Proteins (Biuret test for proteins)

Proteins are organic food substances consisting of carbon, hydrogen, oxygen, and nitrogen. Proteins create growth and repairs damaged tissue. The main source of protein are beans and nuts, meat, fish, milk, cheese, and eggs.

Learning Objectives

- ❖ To carry out test for proteins in a given food sample.

Materials

Biuret reagent/ sodium hydroxide and copper (ii) sulphate, water, food sample containing protein such as egg, beaker, empty, plastic spoon, test tube

Hazards and Safety.

Preparation Procedure

1. Make a small hole at the tip of an egg.
2. Pour some of the egg white into a beaker.
3. Dilute the egg white with 150 mL water.
4. Stir until the solution is clear.

Activity Procedure

1. Put 2 mL/2cm³ of sample solution into a test tube.
2. Add 2cm³ of biuret reagent or 1 mL of sodium hydroxide solution to the test tube, then drops of copper sulphate solution drop by drop shaking and observing after each drop.
3. Record results.

Results and Conclusions

If the solution remains blue, then proteins are absent

If the colour of the food sample will changes from a clear colour to a violet or purple colour. This indicates the presence of protein in the food sample.

Discussion Questions

1. List down any three examples of food that contain the nutrient identified in this experiment.
2. What is the function of this nutrient in the human body?
3. What is the deficiency disease caused by a lack of this nutrient?

Food Test for Starch

Starch is a carbohydrate, specifically a polymer of glucose. Carbohydrates provide the body with energy. Starch is found in food like potatoes, cassava, maize, and wheat.

Learning Objectives

- ❖ To carry out test for starch in a given food sample.

Materials

Iodine solution, water, droppers, heat source, test tubes, and a food sample containing starch such as maize meal/ starch solution.

Hazards and Safety

Iodine solution is harmful to swallow.

Preparation Procedure

1. To prepare a 5% starch solution, dissolve 5g of commercially obtained starch in 100cm³ of boiling distilled water. 5g of sodium chloride salt is then added to the 100cm³ of 5% starch solution. The preparation must be left to cool down to room temperature.

Activity Procedure

1. Place 2 mL of sample solution into a test tube.
2. Add 3 drops of iodine solution to the test tube and shake

NB: If the food sample is in solid form/ powder; place a small amount of sample on the white tile then place two drops of iodine solution to the sample and observe

Results and Conclusions

When iodine is added, the food sample will change to a blue or black or blue-black colour.

This indicates that the food sample contains starch.

If starch is absent then the solution or food sample remains brownish or yellowish.

Discussion Questions

1. List down three foods which contain the nutrient identified in the experiment.
2. What is the importance of this food nutrient to the human body?
3. The nutrient identified above can be stored in special modified roots of cassava. What is the name given to these special storage organs?

Food Test for Reducing Sugars

Reducing sugars are simple sugars with the ability to reduce copper (II) ions to copper (I). All monosaccharides (fructose, glucose, galactose) are reducing sugars as are some disaccharides, such as lactose and maltose. Simple sugars are all carbohydrates, and are used by the body as a source of energy.

Learning Objectives

- ❖ To carry out food tests for reducing sugar in a given food sample.

Materials

Benedict's solution, cooking pot, kerosene stove or charcoal burner or Bunsen burner, droppers, reagent bottles, test tube, test tube holders, and food sample containing a reducing sugar like glucose or onions.

Preparation Procedure

1. Make a solution of a food sample containing a reducing sugar. This can be done by adding a spoonful of glucose to a litre of water or cutting an onion into quarters, grinding them in a mortar and pestle, and collecting and diluting the juice. Let the juice settle and decant the solution for use.

Activity Procedure

1. Put 2cm³ of the food sample solution into a test tube.
2. Add 2cm³ or equal volume of Benedict's solution to the test tube.
3. Hold the test tube upright in the water bath and heat the solution to Boiling while shaking.

Discussion Questions

1. What changes did you observe in the food sample during the experiment?
2. Name any two sources of the food nutrient identified in the experiment above.
3. What is the importance of the identified food nutrient in the human body?

Results and Conclusion

The colour of the food sample will change to green, yellow, orange, and finally form a brick red precipitate. This indicates the presence of a reducing sugar.

If reducing sugars are not present in a sample then the solution remains blue.



The figure illustrates the experiment on test for reducing sugars

Food Test for Non-Reducing Sugars

Disaccharides are compound sugars formed when two monosaccharide molecules combine. Disaccharides are found in sugar cane (sucrose), malt (maltose), and milk (lactose). Some disaccharides are reducing sugars (lactose and maltose), while others are non-reducing sugars (sucrose).

Learning Objectives

- ❖ To carry out food test for non-reducing sugar in a given food sample.

Materials

Benedict's solution, cooking pot, kerosene stove or charcoal burner, droppers, reagent bottles, test tube, test tube holders, citric acid solution, sodium hydroxide solution, food sample containing non-reducing sugar like table sugar or fresh sugar cane.

Preparation Procedure

1. Make a solution of a food sample containing a non-reducing sugar.

Activity Procedure

1. Put 1 mL of the sample solution in a test tube.
2. Add 2 drops of 0.5M hydrochloric acid solution to the food sample.
3. Add 2 drops of 0.5M sodium hydroxide solution to the food sample.
4. Heat the mixture to boiling in a hot water bath to warm the solution.
6. Add 1mL of Benedict's solution to the food sample.
7. Heat the mixture in the water bath again and record your observations.

Hazards and Safety

- _ Sodium hydroxide is corrosive - concentrated solutions can burn skin and wood and even dilute solutions can blind if they get into eyes.
- _ If sodium hydroxide solution spills, neutralize spills with citric acid solution or vinegar.
- _ Close the container of sodium hydroxide solution after use to prevent reaction with atmospheric carbon dioxide.

Discussion Questions

1. What have you observed during the experiment?
2. Name two examples that contain the identified food nutrient in the experiment above.
3. What is the importance of the identified food nutrient in the human body?
4. What is the purpose of adding acid to the sample and heating it?
5. What is the importance of adding sodium hydroxide to the sample?

Results and Conclusions

The colour of the food sample will change from green to yellow and finally to a brick red precipitate. This indicates the presence of a non-reducing sugar.

NB: This experiment will also test positive for all reducing sugars. Therefore, it is important to first perform the test for reducing sugars before considering this test. If the test for reducing sugars is positive, there is no reason to perform the test for non-reducing sugars - the conclusion will be invalid. Non-reducing sugars are a misnomer, that is, their name is incorrect. This test does not test for any sugar that is not reducing. Rather, this is a test for any molecule made of multiple reducing sugars bound together, such as sucrose or starch. When these polysaccharides are heated in the presence of acid, they hydrolyse and release monosaccharides. The presence of these monosaccharides is then identified with Benedict's solution. The purpose of the sodium hydroxide is to neutralize the acid added

for hydrolysis. If the acid is not hydrolysed, it will react with the sodium carbonate in Benedict's solution, possibly making the solution inactive.

Investigating the Structures of a Leaf

Photosynthesis is the process by which green plants make their own food using water, carbon dioxide, and energy from the sun. Photosynthesis takes place in the leaves. The green colour, which is caused by the presence of chlorophyll, absorbs the sunlight and uses that energy to convert CO₂ and H₂O into glucose. A leaf consists of a broad, flat part called the lamina that is joined to the rest of the plant by a leaf stalk or petiole. Running through the petiole are vascular bundles which then form the veins in the leaf. These contain tubes that carry substances to and from the leaf. Each vein contains large, thick walled xylem vessels for carrying water and smaller, thin walled phloem tubes for carrying away food that the leaf has made.

Learning Objectives

- ❖ To describe the different structures in a leaf and their roles in photosynthesis.

Materials

Variety of leaves, razor blades, microscope, plastic slides, plastic cover slips, and water.

Hazards and Safety

- ❖ Use caution when cutting with razor blades. Make sure to cut away from your fingers. Have available soap and water for cleaning cuts. Do not use dull razor blades where you have to apply more pressure, increasing the risk of cuts

Activity Procedure

1. Collect Materials.
2. Cut a leaf in half, vertically. Next, cut a very thin transverse section from the center of the leaf, so that the mid rib is included. The result will be in a thin diamond-like cross section of the leaf.
3. Mount the cross section on a slide with a drop of water and cover it with a cover slip.
4. Observe the specimen under the microscope. You should be able to see the vascular bundles in the mid rib and differentiate between the upper and lower surface.
5. Draw what you see in the microscope.

Results and Conclusions

The upper and lower epidermis will be seen in the microscope.
You should also be able to view the palisade cells.

Discussion Questions

1. Why do you think there is a close package of palisade cells at the upper surface of the leaf?
2. What would happen if the stomata were at the upper surface of the leaf?
3. What is the function of the cuticle on the upper surface of the leaf?
4. Mention the functions of stomata in relation to photosynthesis.

NB: The compound microscope can only show the outlines of cells. The stomata and conducting tissues cannot be seen clearly. The best result can be obtained through the use of succulent leaves like a *Comelina* plant.

Test for Starch in Leaves

Photosynthesis is the process by which green plants and some other organisms use sunlight to synthesize food from carbon dioxide and water. One product of photosynthesis in green plants is starch. The presence of starch can be confirmed by the addition of iodine solution.

Learning Objectives

- ❖ To show that starch is a product of photosynthesis.

Materials

Young green leaves, ethanol, iodine solution, heat source, cooking pots, water, test tube, white tile, dropper, and cotton wool.

Hazards and Safety

Ethanol is very flammable! Make sure that student cover their test tubes with cotton wool to avoid excess release of ethanol vapour. If a test tube catches on fire, instruct student to cover the tube with a non-flammable object to extinguish the flame.

Preparation Procedure

1. Collect green leaves from the environment. Try to find leaves that do not have a very waxy outer coat.
2. Heat water to boiling using the heat source.

Activity Procedure

1. Choose one leaf and submerge a piece of it in the boiling water for about 3 minutes.
2. Remove the leaf from the water and insert it into a test tube containing methylated spirit and plug the test tube with a piece of cotton wool.
3. Submerge the test tube in the boiling water and leave it to boil until the leaf loses all of its colour.
4. Once the leaf has lost its colour, remove it from the ethanol solution and dip it briefly into the boiling water to remove the ethanol and soften it.
5. Spread the decolourized leaf on a white tile and add iodine solution until the whole leaf is covered. Record your observations.

Results and Conclusions

The leaf is dipped in hot water to kill the cells. The leaf is then submerged in boiling ethanol to extract the colour from the leaf. The ethanol will change to a green colour while the leaf should

lose all of its colour to become white. When iodine solution is added, it should turn dark blue/black colour which indicates the presence of starch in the leaf.

Iodine Solution

Discussion Questions

1. What was the reason for boiling the leaf?
2. What was the importance of boiling the leaf in ethanol? What did you observe during this step?
3. Why was the test tube containing methylated spirit plugged with cotton wool?
4. Why was the leaf dipped in boiling water after it was removed from the ethanol?
5. Why was a water bath used to heat the ethanol?
6. What did you observe when the iodine was added to the leaf? What does this indicate is present in the leaf?

NB: It is important that the leaf does not contain a thick waxy coating. Before doing this experiment with students, test some leaves from the local environment to ensure that they respond well to the experiment. Leaves such as *Amaranthus*, beans and *Commilina* respond fast. Make sure that the leaf has been in sunlight for at least 6 hours prior to the experiment or there may not be enough starch present to detect. This practical should not be done in the morning. Ethanol boils at a lower temperature than water, thus it can be boiled in a water bath. Ethanol is very flammable and it is possible that the top of test tube catches fire. If this happens a non-flammable material such as glass or metal can be used to cover the flame and deprive it of oxygen.

DRAWING, MEASUREMENT AND MAGNIFICATION.

Observation made on specimen may be reported in the form of a fully labelled drawing depending on the nature of the specimen. The following considerations should be made when drawing specimens and labelling them.

1.DRAWING

A drawing is a representation of a specimen as seen. The features of the specimen which are seen need to be shown on the drawing. Pupils should always draw what they see and not what they know from a text book point of view. The drawing must be the exact representation of the actual specimen.

HINTS ON A DRAWING

a. Large/Big

The drawing must be large enough. This means that, it must be at least 6.0cm at its longest point or occupy one-third of an A-4 page. This is as it is seen under a hand lens. Even,when there is no hand lens ,a drawing must fit within the space provided on the answer sheet and space for labels must left.

b. Clean and clear

The drawing must be clean and clear, implying that there should be no dirty rubbings, no shading, and no double or disconnected lines.

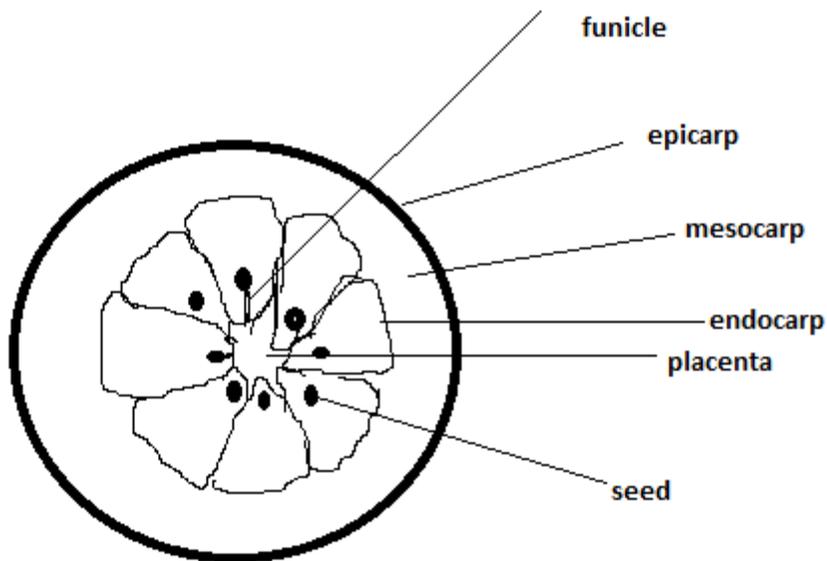
c. Realistic

The drawing should be a true reflection of the specimen provided and not a mere replica of a text book diagram. A drawing should be able to show all important parts of the specimen as they are seen. No effort should be made to make a better drawing than the actual specimen because biological drawings are not artistic impressions.

2.LABELLING

A Candidate is advised to label as many parts/structures as possible on the drawing. The label names should be written horizontally against a solid pointer (label line) and that the label line must make contact/touch the part /structure being labelled. Label lines must never cross each other or else the labels concerned are rejected. Arrow-heads are not required on a pointer as they represent direction.

The following drawing illustrates a drawing of a transverse section of an Orange taking into account principles discussed above.



Transverse section(T.S) of an orange

3.MEASUREMENT

Unless otherwise, instructed measurement of a specimen size must be taken along the longest part. For circular specimen, the longest line passing through the center must be used. A line must be drawn along corresponding part on the drawing. Measurements must be recorded to one

decimal place if recorded in centimeters or a whole number if millimeters are used. For example, it will be correct to record 6.0cm Or 60mm but wrong to record 6cm or 60.0mm.

4.MAGNIFICATION

$$\text{Magnification} = \frac{\text{size of image/drawing}}{\text{size of object/specimen}}$$

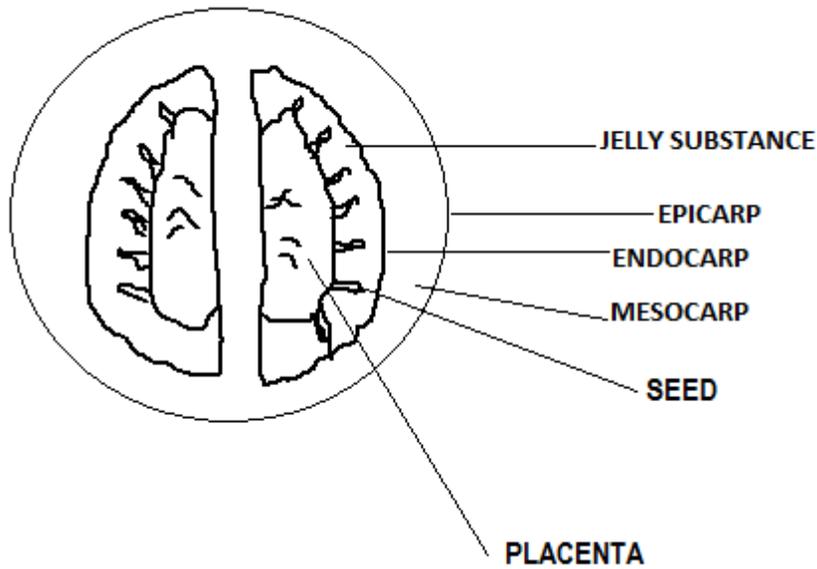
NB: The formula must be stated correctly

- ❖ The substitution must be correctly done with identical units in the numerator and the denominator. When the units differ, substitution is rejected along with the rest of the calculations, for example, if an individual measures the specimen size as being 6.5cm and the corresponding measurement on the drawing is 8.5 cm, the substitution will be correct if written as;
- ❖ $\text{Magnification} = \frac{8.5\text{cm}}{6.5\text{cm}}$
- ❖ Where a candidate decides to work in centimetres then the figures must always be given correct to one decimal place as shown in the example above
- ❖ The candidate/pupil is also allowed to use millimetres instead of centimetres. If millimetres were used then the substitution would be as follows;
- ❖ $\text{Magnification} = \frac{85\text{mm}}{65\text{mm}}$
- ❖ The final answer for magnification has no units but has a symbol X instead to denote the number of times an object has been enlarged or magnified.

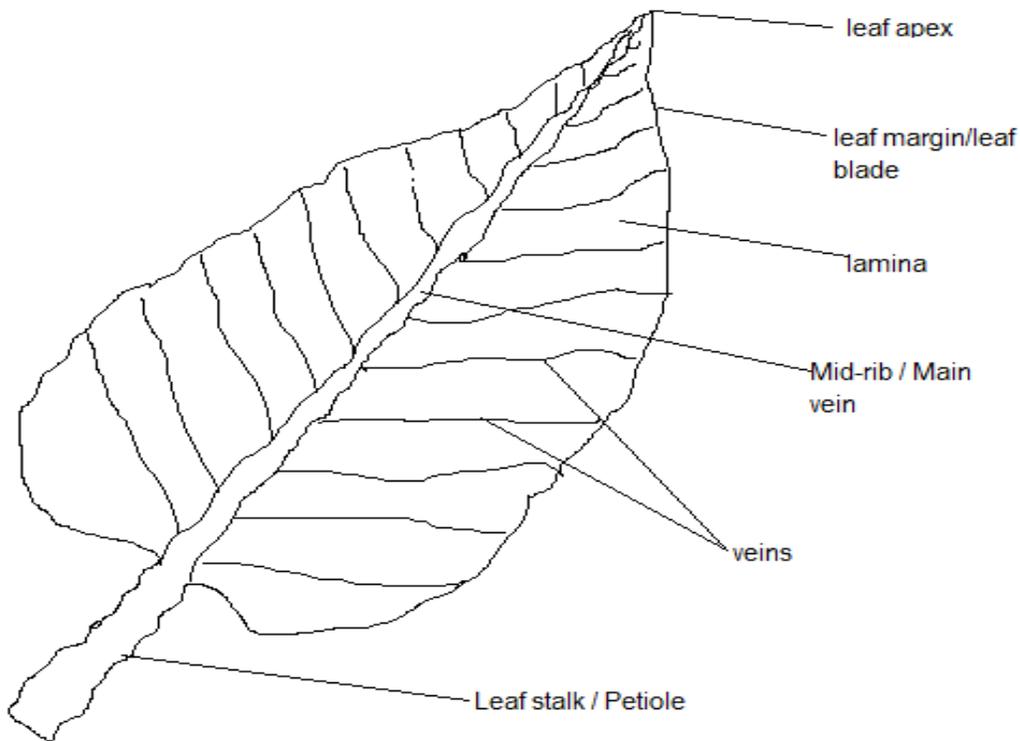
$$\text{Magnification} = \frac{85\text{mm}}{65\text{mm}}$$

$$\text{Magnification} = X1.3$$

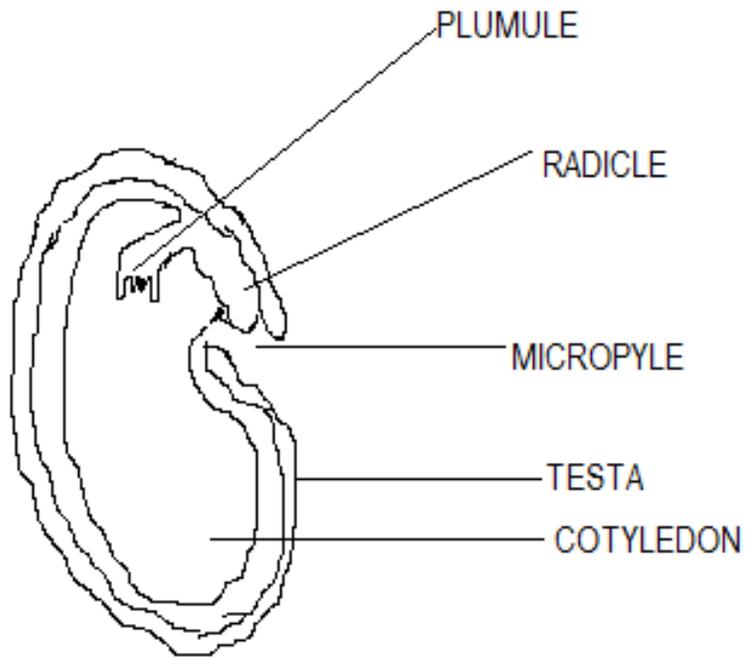
SOME COMMON EXAMINED DIAGRAMS



Longitudinal section (L.S) of an orange



External structure of a leaf



Longitudinal section of a bean seed