

# **SHIKA EXPRESS - BIOLOGY**

## **Version 1.0 TZ**

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HANDS-ON ACTIVITIES COMPANION GUIDE  
TANZANIA

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TEACHER'S GUIDE

June 1, 2014

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# **Part I**

## **Hands-On Activities**

# Biology Activities for Form I

## 1.1 Introduction to Biology

### Characteristics of Living Things

#### 1.1.1 Obvious Characteristics of Living Things



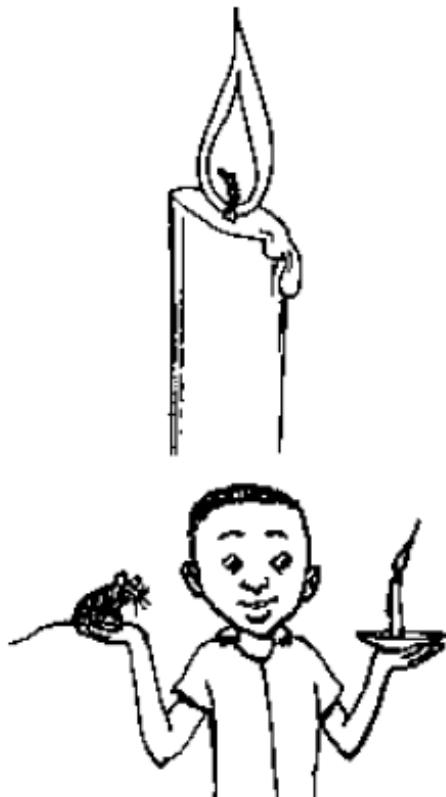
**Procedure:** Display some non-living things such as a stone, piece of wood, glass of water etc., and list any obvious differences between these things and a living organism (i.e. man). Produce a table from the whole class response.

#### 1.1.2 Other Characteristics of Living Things



**Procedure:** Display a potted flowering plant and identify the main characteristics of life. Note that many of these are less obvious in plants than in animals.

#### 1.1.3 Is a Candle Living?



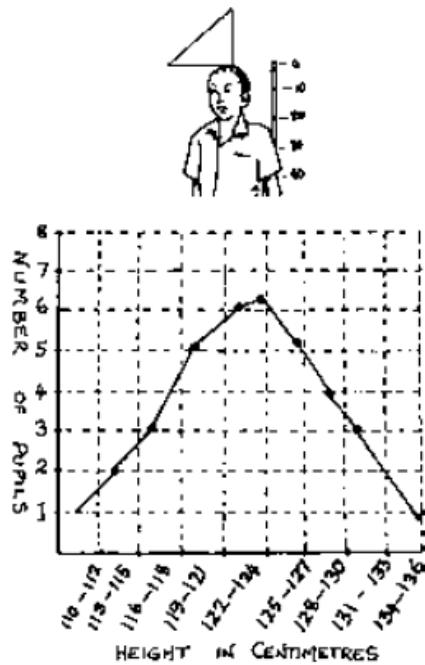
**Procedure:** Look at a burning candle. The candle flame can be considered as an example of a process in a state of dynamic equilibrium.

**Questions:** What are the similarities and differences between a candle flame and a living organism?

**Theory:** A candle flame is the result of a metabolic process. The candle wax is burnt to carbon (soot) and other gaseous substances. The shape, colour and brightness of the flame remains fairly constant, but only as long as there is a supply of wax and air. The flame is not self-sustained and cannot reproduce itself.

## Measurement in Biology

### 1.1.4 Data on Height



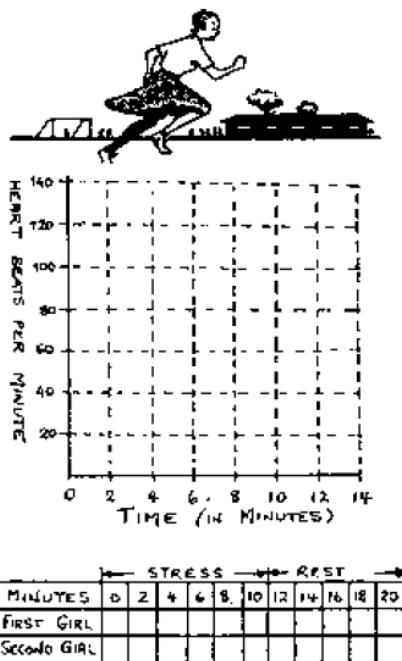
**Procedure:** Obtain the heights of all the students in the class (in centimetres). Use these heights to divide the students into groups (i.e. 110-112 cms, 113-115 cms etc). Count the number of pupils in each group. Plot a graph of height against numbers.

**Questions:** What does the graph look like and what does this show?

**Observations:** A normal distribution curve is obtained showing that a few students are very tall, a few are short, but most of them come somewhere between these extremes.

**Theory:** Members of a species can vary in size between a maximum and a minimum value, but most individuals are near the middle of this range.

### 1.1.5 Data on Pulse Rate



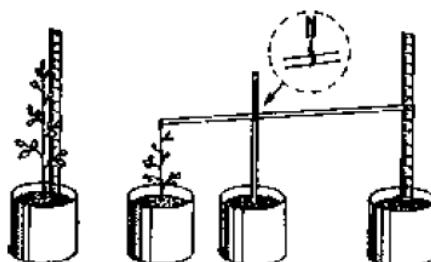
**Procedure:** Take the resting pulse rate of ten students, then ask them to run around the school compound for two minutes. Take the pulse of each student at two minute intervals until the pulse returns to normal. For each student plot a graph of pulse rate against time.

**Questions:** Which pulse rate was the highest and which pulse returned to normal most quickly?

**Observations:** Each curve of pulse rate will be slightly different.

**Theory:** This is due to differences in levels of physical fitness of each student. The less fit ones generally reach a higher pulse rate, which takes longer to return to normal.

### 1.1.6 Measuring Growth



**Procedure:** Take a seedling in a pot (or use a plant in its natural environment) and attach a fine thread to a light stick (as shown above). Alternatively use the simple method for measuring growth. Make measurements at fixed intervals (say 2 or 3 days). Devise a method of presenting your data graphically.

### 1.1.7 Weight Increase by Germinating Seeds



**Procedure:** Place 10 bean seeds between pieces of wet newspaper. Place a second group of 10 beans between dry paper. Measure the weight of each group of beans at daily intervals, and also record any observations.

**Questions:** What are the differences in weight between the two groups of seeds?

**Observations:** The soaked beans swell and the weight increases. No change occurs in the beans on dry paper.

**Theory:** The beans on the wet paper have absorbed water and started germinating. The dry beans did not.

### 1.1.8 Keeping a Written Record



**Procedure:** Pick branches with different numbers of leaves and place each one in containers with the same volume of water (To avoid loss by evaporation pour some oil on the surface). Record the daily loss of water in each container.

**Observations:** The more leaves on the branch, the greater the loss of water.

**Theory:** Leaves are the organs where most water is lost by the plant.

## The Scientific Method

### 1.1.9 Transport of Water



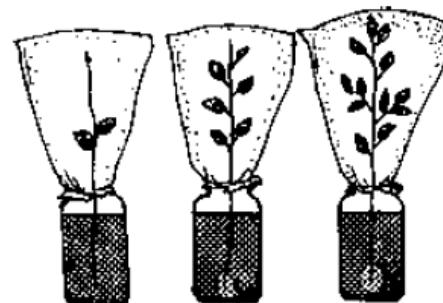
**Hypothesis:** Water is transported to the leaves where it is lost.

**Procedure:** Place a branch of a non woody plant in a solution of coloured ink.

**Observations:** After some time the coloured ink is seen in the stem and leaves of the plant. A lot of liquid has been absorbed.

**Conclusion:** The plant transports water upwards through the stem to the leaves where most of it is lost.

### 1.1.10 Number of Leaves and Water Loss



**Procedure:** Using the same materials, place one plastic bag around a single leaf and another around a branch with many leaves.

**Observations:** More water collects in the bag enclosing the larger number of leaves.

**Conclusion:** Since water is lost from the leaves of a plant, the larger the number of leaves, the greater the amount of water lost.

**Applications:** For better growth, plants need to be supplied with an adequate amount of water. To reduce excessive water losses by transpiration, special methods of cultivation are used.

## 1.2 Safety in Our Environment

### Waste Disposal

#### 1.2.1 Biodegradable Waste

**Materials:** Shovel/jembe, Banana peel, plastic bottle, rubber bands, paper

**Procedure:** Dig several small holes and place a different item in each, covering them with dirt. Check back on the items after several weeks, months, and after a year.

**Observations:** The banana peel shrivels and degrades after a couple weeks, while the other items remain for many months or even years.

**Theory:** Banana peels are an example of organic waste. They are *biodegradable*, meaning that it breaks down in the environment. *Non-biodegradable* waste does not break down, it just piles up.

**Applications:** Do not throw plastic bottles out of the window on buses!!

#### 1.2.2 Trash Journal

**Procedure:** Have each student record in a journal all of the trash that they make every day for 2 weeks. If possible, collect the trash and weigh it every day.

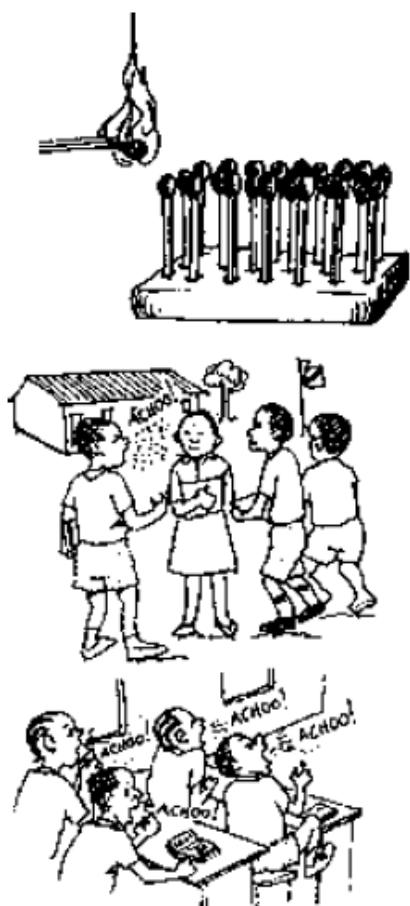
**Observations:**

**Theory:** Trash is a big problem in large towns and cities. Many manufactured goods come with a lot of waste material, which accumulates over time. Many waste items can be *recycled*, or reused for different purposes.

**Questions:** What are some methods for eliminating waste? What effect does burning trash have on the environment?

## 1.3 Health and Immunity

### 1.3.1 Coughs and Sneezes Spread Diseases



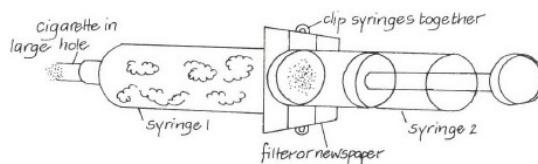
**Procedure:** Place the matches in the match box as shown and ignite one.

**Questions:** Why is it dangerous to sneeze or cough without covering the mouth or nose?

**Theory:** Moisture may be seen leaving an uncovered mouth or nose. The water droplets contain microbes. If one is suffering from an airborne disease such as influenza or tuberculosis sneezing or coughing could be a source of spreading the harmful microbes. It is necessary to be aware of this when coughing/sneezing, so that we do not spread the germs to others.

**Applications:** Doctors and nurses wear masks to stop germs from their noses and mouths getting on to people having operations or on to newborn babies.

### 1.3.2 Smoking and Health



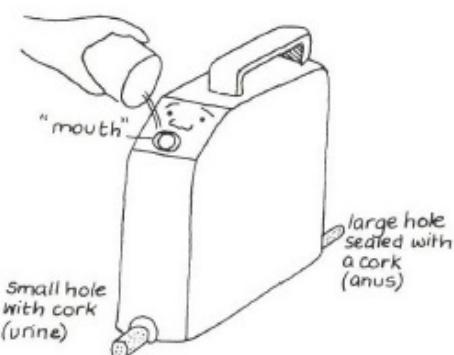
**Materials:** 2 syringes, filter paper, cigarette

**Procedure:** Remove the needle end from one syringe (syringe 2). Remove the plunger from the other syringe (syringe 1) and make a larger hole in the needle end. Join the syringes as shown. Place a piece of filter paper or newspaper between the 2 syringes. Place the cigarette in syringe 1 and light it. Draw air through the cigarette several times.

**Observations:** You will see a dark stain spreading across the filter paper. This is tar from the cigarette.

**Questions:** Ask students what happens to the tar if a person smokes the cigarette and discuss its effect on health.

### 1.3.3 Water Baby



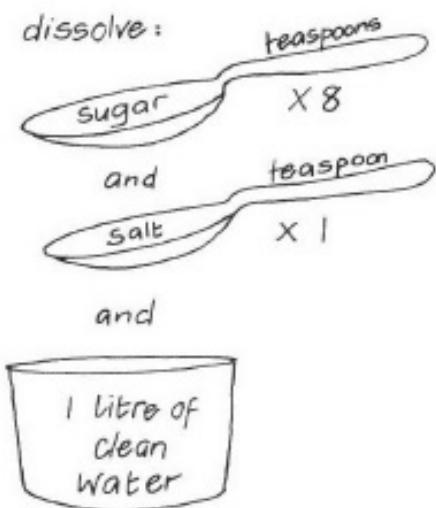
**Materials:** Plastic bottle, 2 corks, water

**Procedure:** Make a model baby from the bottle. The hole in the top represents the mouth. Make a small hole at the bottom to represent water loss through urine and a large hole to represent the anus. Put corks in both holes. Fill the 'baby' with water.

**Observations:** Remove the smaller plug and water will be lost slowly. However, diarrhea can cause severe loss of water, as removing the larger plug illustrates.

**Theory:** Water lost through the holes can only be replaced through the 'mouth'. If more water is lost than is taken in dehydration occurs and this can be fatal especially in small babies.

### 1.3.4 Oral Rehydration Solution



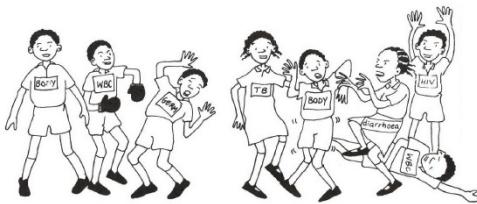
**Materials:** 1 L clean water, 8 teaspoons sugar, 1 teaspoon salt

**Procedure:** Combine the materials to make an Oral Rehydration Solution (ORS) to help treat diarrhea.

**Theory:** Our bodies need water to function normally, but we also need a particular concentration of essential electrolytes, e.g. sodium and potassium. These electrolytes are lost in diarrhea and they must be replaced. Drinking water alone will not save the life of a person who is dehydrated and has lost too many electrolytes. To replace some essential electrolytes and water, the baby, or adult, should drink the Oral Rehydration Solution (ORS) shown here.

**Notes:** This is an emergency solution and does not contain all electrolytes. A severely dehydrated baby may need a more complex solution if diarrhea persists.

### 1.3.5 HIV Acting



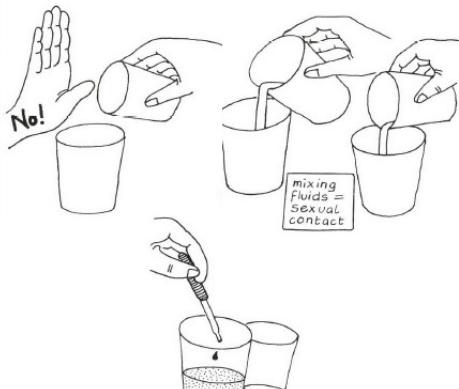
**Materials:** Cards, pins/tape

**Procedure:** Make cards to attach to students.

They should contain a mixture of the following - HIV; diseases, e.g. TB, diarrhea; white blood cell. One of the pupils should represent the human body. Several 'white blood cells' should be protecting one body' to begin with. Ask students to act out the spread of HIV.

**Theory:** White blood cells protect the body from diseases. HIV knocks out the white blood cells and so they can no longer protect the body. This leaves the body open to attack by germs of all kinds. Eventually the body is overcome by diseases which are normally not fatal.

### 1.3.6 Passing On HIV



**Materials:** Cards, starch solution, iodine solution

**Setup:** On the cards write down some sexual case histories. Give each student a card at random. The owner of the card is to follow the behaviour indicated on the card, e.g. faithful to one partner, many partners, no partners.

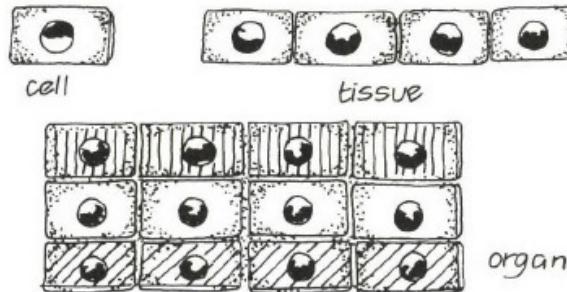
**Procedure:** Give a few of the students a cup of starch solution and give all the others a cup of water. Ask students to follow the case history of the cards and to mix the contents of their cups when they have a partner - mixing represents sexual contact. At some point 'HIV test' the contents of the cups using a few drops of iodine solution. If the solution goes dark then it means there is starch (representing HIV) in the cup.

**Observations:** Discuss how fast the virus spreads.

Also discuss how its spread could be prevented or slowed down.

## 1.4 Cell Structure and Organization

### 1.4.1 Cells, Tissues, Organs



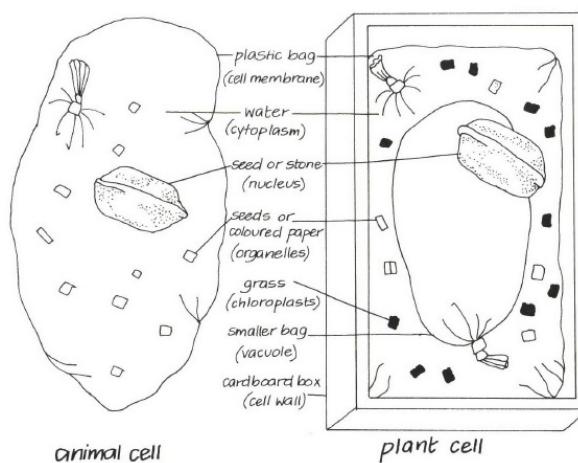
**Materials:** Matchboxes, peas/beans/stones, boxes of different colour or size

**Procedure:** Place a seed in each box. This represents the nucleus: the matchbox the cell. Place groups of cells inside the coloured boxes - the different coloured boxes represent different tissues and the boxes themselves can be joined to make organs.

**Applications:** The school is a useful model of an organism. The bricks (cells) make walls (tissues) and walls make classrooms (organs). The corridors can therefore be used as models for transport systems.

**Notes:** Another analogy might be a town where buildings represent organs, rooms the tissues or cells and people inside the rooms the various functions of the cell.

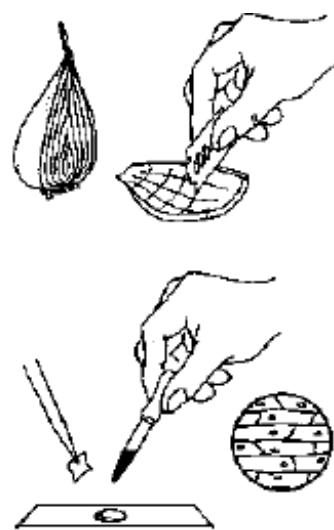
### 1.4.2 Cell Models



**Materials:** 2 large and 2 small plastic bags, water, 2 large seeds/stones, small seeds/coloured paper, grass, cardboard box

**Procedure:** Make models of plant and animal cells as shown.

### 1.4.3 Looking at Cells



**Materials:** Onion, pin/needle, glass, plastic strip, iodine solution

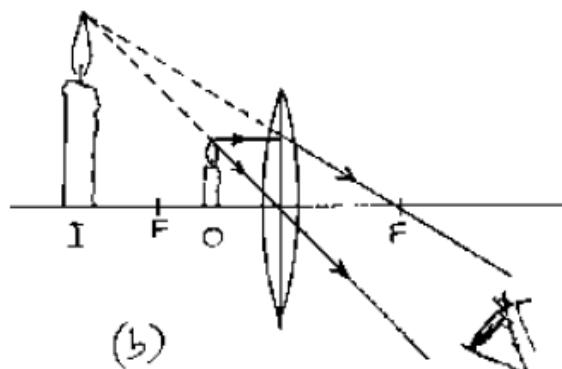
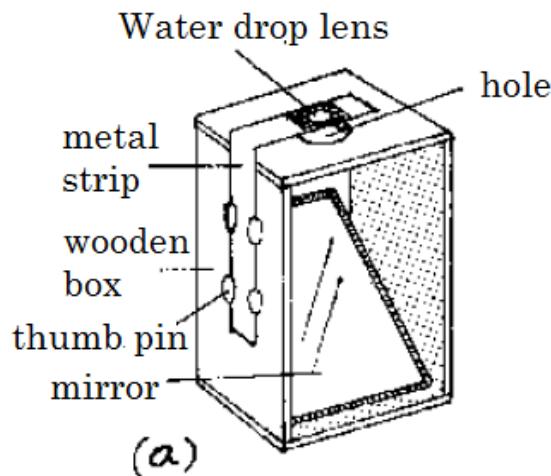
**Procedure:** Cut a slice of onion and gently peel off a piece of the thin inner surface skin layer. With a pin/needle place a piece of 'skin' in a water drop on a piece of glass. Stain the 'skin' with a drop of iodine solution. Lower a cover slip (plastic strip) onto the specimen taking care not to let in any air bubbles. Now view the prepared slide through the microscope.

### 1.4.4 How Many Cells?

**Procedure:** Ask students to estimate how many cells there are in the human body. How many grains of sand would fit in the human body? Have students make a dot with a sharp pencil.

**Theory:** A grain of sand is several thousand times larger than a human cell. Even the largest human cell, the ovum, is smaller than the pencil dot.

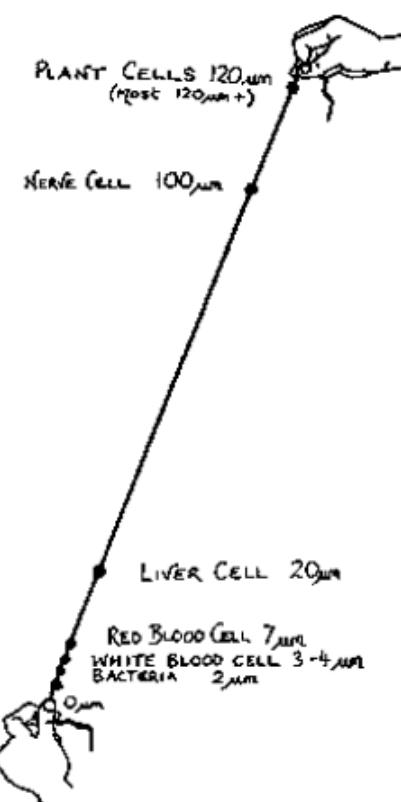
### 1.4.5 Simple Microscope



**Materials:** Soda can, small lens (e.g. pen-torch bulb), aluminium strip, small mirror, piece of glass, rubber band

**Procedure:** Make the microscope as shown. Some care is needed in positioning the lens in the hole made for it in the aluminium strip. The inside of the can may be painted black. Such a microscope is quite adequate for looking at cells.

### 1.4.6 Cell Size



**Materials:** String/chalk

**Procedure:** Take a piece of string (or chalk a line on the ground) about 60 cm long. Mark distances as shown in the diagram above. The lengths represent the sizes of different types of cells enlarged one thousand times.

**Questions:** How many times bigger is a plant stem cell than a blood cell?

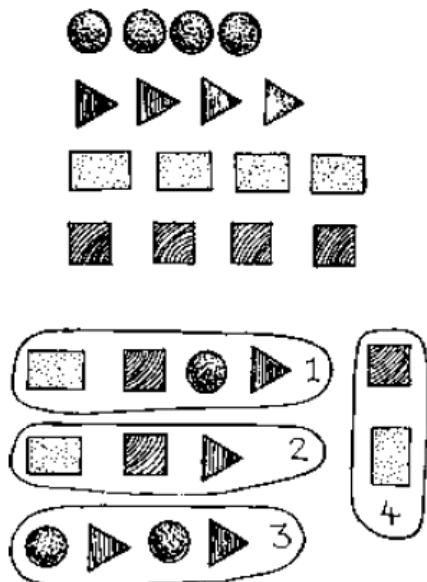
**Observations:** 50 times.

**Theory:** Although almost all cells are too small to be seen with the unaided eye, they show a wide range of sizes (about the same range as a mouse and an elephant).

## 1.5 Classification of Living Things

### Concept of Classification

#### 1.5.1 Arranging Shapes



**Materials:** Paper/card, coloured pens/pencils

**Procedure:** Make four of each of the following shapes: squares ( $3 \text{ cm} \times 3 \text{ cm}$ ) triangle ( $3 \text{ cm}$  sides) rectangles ( $3 \times 4 \text{ cm}$ ) circles ( $3 \text{ cm}$  diameter). Mix the shapes and then sort them according to a chosen feature.

**Questions:** How many different ways can you find of grouping the shapes?

**Observations:** At least 4 can be found.

**Theory:** In Biology, classification is used to group things based on shared qualities (i.e. living and non-living things).

#### 1.5.2 Classification at the Duka



**Procedure:** Observe how goods at the local shop are arranged on the shelves.

**Questions:** Can you find a pattern in the arrangements on the shelves?

**Observations:** The goods will be arranged firstly in large groups, i.e. foodstuffs, non-food stuffs (medicines, etc.), and then into smaller groups such as foods in tins, foods in bottles, etc.

**Theory:** This concept of classification is also used in the study of Biology.

### 1.5.3 Find a Missing Person



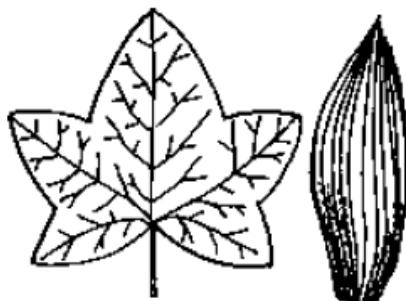
**Procedure:** Imagine that you have been asked to find one particular person on earth.

**Questions:** What information would you require?

**Observations:** Continent, country, region, district, ten cell block, house, name of person.

**Theory:** This procedure can be compared to the process of classifying organisms, firstly in large groups (equivalent to a continent), then smaller groups (equivalent to country, region etc.).

### 1.5.4 Classifying Leaves



**Procedure:** Collect leaves from different plants. Make large groups and small groups using as many different characteristics as possible.

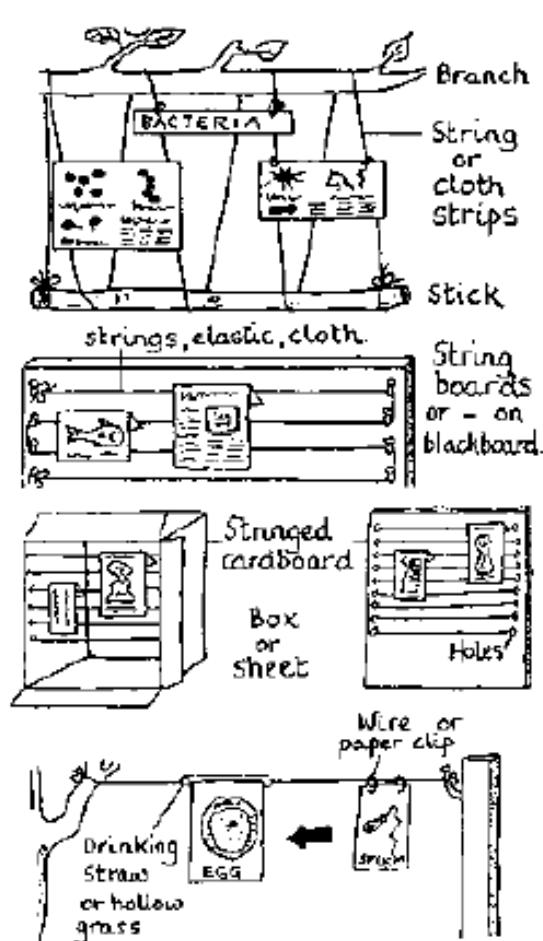
**Questions:** How many ways can you find to group the leaves?

**Observations:** Characteristics like shape, colour, vein pattern, leaf margin etc. can all be used.

### 1.5.5 Scavenger Hunt

**Procedure:** Find different animals, plants, fungi etc. that are available around the school or at their homes (especially mosses in wet places and fungi near decaying material in the shade). Send students to find different specimen giving hints if necessary. When they return, have them classify what has been found.

### 1.5.6 Display Boards



**Materials:** String, sticks/branches, cardboard boxes, nails, tape

**Procedure:** Construct display boards as shown to present information about specimen collected. Students can present their displays to the class or as part of a science fair project.

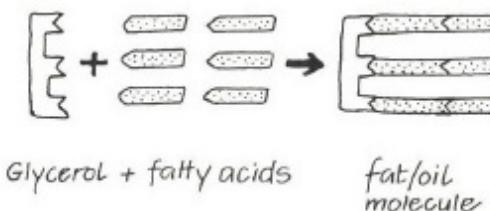
**Notes:** See more display ideas in [Visual Aids and Displays](#) (p. 78).

# Biology Activities for Form II

## 2.1 Nutrition

### Properties of Food Substances

#### 2.1.1 Lipids - Fats and Oils



**Materials:** Card, scissors

**Setup:** Cut out the shapes of the glycerol and fatty acid molecules. They can be combined to form fat (lipid) molecules.

**Procedure:** Ask students to form fats of different types with the cards.

**Theory:** Fats are made up of glycerol and fatty acids. The longer the fatty acid chains the more solid the lipid. Oils have short chains of fatty acids, fats much longer ones.

#### 2.1.2 Solubility of Fats and Oils



**Materials:** Oil, water, petrol, 2 containers

**Procedure:** Mix fats or oil with water. Then in a separate container mix fats or oils with a small amount of petrol.

**Questions:** Look through the two liquids. Is there a difference?

**Observations:** Oils and fats dissolve in organic solvents such as petrol or alcohol, but not in water. However, vigorous shaking with water will produce a cloudy or milky emulsion of suspended fat droplets.

#### 2.1.3 Carbohydrates



**Materials:** Peas, beans or other small identical items

**Procedure:** Arrange peas or other small objects to make carbohydrate chains of different lengths.

**Theory:** Each pea is a monosaccharide, e.g. glucose. Putting 2 together makes a disaccharide, e.g. table sugar, and a long chain of them a polysaccharide, e.g. starch.

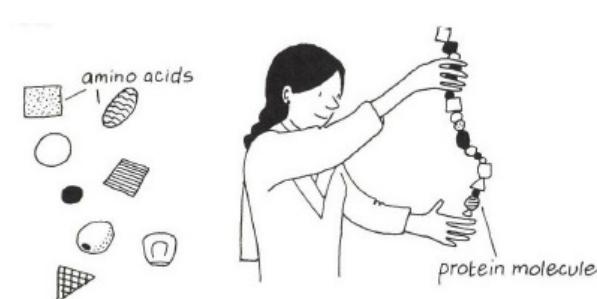
**Notes:** Not all di- and polysaccharides consist of identical units, e.g. sucrose is a disaccharide of 2 monosaccharides glucose and fructose.

#### 2.1.4 Simple Sugar Model



**Procedure:** To illustrate the long chain structure of polysaccharides use strings of beads, toilet roll or a chain of pupils. Each long chain is formed by smaller units which represent simple sugars.

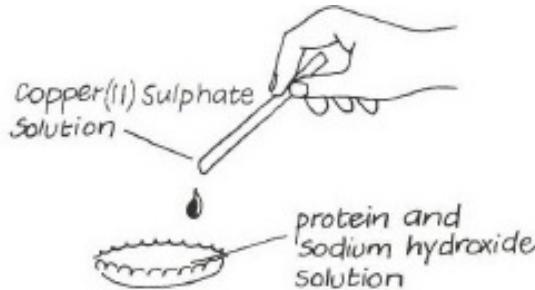
### 2.1.5 Protein Molecules



**Materials:** Bottle caps, seeds, beans, fruits, paper/card, string, scissors

**Procedure:** A variety of different shaped and sized items threaded on a string show how different types of amino acids join together to make a protein molecule. Students can collect their own materials and make their own models, or cut out shapes from paper or card.

### 2.1.7 Test for Protein



**Materials:** Copper (II) sulphate solution, sodium hydroxide solution, food sample (e.g. egg), bottle cap, straw

**Procedure:** Pour a small amount of egg white into a bottle cap. Add a few drops of sodium hydroxide solution, followed by a small amount of copper (II) sulphate solution.

**Observations:** Purple colour indicates the presence of protein in the sample.

## Food Tests

### 2.1.6 Test for Lipids



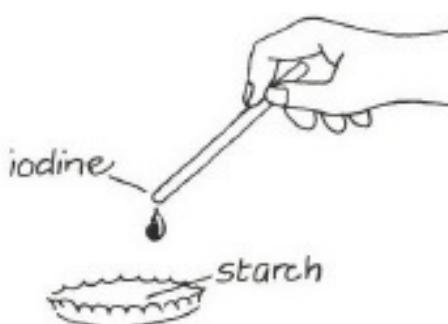
**Materials:** Cooking oil, water, plastic bottles, [Test Tubes](#), iodine solution, straw

**Procedure:** Mix about 10 mL of cooking oil and about 100 mL of water in a plastic bottle and shake vigorously. Pour a small amount into a test tube or syringe. Add 3 drops of iodine solution using a straw and shake the tube.

**Observations:** You should see the formation of a red ring at the top of the solution, indicating the presence of lipids.

**Notes:** Alternatively, rub a piece of food onto a piece of paper. Fat is present if there is a translucent stain.

### 2.1.8 Test for Starch



**Materials:** Maize flour, iodine solution, bottle cap, water, straw

**Setup:** Prepare a food sample solution by either saving the remaining water from boiling pasta/potatoes or by mixing 2 teaspoons of maize flour into a litre of water and heating to dissolve.

**Procedure:** Add a few drops of iodine solution to the sample and observe any changes.

**Observations:** A blue-black colour confirms the presence of starch.

### 2.1.9 Test for Reducing Sugars



**Materials:** Benedict's solution, [Heat Sources](#), bottle cap, straw, food sample (e.g. glucose or onions)

**Procedure:** Dissolve the food in water. Put some into the bottle top and add Benedict's solution. Heat very gently for 1 minute.

**Hazards:** Safety goggles should be worn.

**Observations:** If a precipitate develops - usually green or brown - this confirms the presence of sugar.

### 2.1.10 Test for Non-Reducing Sugars

**Materials:** Benedict's solution, [Heat Sources](#), sodium hydroxide solution, citric acid, water, food sample (e.g. sugar/sugar cane),

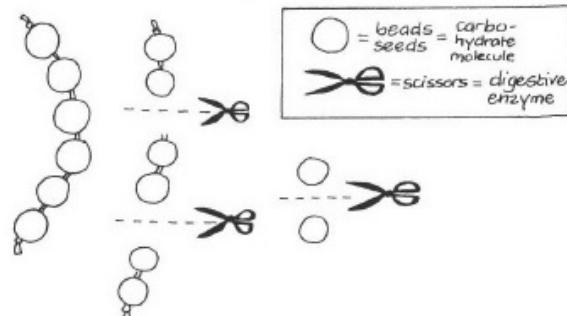
**Procedure:** Dissolve the food in water. Add a small amount of citric acid and bring to a boil. Allow it to cool and add a small amount of NaOH to the solution and shake. Add a small amount of Benedict's solution and boil again. Allow it to cool and observe changes in appearance.

**Observations:** A colour change from green to yellow, then to brick red precipitate indicates the presence of non-reducing sugars.

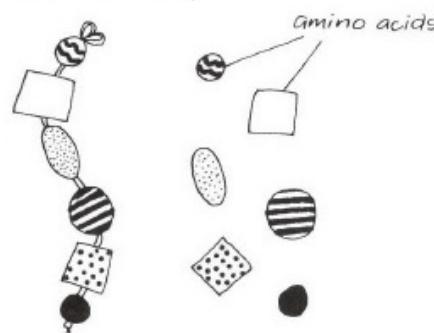
## Human Digestive System

### 2.1.11 Models for Digestion

*digestion of carbohydrates*



*digestion of protein*



**Materials:** Beads/seeds/cards, scissors, string

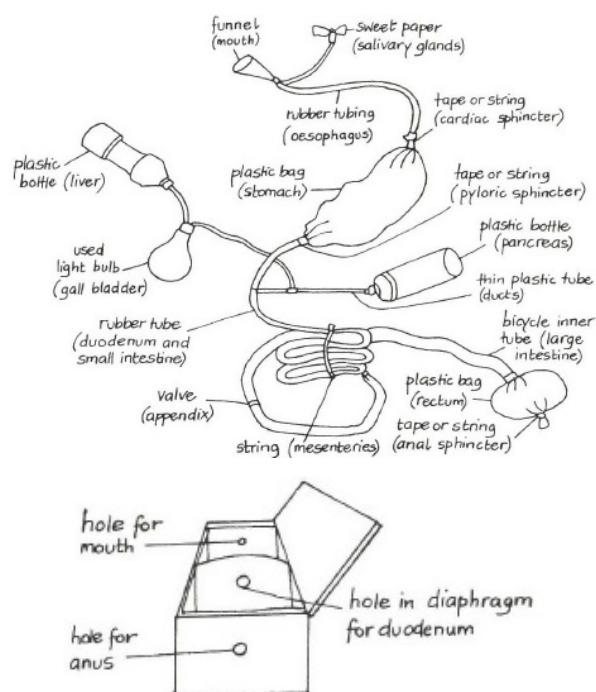
**Procedure:** String several beads or seeds together to make a chain. Or use toilet paper sheets or paper clips. Cut up or separate the models of food molecules to demonstrate digestion.

**Questions:** What action does cutting with scissors represent?

**Observations:** The scissor action represents the action of salivary amylase as it breaks down the long starch chain to simple sugars (maltose).

**Theory:** Starch is a polysaccharide made up of many identical glucose molecules. Proteins are made up from many different amino acids. During digestion large molecules are broken down into smaller ones by enzymes, e.g. starch is broken down into glucose, proteins into the component amino acids.

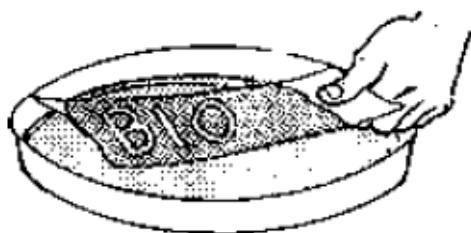
### 2.1.12 Digestive System Model



**Procedure:** Have students construct a model of a digestive system using the local materials shown. Colour and label the different sections and mount on a display board.

**Applications:** Ask students to place inside a box to demonstrate how the intestine passes through the diaphragm.

### 2.1.13 Invisible Saliva Ink



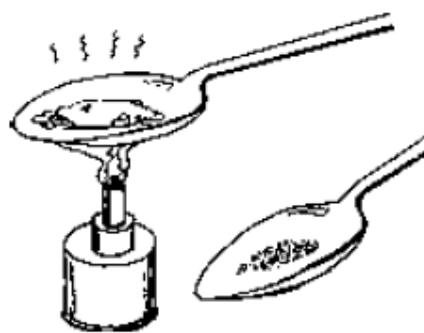
**Materials:** Filter paper/toilet paper, starch solution, iodine solution, matches/cotton swabs

**Setup:** Prepare a starch solution by adding a teaspoon of maize/cassava flour to half a cup of water. Bring to a boil, then allow to cool and filter the liquid through a cloth.

**Procedure:** Soak toilet paper in starch solution. Ask students to use saliva on a matchstick or cotton swab to write their names on the treated paper. Dip the paper in a very dilute iodine solution.

**Theory:** The enzymes in the saliva digest the starch where it touches the paper.

### 2.1.14 Salts in Saliva



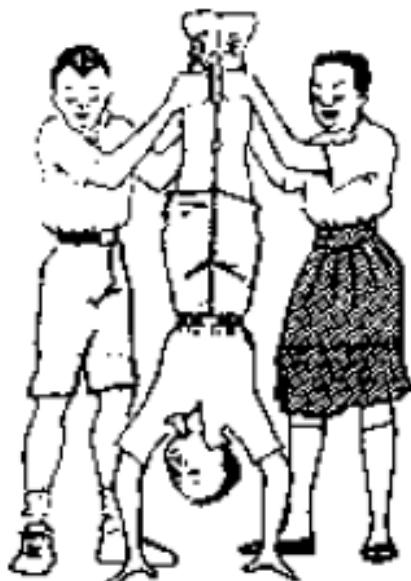
**Materials:** Spoon, candle, dilute HCl

**Procedure:** Gently heat some saliva on a spoon until it is dry and observe. Then add a small amount of dilute hydrochloric acid.

**Observations:** A white residue is left upon heating. Bubbles of carbon dioxide are given off when HCl is added.

**Theory:** Calcium carbonate is the residue and this reacts with the hydrochloric acid to produce carbon dioxide.

### 2.1.15 Swallowing Upside Down



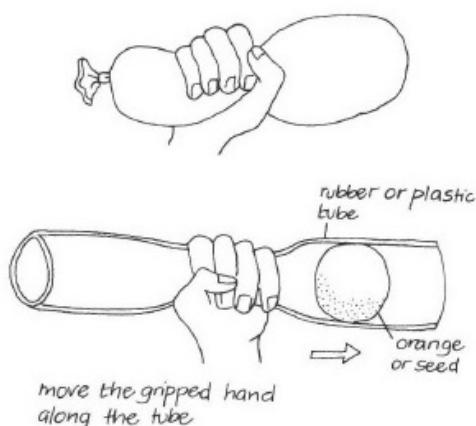
**Materials:** Drinking water/bread

**Procedure:** Drink a mouth full of water from a cup and swallow it. Then fill your mouth again, (without swallowing) and with the help of two friends do a handstand. Then swallow while upside down. Also try with a small piece of bread

**Observations:** You are able to swallow while upside down, but not as easily.

**Theory:** The peristalsis of the esophagus works against the forces of gravity.

### 2.1.16 Peristalsis Model



**Materials:** Balloon, rubber band, orange/large seed, large tube

**Procedure:** A balloon gripped with the hand pushes air along. You can also move an object along a tube by squeezing behind the 'food' ball.

**Theory:** Food is moved by the contraction of the muscular walls of the gut.

### 2.1.17 Intestine Length



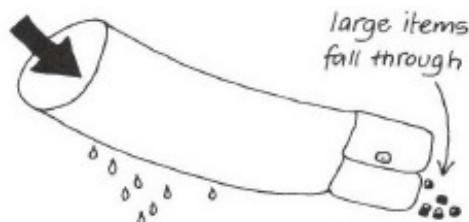
**Materials:** Long piece of rope

**Procedure:** Ask pupils to draw on the ground the shapes of different animals (e.g. rabbit, man, cat/dog, pig, cow). Try to draw them life size. Then coil string or strips of paper inside the abdominal cavity area of the animal shape. Approximate lengths of intestines: rabbit 1 m cat/dog 2 - 5 m, pig 24 m, horse 30 m, cow 50 m.

**Questions:** Why do intestine lengths differ and why do herbivores have longer intestines than carnivores?

**Theory:** Length of intestine corresponds to the type of diet an animal eats. Herbivores have longer intestines than carnivores in order to break down the plants that they eat.

### 2.1.18 Absorption Model



**Materials:** Old shirt sleeve, small objects (e.g. peas), water

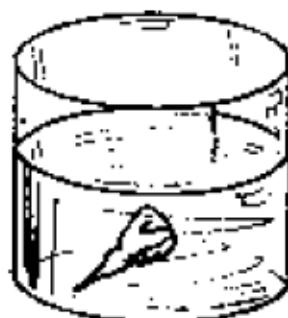
**Procedure:** Place the shirt sleeve over a container to catch the water as it drips through. Pour the mixture of water and peas down the tube.

**Observations:** Water will leak out, but the peas (undigested food) pass straight down. You may need to tie off the end of the sleeve to slow the process down.

**Notes:** Extend the activity by using a semi-permeable plastic bag for the gut. Pour starch and sugar into the tube and test to see what passed through.

## Disorders of the Digestive System

### 2.1.19 Tooth Decay from Soda



**Materials:** Soda, glass, egg or baby tooth

**Procedure:** Place an egg or old baby tooth into a glass of soda (e.g. coke) and let it sit. Place another egg or tooth in water for comparison. After a while remove the eggs and observe.

**Observations:** The soda has reacted with the egg shell or tooth enamel, digesting part of it.

**Theory:** When a person fails to brush their teeth properly, the food that remains on the teeth is acted upon by the bacteria producing acids. These acids eat away the enamel and dentine causing tooth decay.

**Notes:** Try with dilute HCl in place of soda.

## Nutrition in Plants

### 2.1.20 Nutrients from Soil



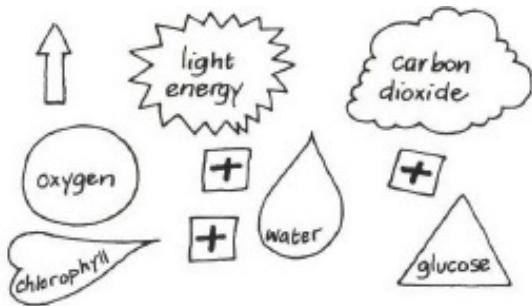
**Materials:** 2 containers, cardboard, soil, seeds

**Procedure:** Fill one container with pieces of card board or foam packing cut into very small pieces. Fill another container with fertile soil and plant a few seeds (peas, beans or maize) in each one. Water each container throughout the experiment. Examine daily.

**Observations:** Seedlings grown in the container without soil are smaller and less healthy with yellow leaves.

**Theory:** As well as water, carbon dioxide and sun-light, plants require mineral salts in order to grow and remain healthy. The seedlings grown without soil get only water and so are lacking these salts.

### 2.1.21 Photosynthesis Model

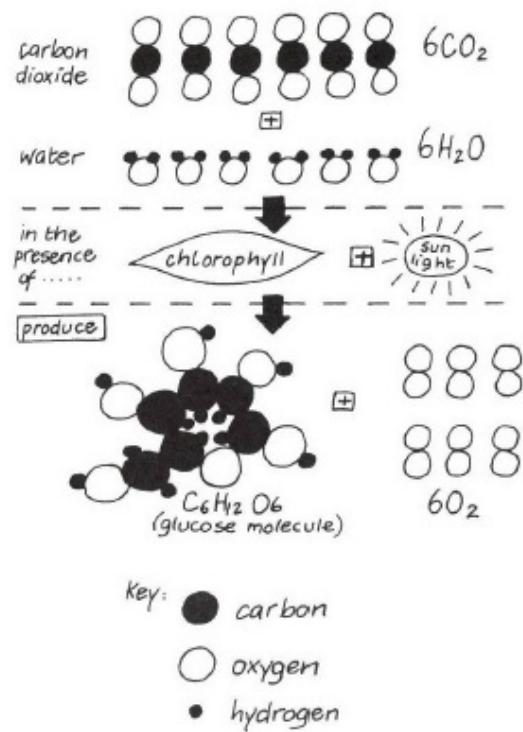


**Materials:** Card/paper, matches

**Procedure:** Draw and cut out the symbols shown above. Then arrange them in the correct order to show the chemical equation for photo-synthesis. Use matchsticks for arrows and + symbols.

**Notes:** Repeat the above procedure but replace the words in the shapes with the chemical formulae of the substances involved. These may be written on the reverse side of the first set of cards.

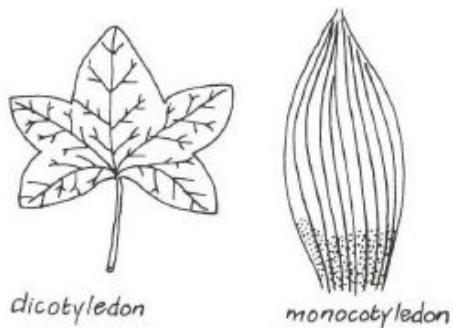
### 2.1.22 Photosynthesis Equation Game



**Materials:** Beans, stones, coins, bottle caps, etc.

**Procedure:** Arrange the items so they represent the stages of photosynthesis as shown in the diagram.

### 2.1.23 Leaf Structure



**Materials:** White paper, leaves, pencils

**Procedure:** Cover a leaf with a piece of paper and gently run a pencil over the paper to reveal the outline of the leaf. Repeat for different leaves and identify the different features of the leaves.

### 2.1.24 Plants Need Light



**Materials:** Stone/brick or black plastic bag

**Procedure:** Cover an area of grass with a large flat brick/stone or with a black plastic bag so that no light reaches the plants. Examine the grass after a few days. An alternative is to place a black plastic bag over green leaves at the end of a branch and seal it by using string, tape or wire.

**Questions:** What changes take place in the appearance of the leaves?

**Observations:** The plants and leaves become pale green or yellow in colour and die eventually.

**Theory:** Plants need light for photosynthesis. When they lose their green chlorophyll no more light can be absorbed and they die.

### 2.1.25 Extracting Chlorophyll



**Materials:** Green leaves, 2 rocks

**Procedure:** Pick about 5, large soft green leaves.

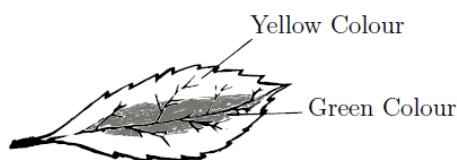
Cut these into small pieces and grind with a stone. Add a little water to the pulp and pour the mixture into a glass jar or test tube. Leave to settle.

**Observations:** The solid material settles out, leaving a green solution.

**Theory:** The green substance in the water is chlorophyll, which has been released from the cells by mechanical breaking of the cell membranes by grinding.

**Notes:** The extraction of chlorophyll works better in alcohol or spirit.

### 2.1.26 Chlorophyll and Photosynthesis

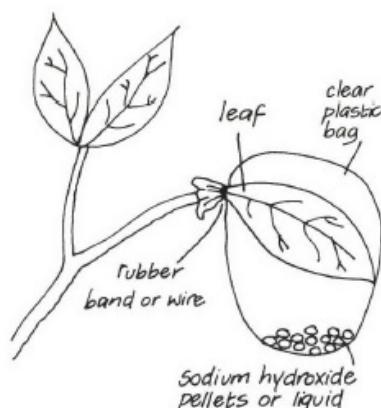


**Materials:** Variegated leaf, alcohol, water bath, Heat Sources, iodine solution

**Procedure:** Find a leaf which is not all green. Draw the leaf, carefully identifying the green areas where chlorophyll is present. Test the leaf for starch. (Boil the leaf in alcohol first).

**Observations:** The areas which turn blue-black during the test are the areas of the leaf which were green.

### 2.1.27 CO<sub>2</sub> and Photosynthesis



**Materials:** Plant, clear plastic bag, rubber band/wire, sodium hydroxide, alcohol, water bath, Heat Sources, iodine solution

**Procedure:** Place a clear plastic bag over one leaf of a plant as shown and leave it for a day. Test the leaf in the bag for starch and also test another on the plant. (Boil leaves in alcohol before testing for starch.)

**Observations:** The leaf which has been in the bag will not have starch in it, i.e. no photosynthesis has taken place.

**Theory:** Sodium hydroxide absorbs carbon dioxide.

### 2.1.28 Starch as a Product of Photosynthesis



**Materials:** 2 potted plants, alcohol, iodine solution, [Heat Sources](#), straw

**Procedure:** Take two plants grown in pots and place one in sunlight and the other in a dark cupboard for 2 days. Pick a leaf from each, but keep them separate. Heat each leaf in some alcohol for about 5 minutes to remove some of the green colour. Take each leaf out and lay it on a flat surface. Add a few drops of iodine solution.

**Observations:** The leaf from the plant grown in the light became a blue-black colour, whereas the one from the dark was the pale brown colour of iodine.

**Theory:** When a leaf is exposed to light, photosynthesis occurs producing sugar, which is then converted to starch for storage. This gives the blue/black colour with iodine. In the dark, no photosynthesis can take place, so no starch is produced.

### 2.1.29 Oxygen as a Product of Photosynthesis



**Materials:** Plastic bottle, large container, water, plants

**Procedure:** Cut the neck from a plastic bottle, leaving the screw cap in place. Place in a large container of water making sure the bottle is completely filled with water. Place some aquatic plants under the bottle and leave for a few days in sunlight.

**Observations:** The water level goes down.

**Theory:** Oxygen produced by photosynthesis forms as bubbles on the leaves, which rise and collect in the bottle neck.

## Food Preservation

### 2.1.30 Food Preservatives

**Materials:** 4 glasses, bullion cubes, salt, sugar, vinegar, water

**Procedure:** Heat bullion cubes in water. Pour equal amounts into each of the four glasses. To the first glass, add a spoonful of salt; to another a spoonful of sugar; to another 3 spoonfuls of vinegar; and add nothing to the final glass. Label the glasses accordingly and set in a warm place for 2-3 days.

**Observations:** After a couple days, the glass with nothing added is much cloudier than the others.

**Theory:** The other 3 glasses have been *preserved* using food additives. The glass with no preservative allows more bacteria to grow in the bullion solution.

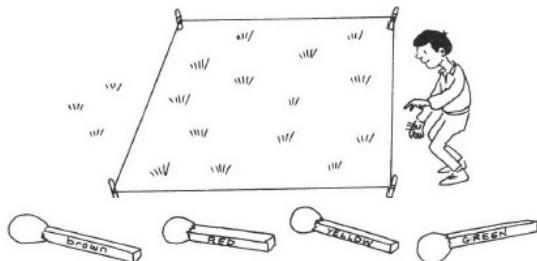
**Applications:** Canned foods, food processing

**Notes:** Conduct an experiment using slices of bread with different preservatives to see which is most effective.

## 2.2 Balance of Nature

### The Natural Environment

#### 2.2.1 Camouflage and Protection



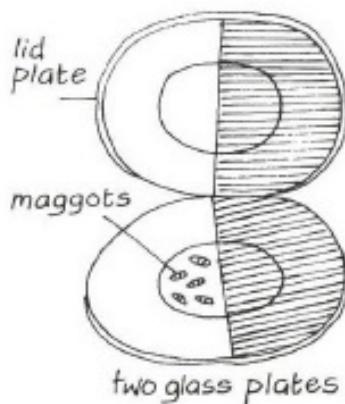
**Materials:** Long piece of string, 4 pegs, matches, marker pens

**Procedure:** Mark out an area of grass with the string and pegs. Colour the matchsticks with markers. Make some the same colour as the grass and others very bright. Drop the matches over the area of grass.

**Observations:** The green matches blend into their surroundings and hence are safer from predators.

**Notes:** Alternatively, cut moth shapes from newspaper and white paper and place both types on either kind of paper. Which are easier to see?

#### 2.2.2 Reactions to Light

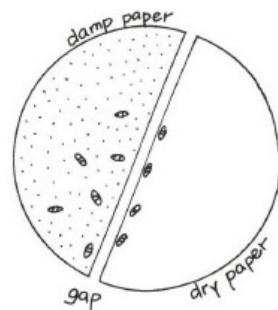


**Materials:** 2 plates, maggots

**Procedure:** Paint or cover one half of each of the plates. Put the plates together so that half is dark and half in bright light. Put 10 maggots into the centre of the bottom plate and put the 'lid' back. Count how many maggots are in each side every 10 minutes.

**Observations:** The maggots prefer the light.

#### 2.2.3 Reactions to Humidity



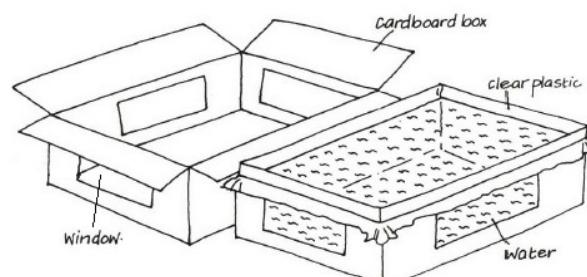
**Materials:** Plate, toilet paper, cloth

**Procedure:** Put dry toilet paper on one side of a plate and damp paper on the other. Put a plate on top and cover it with a cloth so it is dark underneath. Count how many maggots are on each side every 10 minutes.

**Observations:** The maggots prefer a humid environment.

**Applications:** Investigate several conditions at once. For example, put damp filter paper on one half of the 2 plates. Is the result the same if both plates are in sunlight? Which is more important, dampness or darkness?

#### 2.2.4 Aquarium

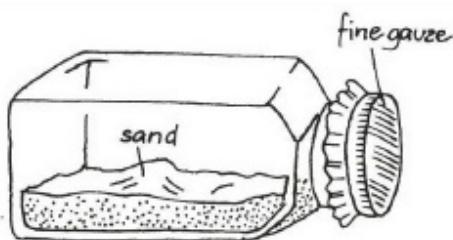


**Materials:** Cardboard box, clear plastic, tape, scissors, water

**Procedure:** Cut viewing windows in the sides of a box. Line the box with a large sheet of clear plastic and fill it with water. Attach the plastic firmly around the edges (e.g. with tape).

**Theory:** Unlike the terrarium, the aquarium is not sustainable because aquatic organisms often require more oxygen dissolved in the water than the container can hold. Adding aquatic plants increases the amount of oxygen in the aquarium.

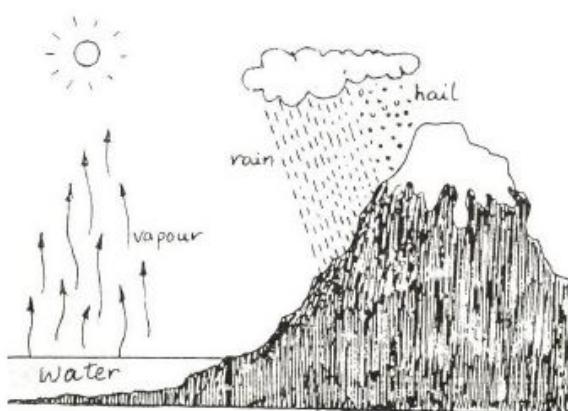
### 2.2.5 Terrarium



**Materials:** Square plastic bottle, sand, soil, rocks, plants, insects, fine gauze

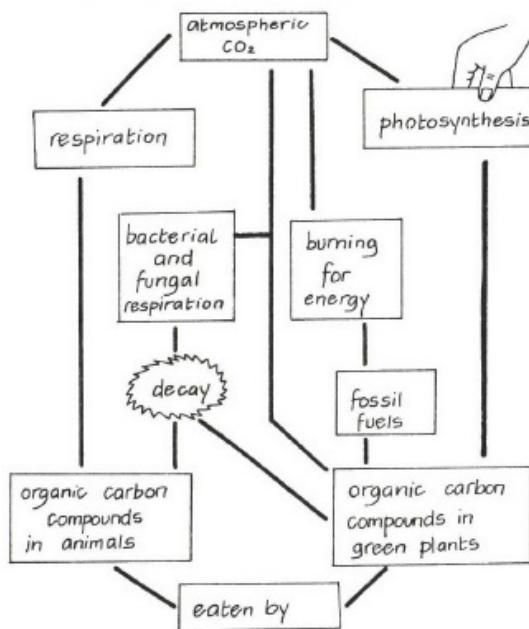
**Procedure:** Cut a square plastic bottle in half lengthwise. Fill one side with soil, rocks, sticks, moss, insects, etc. and cover and tape with the top half. Poke a few holes for air to enter. Periodically add water by removing and replacing the top lid.

### 2.2.7 Water Cycle



## Interaction of Living and Non-Living Things

### 2.2.6 Carbon Cycle Cards



**Materials:** Cards, paper strips, string

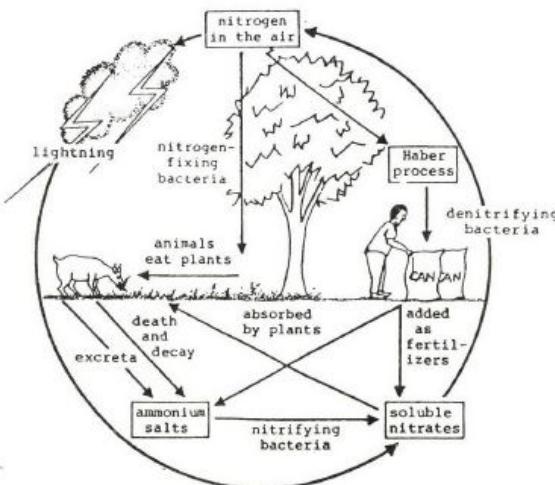
**Procedure:** Cut out cards showing stages of the carbon cycle. Link them together with the paper strips or string to make a balanced carbon cycle. Discuss with students the consequences of increasing one stage, e.g. burning extra fossil fuels.

**Notes:** Cards can be made for other cycles as well (e.g. water cycle, nitrogen cycle).

**Materials:** Cards, paper strips, string

**Procedure:** Prepare activity cards as with the carbon cycle.

### 2.2.8 Nitrogen Cycle



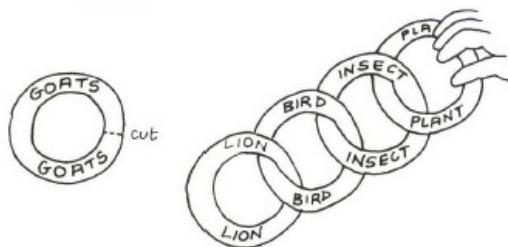
**Materials:** Cards/manila, flip chart

**Procedure:** Prepare a wall chart of the natural nitrogen circulation or make cards of the various steps for students to place.

**Theory:** When proteins are broken down in the body, combined nitrogen containing compounds leave the body with the urine. These compounds are broken down further by bacteria to ammonia ( $\text{NH}_4$ ) which makes public places of urination smell very badly. Dead plant and animal tissues are similarly broken down. The ammonia formed is washed into the soil, where it is acted upon by different types of bacteria, eventually converting it into nitrates and ammonium salts which are needed by plants to produce proteins. Hence they are important fertilizers.

## Food Chains and Food Webs

### 2.2.9 Food Chain Links



**Materials:** Cardboard, scissors

**Procedure:** Cut links of the food chain from stiff cardboard. Label each link with one part of the food chain. Put the links together to make a chain. Make both simple and more complicated chains.

**Questions:** What happens if one link in the middle is removed?

**Observations:** If a middle link is removed, many other links are impacted.

**Theory:** Removing a single species can have a dramatic impact on the entire ecosystem.

### 2.2.10 Food Webs



**Materials:** Card, pictures of animals and plants (optional)

**Procedure:** Either draw pictures of animals and plants on cards or stick on pictures cut out from magazines etc. Make arrows and write on them the links shown. Arrange the cards and arrows to make a food web.

### 2.2.11 Food Web Connections

**Materials:** Long rope/string, students

**Procedure:** Organize students into a circle. Holding the rope tightly, throw the rope to another student. They pull it tight and throw to another (throws do not need to be adjacent). Once the chain is complete, have one student let go of the rope.

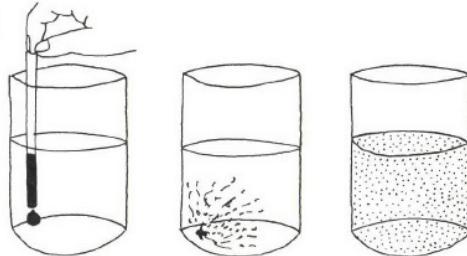
**Theory:** The food web represents the different interconnected species in an ecosystem - each student is a member of the food chain. If one species becomes extinct (i.e. one student drops the rope), then it impacts the entire food chain. Other species lose connections (i.e. food) and are in threat of extinction themselves.

**Notes:** Alternatively, select students to sit down, meaning they have gone extinct as a species. This makes it more difficult for the others to remain standing, i.e. adds strain on their existence.

## 2.3 Transport of Materials in Living Things

### Diffusion

#### 2.3.1 Diffusion in Liquids



**Materials:** Plastic water bottle, food colour (liquid or powder)

**Procedure:** Put a drop or small amount of powdered food colour into the water without shaking and observe what happens.

**Observations:** The colour gradually spreads throughout the water.

**Theory:** This spreading is due to the motion of the particles of food colour. This process is called *diffusion*.

**Applications:** Organisms utilize diffusion to balance nutrient concentrations in cells and to transfer oxygen into the bloodstream during respiration.

#### 2.3.2 Smelling Particles

**Materials:** Orange or other citrus fruit, box

**Procedure:** Peel an orange and have students raise their hands when they begin to smell it. Now place a box in front of the orange and repeat the test.

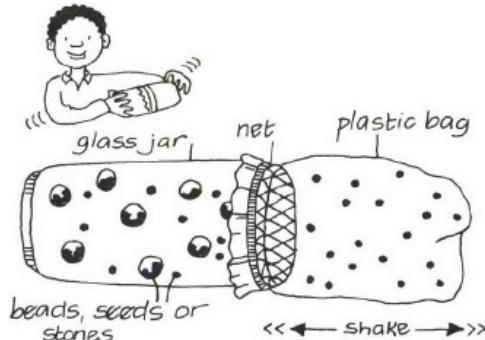
**Observations:** Students in the front center of the room should be the first to raise their hands, followed by those near the sides and in the back. When the orange is peeled behind the box it takes longer for the smell to reach the students.

**Theory:** Tiny particles from the orange peel spread by diffusion to students' noses. The box hinders the motion of the particles and so they reach the students more slowly.

**Applications:** Air fresheners and other sprays

### Osmosis

#### 2.3.3 Semi-Permeable Membranes



**Materials:** Glass jar, clear plastic bag, small beads or stones, beans, netting, string/rubber band

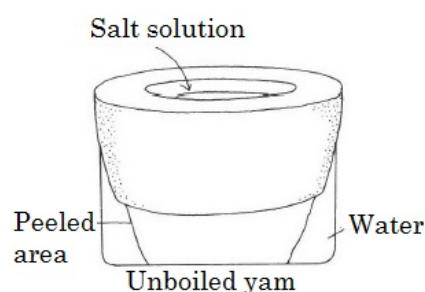
**Setup:** Place the mixture of beads and beans in the jar. Place the net and plastic bag over the top and tie them on securely.

**Procedure:** Shake the apparatus for a few seconds.

**Observations:** Only the small beads pass through the netting. The beans remain in the jar.

**Theory:** The beads represent small molecules and the net is a semi-permeable membrane. The beans are too large to pass through and hence remain in the jar.

#### 2.3.4 Osmosis in Dead and Living Tissues



**Materials:** Potato, knife, 2 dishes of water

**Procedure:** Cut the potato in half and boil one piece. When it has cooled, hollow out the centre of both pieces and half fill with the sugar solution. Peel the lower half of both pieces and then place each in a dish of water for an hour or so.

**Observations:** Water will only enter the unboiled potato.

**Theory:** Boiling one potato kills its cells and so osmosis does not occur.

### 2.3.5 Vanilla Balloon



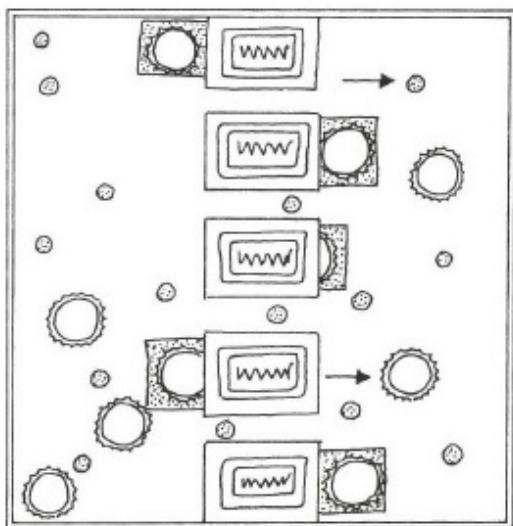
**Materials:** Balloon/plastic bag, vanilla, straw/syringe

**Procedure:** Place a few drops of vanilla in a deflated balloon. Now blow up the balloon and tie it shut.

**Observations:** You can smell the vanilla through the surface of the balloon.

**Theory:** The balloon acts as a *semi-permeable membrane* which allows some of the vanilla particles to pass through and reach your nose. Other particles remain inside the balloon.

### 2.3.6 Osmosis/Active Transport Model



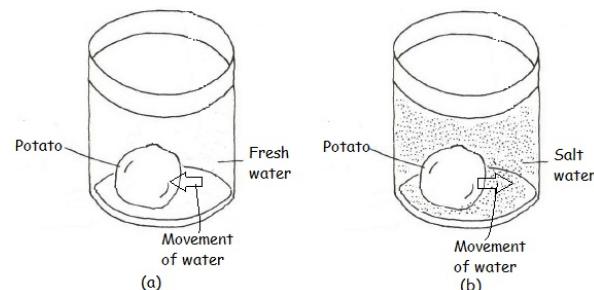
**Materials:** Cardboard tray, matchboxes, peas/beans, bottle caps, tape

**Setup:** Tape the matchboxes to a tray, spaced as shown.

**Procedure:** Place ten soda caps and ten peas in one side of the tray and twenty peas in the other side. Shake the tray gently. Count the peas in each side.

**Theory:** The matchboxes represent a selectively permeable membrane. The spaces allow small objects through, but not larger ones. The peas represent water molecules which move freely. The bottle caps represent larger glucose molecules which need to be placed in the matchbox drawers and actively pushed through to the other side.

### 2.3.7 Potato Osmosis



**Materials:** Potato, 2 water bottles, salt, water

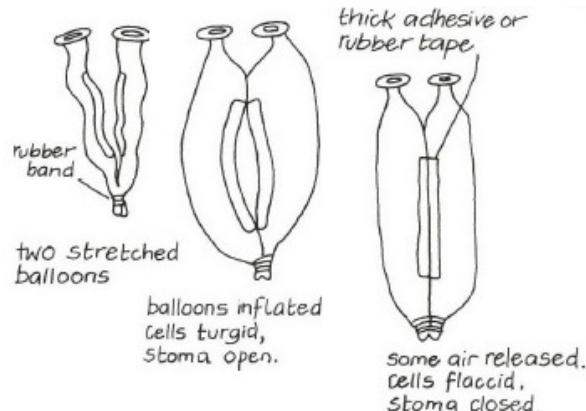
**Setup:** Cut two equal size pieces of potato. Fill one bottle with fresh water and the other with a salt water solution.

**Procedure:** Put one piece of potato in each bottle. Observe over the next few hours.

**Observations:** The potato in fresh water swells while the potato in salt water shrivels up.

**Theory:** Through osmosis, water moves from a region of low concentration to one of high concentration through a semi-permeable membrane (the potato). In fresh water, the potato has the higher salt concentration, so water enters in order to make a balance. In salt water, the concentration of the surrounding water is higher than that of the potato, so water inside the potato moves outside to dilute the salt solution.

### 2.3.8 Guard Cells in Osmosis



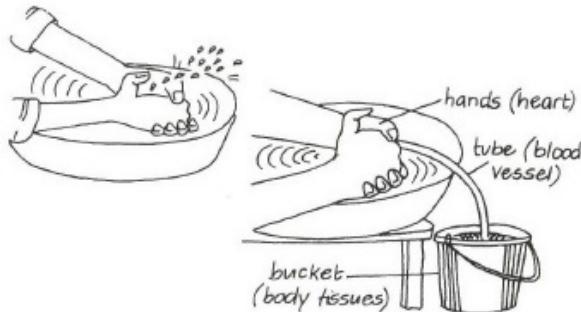
**Materials:** 2 long balloons, tape, rubber band

**Procedure:** Stick the adhesive tape down one side of each balloon as shown. When the balloons are both fully inflated (turgid) the 'stoma' is open. If you let out some of the air, (the 'guard cells' become flaccid), the 'stoma' closes.

## Transport in Mammals

### The Mammalian Heart

#### 2.3.9 Heart Pump Action

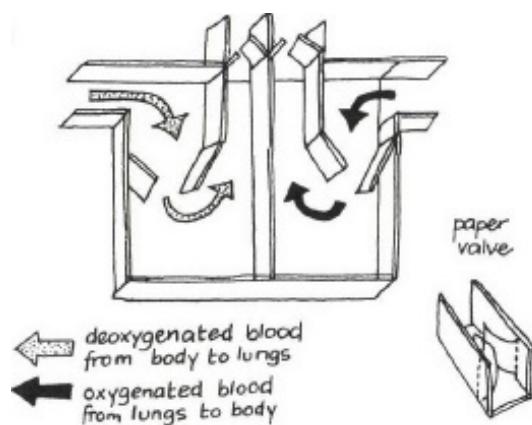


**Materials:** 2 bowls or buckets, rubber/plastic tubing

**Procedure:** Open and close your hands as shown while they are in a bucket or bowl of water. Now hold a rubber tube as shown. Open and close the palms again.

**Theory:** The opening and closing of the palms represent the relaxation and contraction of the heart muscles. Blood enters the chambers of the heart when the muscles relax and is forced out into the vessels as they contract.

#### 2.3.10 Heart Model



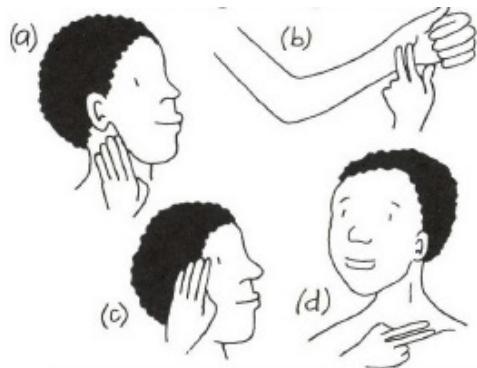
**Materials:** Cardboard box, paper

**Procedure:** Make a model of the heart from a cardboard box as shown. Thin paper is used for the valves.

**Theory:** The heart is a four-chambered muscular organ. The upper chambers are thin-walled atria, which receive blood from the veins. The lower two chambers are the thick-walled ventricles which pump blood into arteries.

## Blood Vessels

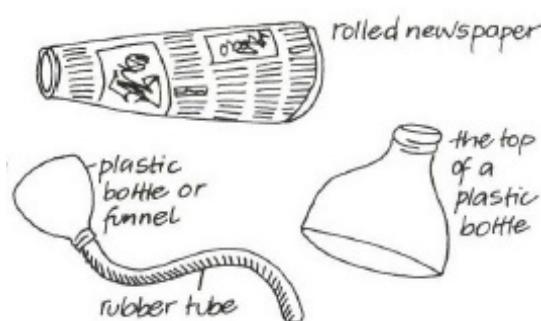
#### 2.3.11 Measuring Pulse



**Procedure:** There are various places on the body where the pulse may be taken. They are (a) under the ear beside the angle of the jaw, (b) at the wrists, (c) at the temple, (d) behind the collar bone. Ask students to find the pulse of a partner. If they have difficulty, they should move their fingers around or apply a little more pressure.

**Applications:** Students can compare a partner's pulse rate before and after exercise.

#### 2.3.12 Simple Stethoscope



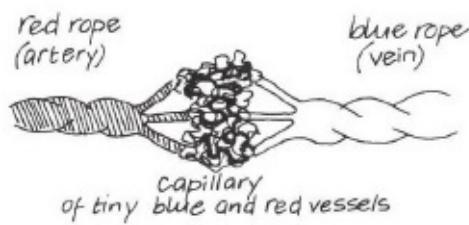
**Materials:** Newspaper, plastic bottle, rubber tube

**Procedure:** Roll a newspaper up into a hollow tube. Place one end of tube against another student's rib cage (in the area of the heart).

**Observations:** The heartbeat can be heard.

**Applications:** A doctor uses a stethoscope to focus the sound from the heart. Another stethoscope idea could use funnels and plastic tube.

### 2.3.13 Blood Vessel Model



**Materials:** 2 coloured ropes/strings (1 red, 1 blue)

**Procedure:** Untwist an end of each rope until each end becomes a mass of tiny thin strings. If you twist the thin strings together they form a mass of fine capillaries.

## Blood

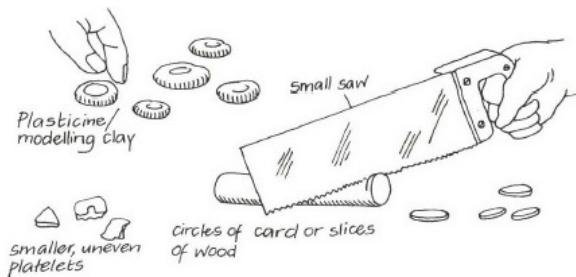
### 2.3.14 Blood as a Transporter



**Applications:** Blood brings substances to the cells, e.g. food and oxygen, and removes others (waste and CO<sub>2</sub>). A food bar or shop has items delivered, gives out items and produces waste. This gives a good analogy for the blood system. Students can act out the role of blood by picking up or putting down items at different shops (sites of the body).

**Questions:** Ask students what they pick up and put down at the following sites: lungs, liver, muscles, kidneys, etc.

### 2.3.15 Red and White Blood Cell Models

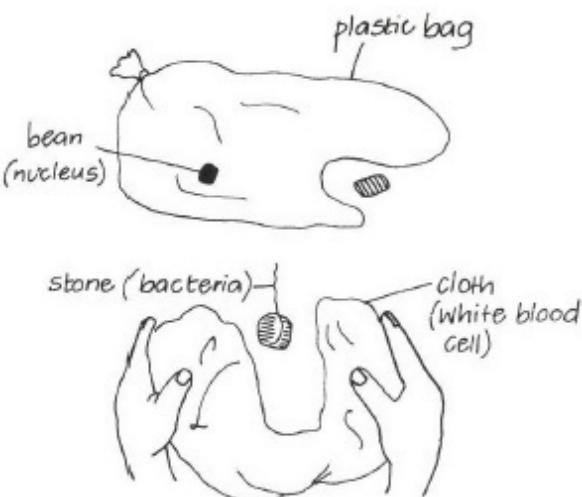


**Materials:** Plasticine, clay or wooden rod, card or sponge

**Setup:** Red blood cells are biconcave discs with no nucleus. You can make models from Plasticine or circles of wood. White blood cells could be cut from thin sponge rubber sheet. They contain a nucleus which can be drawn in on the sponge. Platelets, essential for clotting at open wounds, can be made from smaller, irregular pieces of sponge, clay etc.

**Procedure:** Make red and white blood cells by cutting shapes from cardboard, paper or plastic. Add platelets and then put everything into water. Ask students what the water represents.

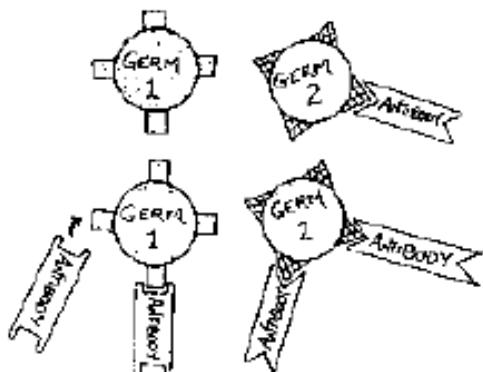
### 2.3.16 Engulfing Model



**Materials:** Clear plastic bag of water or cloth, stone or bean

**Procedure:** Partly fill a clear plastic bag with water. Put a stone or bean inside to represent the nucleus. By shaping the bag, the action of a white blood cell engulfing a foreign body can be demonstrated. You could use a cloth, handkerchief or blanket as a white blood cell. Shape the cloth to show the pseudopodia surrounding the foreign body.

### 2.3.17 Germs and Antibodies



**Materials:** Card, scissors

**Procedure:** Prepare circles of card with different shapes on their edges as shown in the diagram. The circles represent the germ and the edge shapes their antigens. Now cut strips of card and alter one end of each so it matches the edge shapes of the "germ circles".

**Theory:** The strips of card represent the antibodies produced by the body to combat the antigens of the germs. The antibodies will be able to act on a specific antigen.

**Applications:**

### 2.3.18 Blood Clotting



**Materials:** Red and white beans, container, grass or paper strips

**Procedure:** Place some red and white beans in a container to represent red and white blood cells. Move them around by gently shaking. Mix thin strips of grass or paper with the beans and repeat the shaking action.

**Observations:** The beans are packed more securely by the strips.

**Theory:** The strips represent the fibrin network

### 2.3.19 Transfusion Checkers

blood group	donor			
	A	B	AB	O
Patient A				
Patient B				
Patient AB				
Patient O				

blood group	donor			
	A	B	AB	O
Patient A	○	○	○	○
Patient B	○	○	○	○
Patient AB	○	○	○	○
Patient O	○	○	○	○

○ = blood clots

○ = safe transfusion

**Materials:** Bottle caps (2 types), card, coloured pens

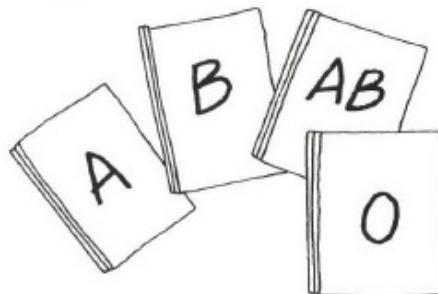
**Procedure:** Draw out a base grid as shown. Use 2 types of bottle caps or counters to show 'safe' or 'clot' transfusions.

**Questions:** Can you place the tops on the right square to show which blood groups are compatible? Which ones aren't?

**Theory:** The main red blood cells contain antigens, classified as blood groups A, B or AB. Blood group O cells do not have antigens. Antibodies in plasma clump blood cells together.

### 2.3.20 Transfusion Card Game

"clot!"      "safe!"



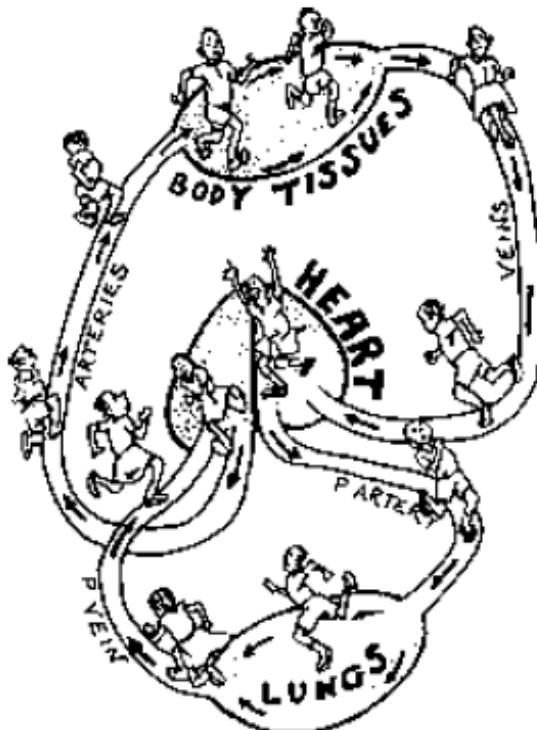
**Materials:** Cards, pen

**Setup:** Cut out 20 cards and label 5 for each blood group.

**Procedure:** Shuffle the cards and turn one card face up. This is the patient's blood group. The next card turned over is the donor's blood group. If a transfusion is possible, players must call 'safe'. If a transfusion would be dangerous they call 'clot'. The first player to call correctly wins the 2 cards. The player with the most cards wins the game.

## Blood Circulation

### 2.3.21 Circulation Game



**Materials:** String or chalk, red and blue flowers/papers, students

**Setup:** Mark out a model of the circulatory system on the ground using stones, string or chalk. Put pieces of red flowers or paper in the area marked lungs and pieces of blue flowers or paper in the area marked body tissues.

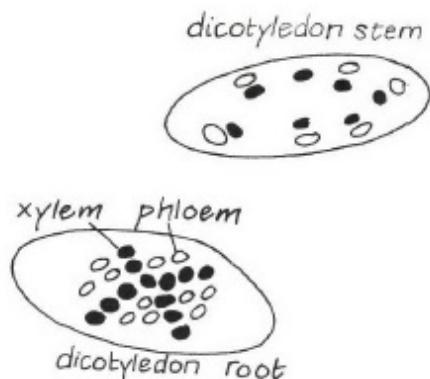
**Procedure:** To begin the game two or three pupils pick up blue petals at the body tissues and follow the arrows through to the heart and on to the lungs. At the lungs the pupils drop the blue flowers and pick up the red and return to the body tissues via the other side of the heart.

**Observations:** The pupils represent the flow of blood in the body. They must go through the heart twice before completing the cycle of double circulation.

**Theory:** As blood flows it transports substances such as oxygen (red flowers), carbon dioxide (blue flowers) and food materials. Pupils can also act as heart valves.

## Transport in Plants

### 2.3.22 Xylem and Phloem Game



**Materials:** Chalk, card/paper, coloured markers

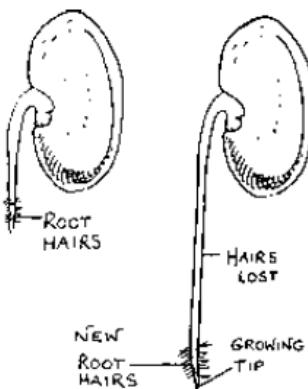
**Procedure:** Chalk 2 circles on the floor or table.

Cut out 20 discs from card or paper. Colour 10 to represent xylem vessels and 10 to represent phloem tubes. Use the discs to show the arrangement of vascular tissue in a root and a dicotyledon stem.

**Questions:** What are the differences in arrangement between stem and root?

**Theory:** Vascular tissue forms a ring of bundles in the stem but a central column in the root.

### 2.3.23 Root Hairs



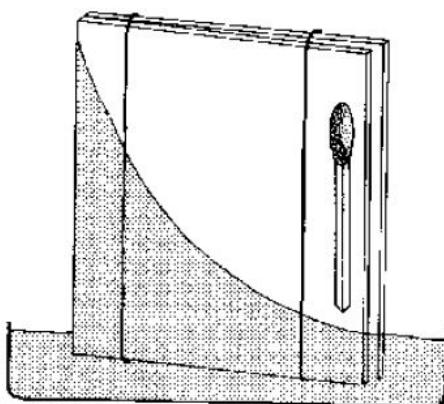
**Materials:** Pea/bean seeds, damp cloth

**Procedure:** Germinate some peas or bean seeds on a damp cloth or newspaper. Leave them until the young root emerges. Observe the root tip using a hand lens if necessary.

**Observations:** A fine covering of thin hair-like structures can be seen, just behind the root tip.

**Theory:** A root develops hairs just behind the growing tip. As the root gets older and larger the root hairs are lost. Root hairs increase the surface area of the root for absorption of water and mineral salts.

### 2.3.24 Capillary Rise



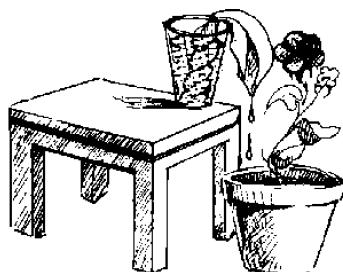
**Materials:** 2 glass sheets, match, rubber bands, water, food colour (optional)

**Procedure:** With the help of a rubber band and a matchstick, arrange two clean glass sheets as shown in the diagram. Place the arrangement in a plate containing some water.

**Observations:** Water rises to different heights along and between the glass sheets.

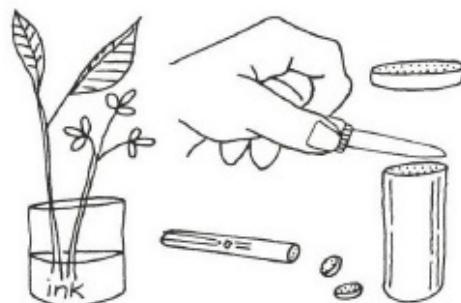
**Theory:** This is capillary action. Capillary rise results from adhesion, allowing the liquid to climb along the surface of the glass, as well as cohesion, which pulls the remainder of the liquid up. Water rises more where the glass sheets are closer together.

### 2.3.25 Automatic Irrigation



**Applications:** Capillary action can be used to provide automatic irrigation for plants. Students can perform irrigation by dipping a porous material such as paper or cotton cloth in water.

### 2.3.26 Water Movement in Plants

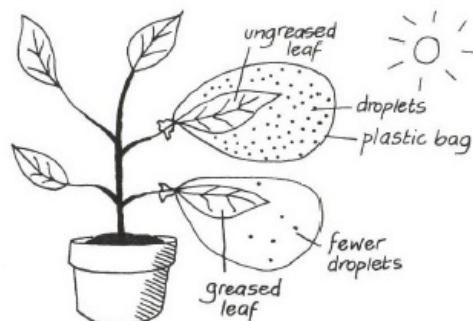


**Materials:** Various plant stems, food colour/ink (not black), water, knife

**Procedure:** Place a variety of different types of plants in coloured ink or dye and leave them for a few hours. Slice off sections of the stem with a sharp knife and examine them under a hand lens.

**Observations:** The colour is located in the xylem vessels which shows water is transported in the xylem. Some very young plants, such as Balsam, are so transparent that you can see the colour move up the stem.

### 2.3.27 Transpiration



**Materials:** Potted plant, 2 small plastic bags, string, grease/Vaseline

**Procedure:** Place a polythene bag over the leaf of a living plant. Secure the bag to the stem with a thread. Repeat the experiment with a greased leaf of the same size.

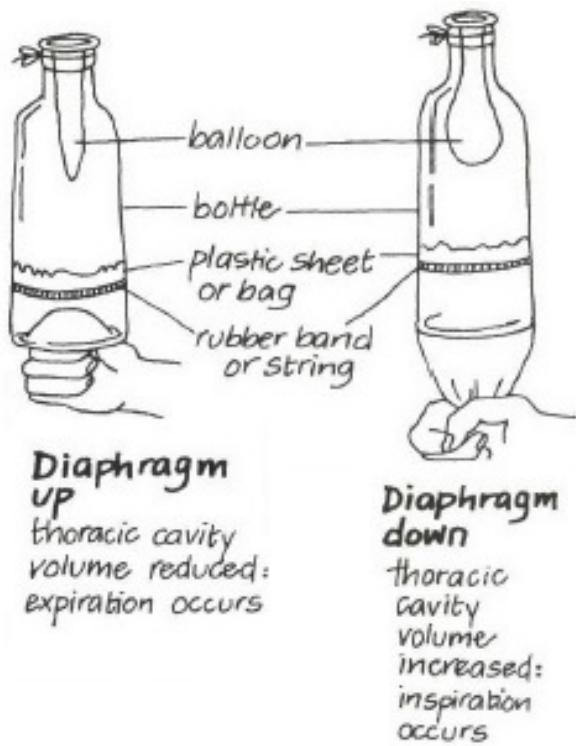
**Observations:** Water droplets appear on the inside of the bag placed over the ungreased leaf. Very little or no water collects in the other bag.

**Theory:** Water, which is absorbed from the soil by the plant, is lost through the pores (stomata) of the leaf. This is transpiration. There is no water loss from the greased leaf because the grease blocks the pores.

## 2.4 Gaseous Exchange and Respiration

### Gas Exchange in Mammals

#### 2.4.1 Breathing Model



**Materials:** Plastic bottle, balloons, plastic bag, string/rubber band, straw

**Procedure:** Cut the bottom off a plastic bottle. Attach a balloon over the bottle mouth so it hangs inside. Fix a piece of plastic bag over the cut base end using string or a rubber band. (Optional: Fix a straw through the bottle top and attach 1 or 2 balloons to the end inside the bottle.)

**Observations:** Pulling the plastic bag down causes the balloon to inflate; pushing it up causes the balloon to deflate.

**Theory:** The balloon(s) represents the lung(s), the plastic bag the diaphragm, the bottle the thoracic cavity (and the straw the esophagus). Pulling the plastic sheet down causes an expansion of the cavity bringing about inspiration and causing the balloon to inflate. Pushing the sheet up reduces the volume of the cavity, causing expiration and the balloon to deflate.

**Notes:** Tell students that this model does not show the expansion and contraction of the rib cage with breathing.

#### 2.4.2 Lung Capacity



**Materials:** Large plastic bag, bucket, water, basin

**Procedure:** Fill the bucket to the brim with water and stand it in the basin. Blow into an empty plastic bag or balloon. Submerge the bag in the bucket. Collect the overflowing water and measure the volume. Do this for regular breaths, deep breaths and breaths after holding for 10 seconds.

**Observations:** A regular breath may be around 0.5 L, while a full breath can exceed 3 L.

#### 2.4.3 Gas Exchange Game

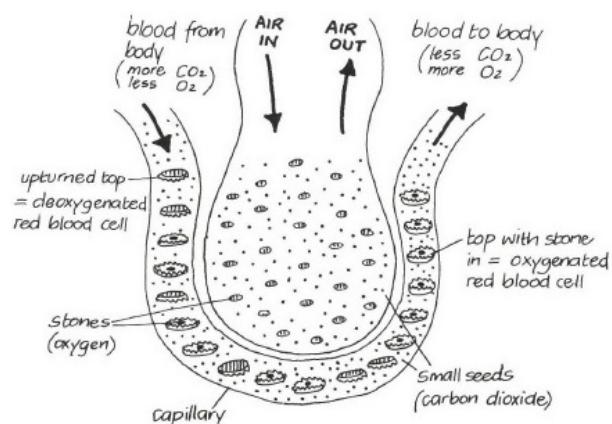


**Materials:** Cards, table

**Procedure:** The table represents the alveolus. Students wear either an 'R' or 'P' card and act as red blood cells (R) or plasma (P). When going round the table the 'R' students pick up cards with 'O' (oxygen) on them. The 'P' students put down the 'CO<sub>2</sub>' (carbon dioxide) cards.

**Applications:** Link this activity with [Circulation Game](#) (p. 30).

#### 2.4.4 Gas Exchange Board Game



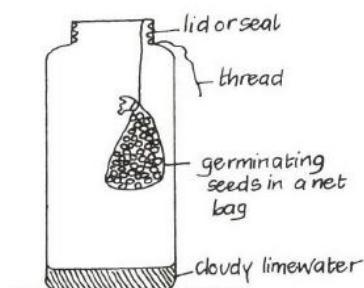
**Materials:** Large sheet of paper, bottle caps, seeds, stones

**Procedure:** Draw the capillary and alveolus as shown. Students arrange the stones (oxygen), seeds (carbon dioxide) and bottle caps (red blood cells) on the drawing. Colour the bottle caps red inside and blue outside.

**Theory:** As the caps (red blood cells) enter the capillary, most are turned to blue to show they contain no stone (oxygen). Stones are placed inside the alveolus which get moved into the capillary and transported away inside red upturned bottle caps (oxygenated red blood cells). The seeds (carbon dioxide) are moved from the capillary plasma area into the alveolus.

#### Gas Exchange in Plants

##### 2.4.5 Germinating Seeds



**Materials:** Glass jar, limewater, plastic bag, peas

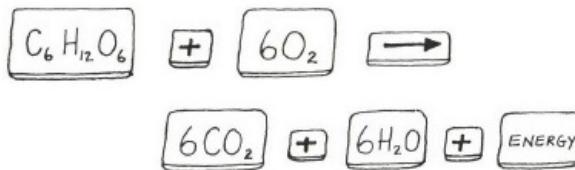
**Procedure:** Put some lime water into a wide-mouthed glass jar and hang a perforated plastic bag, containing soaked and germinating peas. Make sure that the peas are separated from the liquid. Seal the jar well and leave it to stand for a few hours.

**Observations:** The limewater becomes cloudy.

**Theory:** The germinating peas respire, giving out carbon dioxide.

#### Respiration

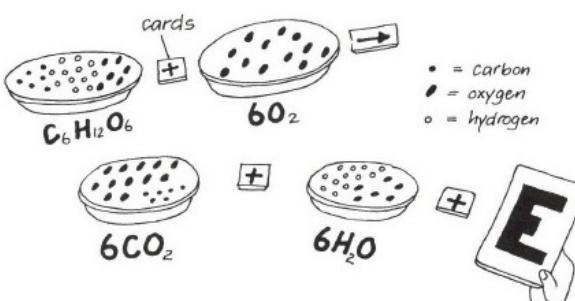
##### 2.4.6 Respiration Cards



**Materials:** Cards

**Procedure:** Cut out cards to represent the substances involved in respiration. Label some cards with a '+' or an arrow. Mix up the cards and ask students to arrange them correctly as shown.

##### 2.4.7 Respiration Plates



**Materials:** Various seeds, bottle caps, coins, etc., plates, card

**Procedure:** Choose 3 different types of seed, coin or bottle cap to represent carbon, hydrogen and oxygen. Arrange 4 plates or boxes on a table as shown. Ask students to place the correct number of seeds etc. on the plates. When the seeds are placed correctly the card carrying the 'E' for energy is added.

**Applications:** Demonstrate that the reverse equation is the process of photosynthesis.

### 2.4.8 Exhaling CO<sub>2</sub>



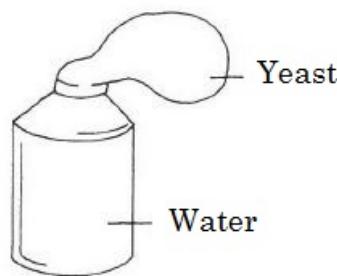
**Materials:** Straw or pen tube, limewater

**Procedure:** Breathe out through a straw or the barrel of a ball point pen into filtered lime-water.

**Observations:** The limewater goes cloudy then later clear.

**Theory:** The exhaled carbon dioxide reacts with the calcium hydroxide solution (lime water) making a precipitation, which later dissolves by more carbon dioxide to soluble calcium hydrogen carbonate.

### 2.4.9 Yeast Balloons



**Materials:** Bottle, balloon, warm water, sugar, yeast

**Procedure:** Fill a bottle partly with a warm water/sugar solution. Add a small amount of yeast into a balloon. Stretch the mouth of the balloon over the bottle, then lift the balloon to empty its contents into the bottle.

**Observations:** After a few hours, the balloon inflates.

**Theory:** Yeast is an organism that eats sugar and breaks it down into alcohols and carbon dioxide. The carbon dioxide gets collected in the balloon.

**Applications:** This process is the basis for making beers, wines and other alcoholic beverages.

### 2.4.10 Fermenting Fruits



**Materials:** Fruit pulp (e.g. pawpaw), sugar, water, container

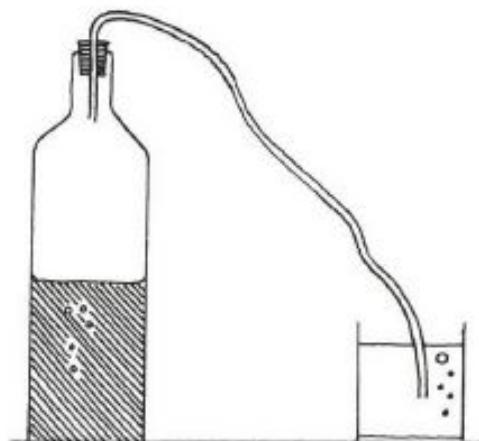
**Procedure:** Prepare a pulp of paw paw. Put the pulp into a glass. Let it stand for some time in a warm place.

**Observations:** Gas bubbles are formed in the pulp

**Theory:** The pulp is fermented because the sugar contained in it is acted on by wild yeast, which grows on the skin of the fruit. Yeasts are also found in air.

**Applications:** Making local brews (e.g. pombe)

### 2.4.11 Fermenting Sugar



**Materials:** Yeast, sugar, bottle, tube, water, lime-water (optional)

**Setup:** Poke a hole through a bottle cap using a hot nail and insert a plastic tube. Seal with super glue.

**Procedure:** Place some yeast in a solution of sugar and water. Cap the bottle and feed the free end of the tube into a dish containing limewater or another bottle full of liquid.

**Observations:** The limewater turns cloudy or air bubbles can be seen escaping from the liquid in the dish.

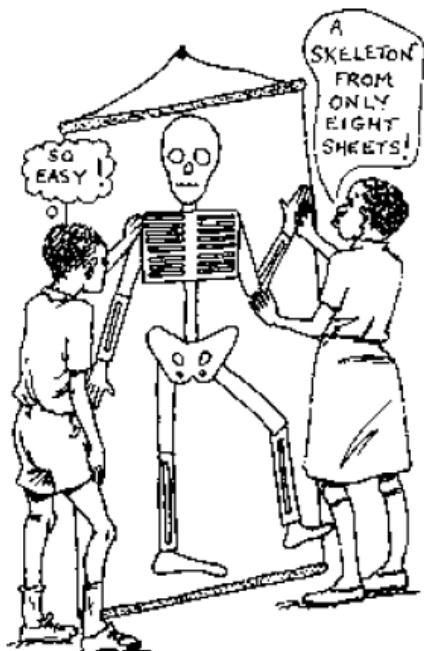
**Theory:** The yeast organisms break down the sugar and produce carbon dioxide gas through respiration.

# Biology Activities for Form III

## 3.1 Movement

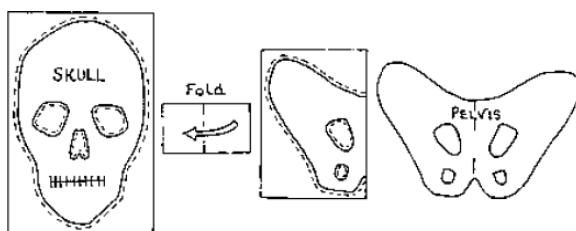
### Human Skeleton

#### 3.1.1 Paper Skeleton



Construct a paper skeleton as shown using 8 sheets of A4 paper. Pin or staple the skeleton together or mount it on a hanging mat.

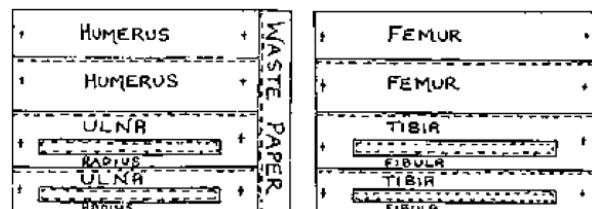
#### Skull and Pelvis



**Skull:** Cut around the dotted line after drawing. The teeth and mouth can be cut without removing any paper.

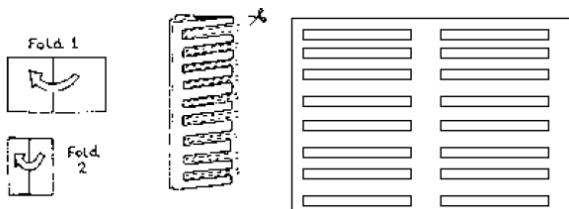
**Pelvis:** Draw half of the pelvis and cut out the basic shape when the paper is folded

#### Limbs



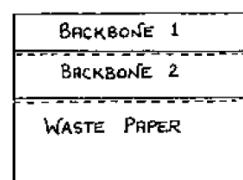
The lower limbs are cut out from one piece of paper. The upper limbs all fit onto another piece.

#### Rib Cage



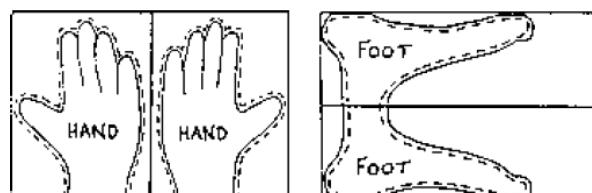
Fold the paper twice and then cut along alternate lines. Use a ruler to measure accurately if you want to have the exact number of ribs. You can cut the ribs out of the paper lengthwise instead.

#### Backbone



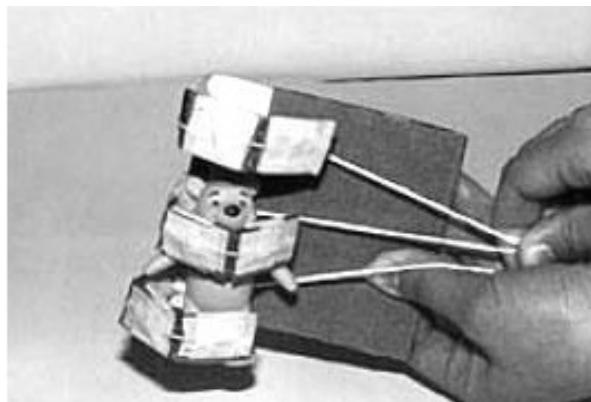
Cut out 2 strips for the backbone to give extra strength. piece to each side of the skeleton.

#### Hands and Feet



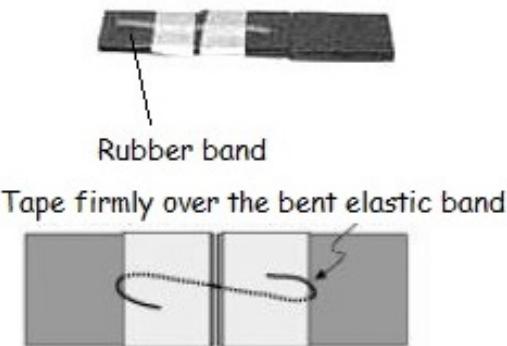
Fold the paper in half and draw around a hand. Use another piece of paper for the feet.

### 3.1.2 Robotic Hand



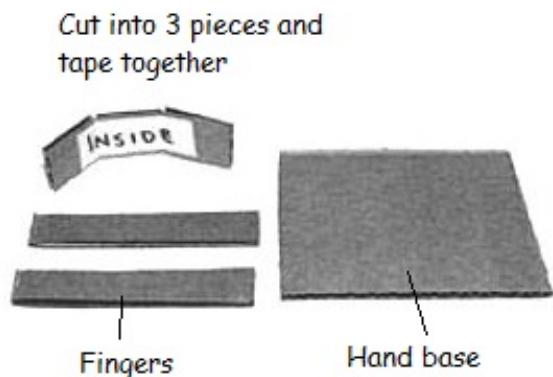
**Materials:** Rubber bands, straws, cardboard, string, masking tape, scissors

#### Fingers



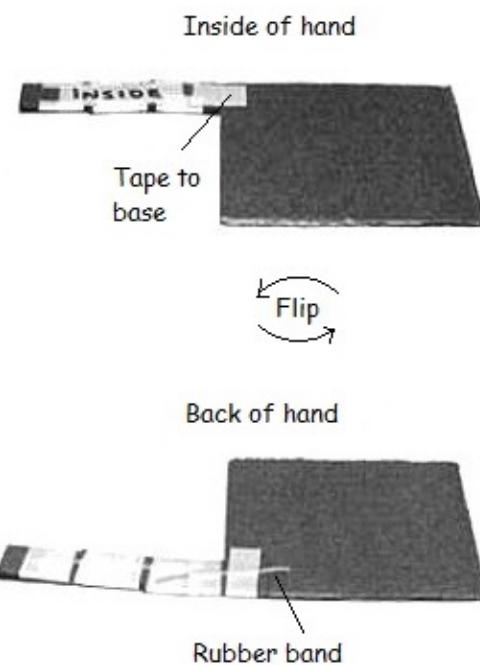
**Procedure:** Cut a piece of elastic about 5 cm long. Turn the finger over (inside facing down) and place the elastic across the middle of the first joint. Tape the elastic on either side of the joint, leaving the ends of the elastic untaped (rip tape to make it thin). Bend the ends of the elastic as shown and tape firmly. This will help prevent the elastic from slipping. Repeat for the second joint.

#### Hand Structure



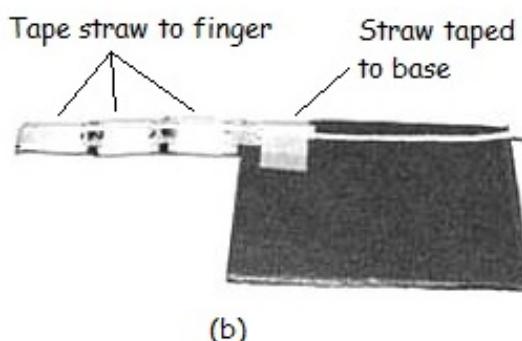
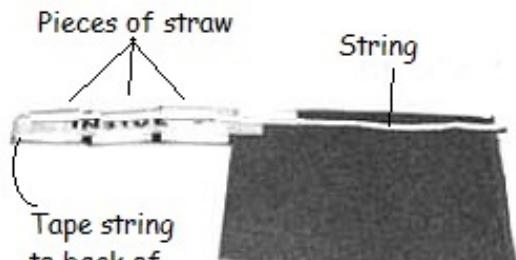
**Procedure:** Cut a piece of cardboard about 10 cm  $\times$  10 cm. This is the “palm” of the hand. Cut three pieces of cardboard about 2 cm  $\times$  9 cm. These are the “fingers”. Cut one finger into three equal pieces. Place the three finger pieces back together and put a piece of tape over the two finger joints. Label the tape “inside”.

#### Attach Fingers



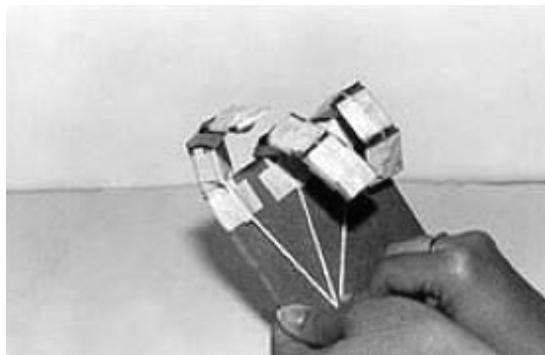
**Procedure:** Tape the finger (inside up) onto the palm. Turn the hand over and fasten the last finger joint to the palm using the same method as above.

## Moving Joints



**Procedure:** Cut a piece of string about 35 cm long and tape one end firmly over the end of the finger. Cut four pieces of straw each about 2 cm long and thread them onto the string. Tape three of the straws in the middle of each of the finger sections. Tape the last straw to the palm as shown.

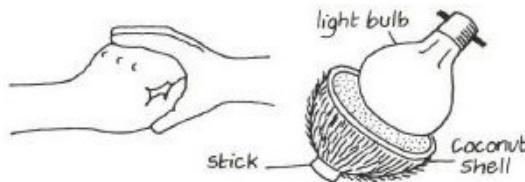
## Completing the Hand



**Procedure:** Repeat the steps above for the last two fingers. When finished, operate the hand by pulling the strings. You should be able to pick up empty soda cans and other light objects with your hand.

## Joints

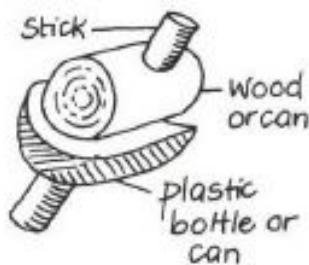
### 3.1.3 Ball and Socket



**Materials:** Light bulb, coconut shell, stick

**Procedure:** The hip joint, which allows the thigh to move, is a ball and socket joint. You can demonstrate such a joint by cupping your hands or making one as shown.

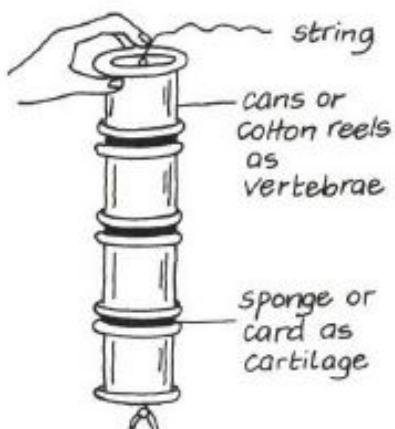
### 3.1.4 Hinge Joint



**Materials:** Stick, round piece of wood or can, plastic bottle or can

**Procedure:** The elbow and knee are both hinge joints and allow movement in only one direction - like a hinge. You can make a model of a hinge joint as shown.

### 3.1.5 Sliding Joint

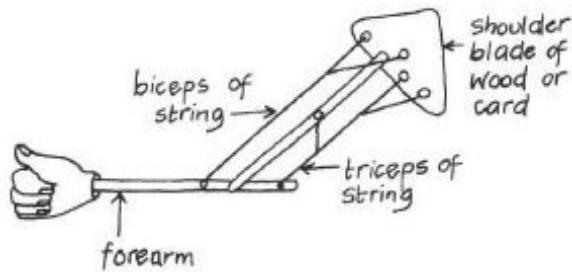


**Materials:** String, cans/cotton reels, sponge or card

**Procedure:** The joints between vertebrae allow movement of the spine. Make a model of the spine as shown.

## Muscles

### 3.1.6 Forearm Lever



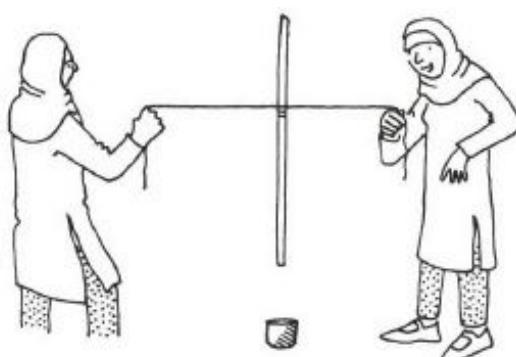
**Materials:** Card, string, 2 strong straight sticks  
**Procedure:** Make a model of the forearm as shown.

**Observations:** Notice that the arm can only be bent by shortening one 'muscle' at a time.

**Theory:** Muscles can only pull, which in turn causes the motion of complementary muscle groups.

**Notes:** Try using rubber bands instead of string.

### 3.1.7 Muscles Work in Pairs

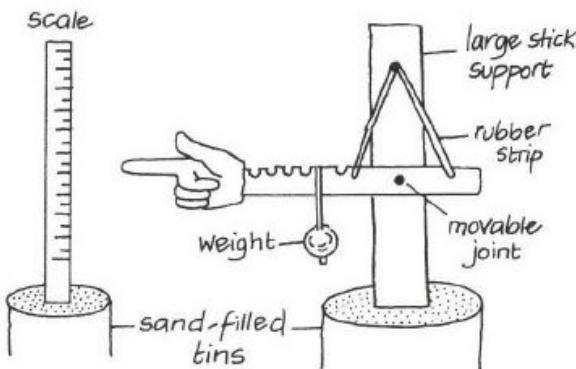


**Materials:** Rod, rope/string, small tin

**Procedure:** Tie the string to the rod as shown and ask pairs of students to manoeuvre the stick into the tin, or onto a chalk mark on the floor.

**Theory:** The rope can only pull the rod, not push it. Muscles can only pull as well.

### 3.1.8 Effect of Load on Muscle

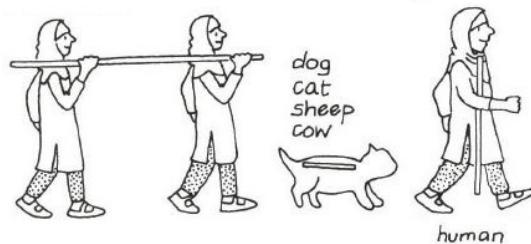


**Materials:** 2 tins filled with sand, ruler, rubber band, 2 strong sticks, weights

**Procedure:** Make a model arm as shown. Use a light weight to begin with and then increase the load. Discuss what happens to the muscle as you increase the load (weights) on the lever (arm) and the effect of the position of the weight on the 'arm'.

**Applications:** Students should move their arms to correspond to the model. Discuss with them where they usually carry loads on their arms and why.

### 3.1.9 Support of the Spinal Column

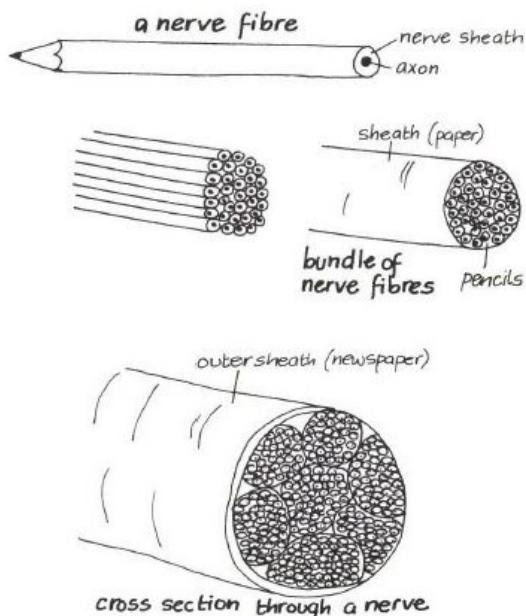


**Theory:** The diagrams show the position of the spinal column in relation to the legs. Ask students to load the 'backbone' by adding weights to it and discuss the effect on the joints. Discuss the role of muscles in maintaining the posture of each animal.

## 3.2 Coordination

### The Nervous System

#### 3.2.1 Nerve Model

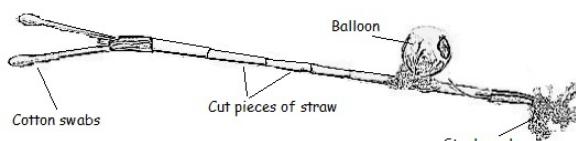


**Materials:** Pencils, paper, newspaper

**Procedure:** Use a pencil to represent a nerve fibre. Roll many pencils in a sheet of paper to represent a bundle of fibres. Roll many bundles in a newspaper to represent a nerve.

**Notes:** Use sticks, straws or grasses as substitutes for pencils.

#### 3.2.2 Neuron Models



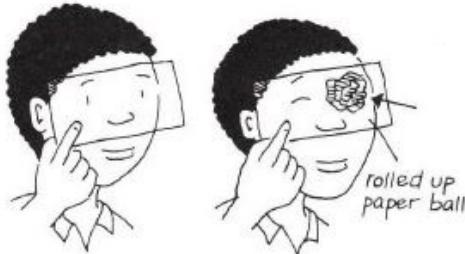
**Materials:** Straight stick/bamboo skewer, straws, tape, balloon, steel wool, cotton swabs, scissors

**Procedure:** Cut several short lengths of straw and place them over a bamboo skewer or straight stick. Fill a balloon slightly and tape it a few centimetres from one end. Draw a large black dot on the balloon. Attach steel wool and cotton swabs to the ends as shown.

**Notes:** Use similar materials to make models of other types of neurons.

### Reflex Actions

#### 3.2.3 Blinking Reflex

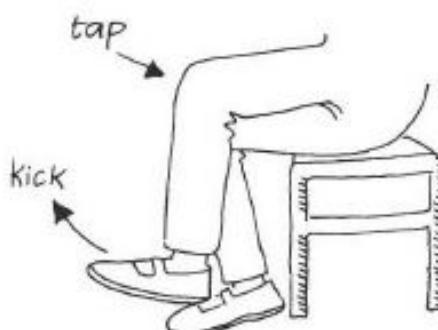


**Materials:** Plastic sheet, paper ball

**Procedure:** One student holds a clear piece of plastic to protect his or her eyes. The plastic from a large plastic bottle is suitable. Another student throws a crumpled ball of paper at the plastic.

**Observations:** The first student blinks. Blinking is a reflex reaction.

#### 3.2.4 Knee Jerk

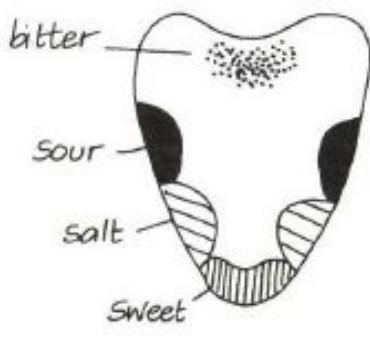


**Procedure:** Cross one leg over the other. Tap just below the knee cap as shown.

**Observations:** The tapped leg kicks up in an involuntary reflex response.

## Sense Organs

### 3.2.5 Taste Map



**Materials:** 4 glasses, spoon, coffee, vinegar, salt, sugar, water

**Setup:** Prepare the 4 taste solutions as follows:

- Bitter: Lemon peel, coffee dissolved in water or strong cold tea
- Sour: Vinegar or lime juice
- Salty: Salt dissolved in water
- Sweet: Sugar dissolved in water

**Procedure:** Use a spoon to pour a small amount of each solution in students' hands, one at a time. Have them taste the solution and describe the taste, as well as where on their tongues the taste is found.

**Theory:** The tongue has receptors for different tastes in different places. Make a diagram of the tongue as shown to display in the class.

### 3.2.6 Tasteless Food

**Materials:** Onion, apple or other fruit

**Procedure:** Cut an onion and an apple into small pieces. Blindfold the person to be tested and make them hold their nose.

**Observations:** They will find the apple and onion taste the same! If students can detect the difference, try giving them the smell of onion as they eat the apple!

**Theory:** Smell is very important in identifying foods. A cold or a blocked nose makes it difficult to taste properly.

### 3.2.7 Sound and Direction



**Materials:** Cloth/kanga

**Procedure:** One student is blindfolded and stands in a circle made by the others. One at a time each person in the circle makes a small noise. At each noise the blindfolded student points to the direction of the sound.

**Questions:** How accurately can students detect the direction of the sound?

**Notes:** Cover one ear (with cotton wool or a cloth).

### 3.2.8 Sight and Balance



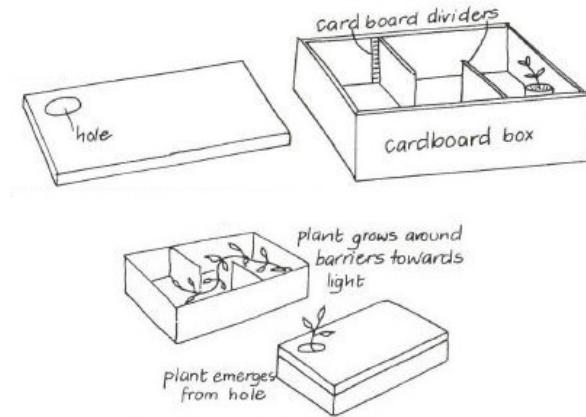
**Procedure:** Try balancing on one leg with both eyes closed. Now try with the eyes open.

**Observations:** It is easier to balance with the eyes open - sight is an aid to balance.

**Applications:** Ask students to spin round and discuss whether it is easier to regain balance when the eyes are open.

## Coordination in Plants

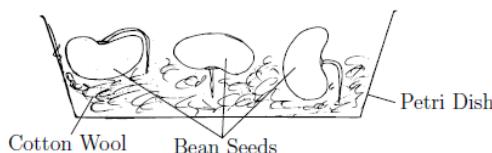
### 3.2.9 Phototropism



**Materials:** Cardboard box, seedlings in small pots  
**Procedure:** Make a light maze box as shown. Lift the lid daily to watch progress.

**Applications:** Farmers and gardeners see leaves turning to the Sun after disturbance or transplanting. Place a house plant next to a window letting in sunlight. Leave it for a few days. Now rotate the pot and note the position of the leaves. Examine the plant over the next few days. The leaves turn towards the light as the plant grows.

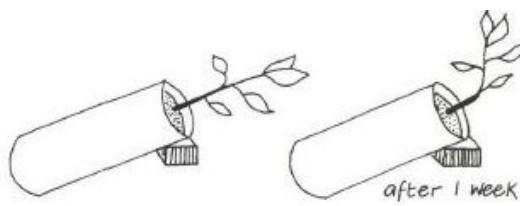
### 3.2.10 Geotropism - Roots



**Materials:** Cotton wool, bean seeds, plastic bottle  
**Procedure:** Cut the bottom of a plastic bottle to act as a petri dish. Place damp cotton wool at the bottom and a few bean seeds on top.

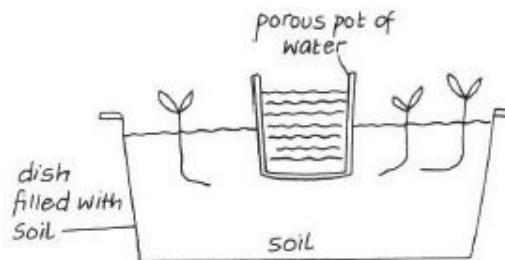
**Observations:** Plant roots will grow towards gravity, showing positive geotropism. The stems will grow away from gravity, thus showing negative geotropism.

### 3.2.11 Geotropism - Shoots



**Procedure:** Lean a pot plant at an angle. Leave it for a week. Notice that after this time the leaves turn upwards.

### 3.2.12 Hydrotropism

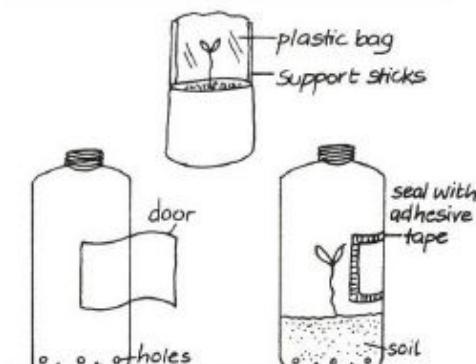


**Materials:** Large dish, porous pot, soil, water, seedlings

**Procedure:** Fill the porous pot with water as shown.

**Observations:** The seedlings' roots will grow towards the porous pot (source of water).

### 3.2.13 Hothouses



**Materials:** Plastic bags, wire/stick supports, plastic bottles

**Procedure:** Use plastic bags supported by sticks or wire to form a hothouse over any container. Or cut a door in a plastic bottle and plant seeds inside the mini-hothouse.

**Theory:** Hothouses are warmer than the outside air and so crops, such as lettuce or tomatoes will grow faster.

### 3.3 Regulation

#### Temperature Regulation

##### 3.3.1 Cooling by Sweat



**Procedure:** Walk around or do exercise on a hot day.

**Theory:** To regulate temperature, our bodies produce sweat. Water droplets on our skin require energy to evaporate, which cools our bodies.

##### 3.3.2 Evaporation and Cooling



**Materials:** Petrol/spirit (e.g. Konyagi)

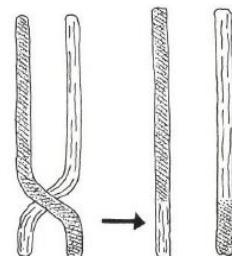
**Procedure:** Pour some petrol or spirit on the back of your hand.

**Theory:** The back of the hand feels cold, because evaporation of the spirit needs energy which it absorbs from the skin.

**Applications:** When you go swimming and come out of the water, you feel cold because evaporation of water from your body absorbs heat from your skin. This is also why the body produces sweat in order to cool down.

## 3.4 Reproduction

### 3.4.1 Meiosis Models



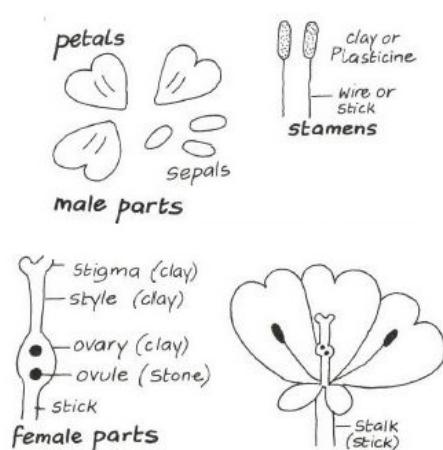
**Materials:** Manila paper, cotton swabs, tape, string, markers

**Procedure:** Construct models of the different stages of meiosis using cotton swabs or toothpicks. Overlap two and tape together to show crossing over.

**Theory:** In meiosis pairs of chromosomes come to lie next to each other. At points called chiasmata, parts of chromosomes are exchanged. This crossing over results in exchange of genes.

## Reproduction in Flowering Plants

### 3.4.2 Flower Structure

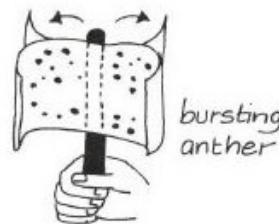
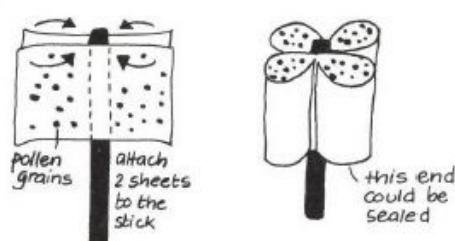


**Materials:** Card or plastic, sticks, stones paper, clay or Plasticine

**Procedure:** Make the major parts of a flower from card or plastic, sticks and clay. Petals can be made from paper.

**Applications:** Look at a variety of flowers, fruit and seeds from the local environment.

### 3.4.3 Anthers and Pollen



**Materials:** Paper, sticks

**Procedure:** Make a model of an anther as shown.

Lightly glue small pieces of card or stick onto paper to represent pollen. Alternatively draw circles to represent the pollen.

**Theory:** When the paper is folded it represents anthers full of pollen. They are ready to burst open and shed pollen into the wind or onto insects.

**Applications:** Look at a variety of flowers, fruit and seeds from the local environment.

## Reproduction in Mammals

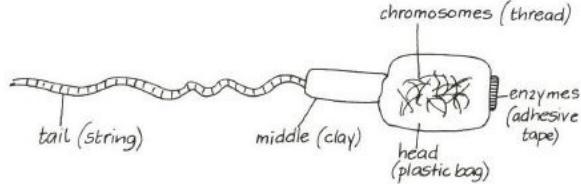
### 3.4.4 Sperm and Egg



**Materials:** Football, bean

**Theory:** The football represents the human egg, the bean a human sperm

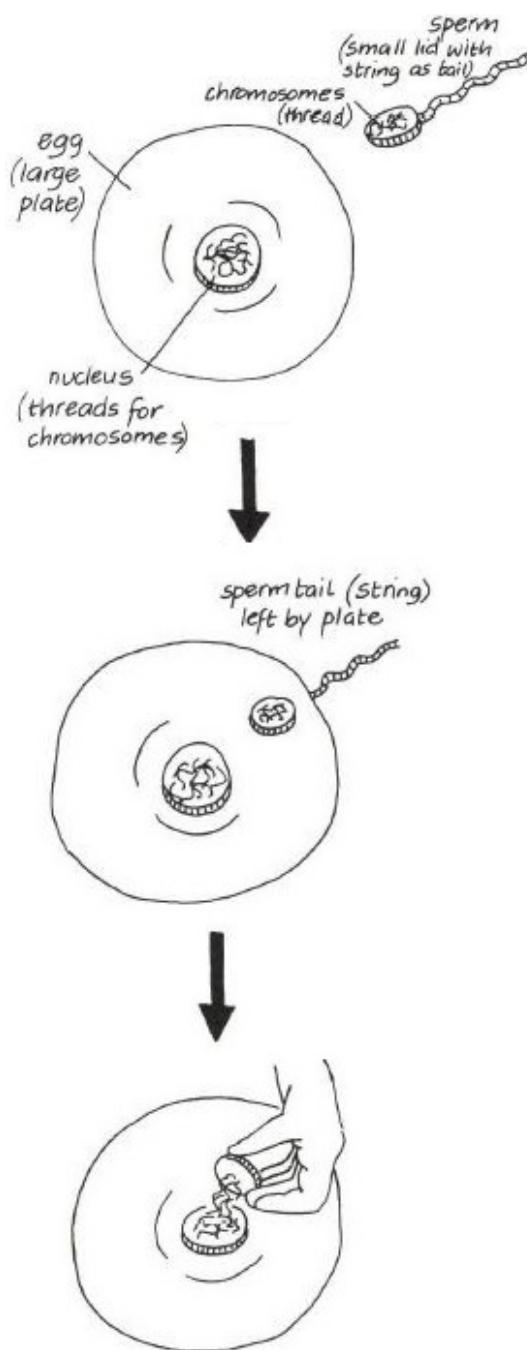
### 3.4.5 Sperm Model



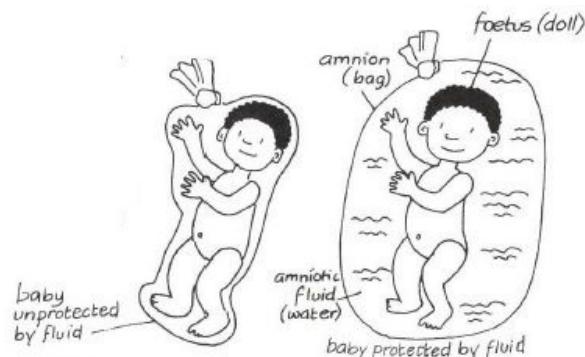
**Materials:** Plastic bag, tape, string, thread/steel wool, clay

**Procedure:** Construct a simple sperm model as shown.

### 3.4.7 Fertilisation



### 3.4.6 Amniotic Sac Protection



**Materials:** Doll, clear plastic bag, water

**Procedure:** Place a plastic doll into an empty, clear plastic bag. Fill the plastic bag with water, place the doll inside and knot the opening so it is sealed. Pass the water-filled bag around and discuss with students what protects a baby inside the mother.

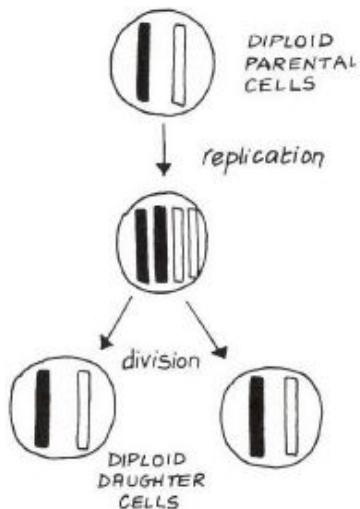
**Materials:** 2 bottle lids, thread, string, large plate

**Procedure:** Make the sperm and egg cell as shown. Note that the lids represent the nuclei of the female and male cells. The plate represents the egg cell. The fine threads represent chromosomes. Move the sperm towards the egg cell until it touches the nucleus of the egg cell. Mix the threads from both lids. This represents the sperm head bursting and the mixing of chromosomes.

# Biology Activities for Form IV

## 4.1 Growth

### 4.1.1 Mitosis Model



**Materials:** Matches or paper strips

**Theory:** In the model shown here, only one chromosome pair is shown in the original cell. In a human cell, one chromosome from the pair came originally from the sperm, the other from the ovum. 'Parent' and 'daughter' cells have identical chromosomes.

**Notes:** The model would be more realistic and complex if the full complement of 26 pairs of chromosomes were used instead of just one.

## Germination

### 4.1.2 Seed Germination

**Materials:** Seeds or beans, small bottles, water, avocado pits

**Procedure:** Cut plastic bottles to make containers. In the first, add soil with beans and water every day. In the second, fill mostly with water and place an avocado seed inside. In the third, fill mostly with water and place a potato inside.

**Observations:** The stages of germination can be seen over time.

**Theory:** The avocado and potato undergo hydroponic germination, since the seed is sprouted by water, air and sunlight only.

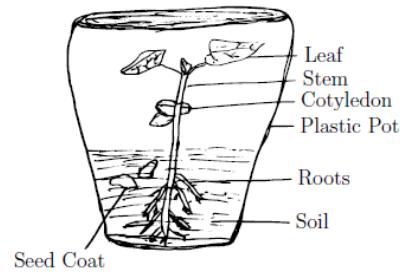
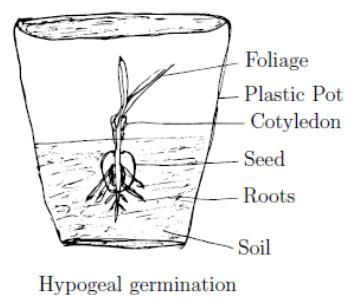
### 4.1.3 Conditions for Germination

**Materials:** 4 bottles or syringes, cotton wool, beans or seeds, water, oil

**Procedure:** Place cotton wool at the bottom of each container and add a few beans or seeds to each. In container 1, add enough water to soak the cotton wool. In 2, add cool boiled water to flood the seeds and a small amount of oil. In 3, add ice water. In 4, do not add any water. Record observations over several days.

**Observations:** Only container 1 will show proper germination. The others will show little or no growth because they do not have the conditions necessary for germination.

### 4.1.4 Hypogeal and Epigeal Germination



**Materials:** 2 pots or bottles, beans, maize seeds

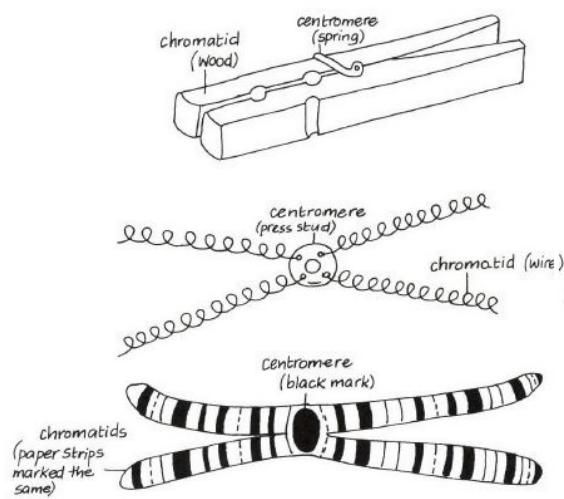
**Procedure:** Add soil to 2 pots or bottles. Place a few bean seeds in one and a few maize seeds in the other.

**Theory:** In epigeal germination cotyledons are carried above the soil, as in the germination of bean seeds (dicotyledonous seeds). In hypogeal germination cotyledons remain underground, as in the germination of maize seeds (monocotyledonous seeds).

## 4.2 Genetics

### Genetic Materials

#### 4.2.1 Chromatid Models

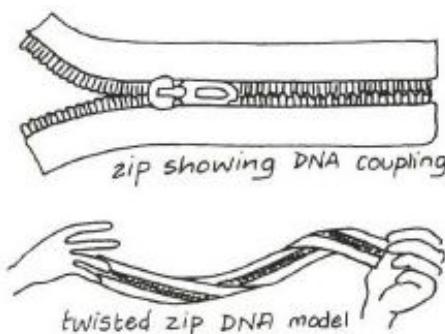


**Materials:** Clothespin, wire, washer/button, paper strips

**Procedure:** Construct the chromatid models as shown.

**Theory:** During the late stage of prophase in mitosis each chromosome can be seen as 2 parts, called chromatids. These chromatids are joined together by the centromere.

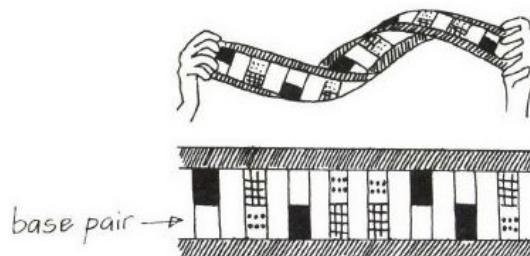
#### 4.2.2 DNA Zipper



**Materials:** Zipper

**Theory:** DNA is wound in a double helix. The strands of the helix are chains of sugars and phosphates. The 2 strands of the helix are linked together by bridges made of pairs of organic nitrogenous bases which are joined to the sugar molecules. A zip provides a good visual analogy.

#### 4.2.3 DNA Helix Model



**Materials:** Card/paper strips, 4 colours

**Procedure:** Make your helix model from strips of strong card or paper. It should be strong enough to twist as shown.

**Theory:** A gene can have a sequence of up to 1000 base pairs in a DNA molecule.

#### 4.2.4 DNA Extraction

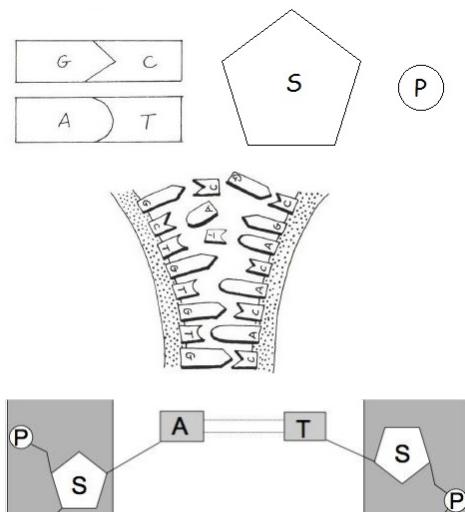
**Materials:** Salt, soap, water, methylated spirit, bottle

**Procedure:** Prepare a salt solution by mixing with water. Have students swish the solution in their mouths for about a minute and then spit into a container. Add this to a soap solution and gently swirl for a few minutes. Pour methylated spirit down the inside of the container to form a layer on top.

**Observations:** Transparent strands of DNA should precipitate at the boundary between the two layers. Strands can be picked up with a toothpick.

**Theory:** The enzymes in the soap break down the lipids of the nuclear membranes, releasing the DNA. Salt neutralizes the DNA by providing '+’ ions. The DNA slowly rises to the alcohol layer above the water.

#### 4.2.5 DNA Model Game



**Materials:** Card/paper, scissors

**Setup:** Cut out pieces of card to represent the paired bases, sugars and phosphate groups.

**Procedure:** Construct a DNA model by correctly joining the parts of the nucleotide. The phosphate group (P) should be atop the deoxyribose sugar (S) and the base pairs should bond to the deoxyribose sugar as shown. Students must match the bases to ‘zip up’ the DNA molecule.

**Observations:** The bases always combine in the same pairs: thymine with adenine and cytosine with guanine.

**Theory:** DNA is a double-stranded helical (spiral) molecular chain that is found in the nucleus of the cell. It contains the genetic information of organisms. DNA is made up of many *nucleotides*. The components of a DNA nucleotide are a deoxyribose sugar, phosphoric acid, and an organic base. The four bases of DNA are guanine, cytosine, adenine, and thymine. In humans, DNA determines physical features such as the colour of the skin, eyes, and hair as well as a person’s height and the presence or absence of genetic disorders.

#### Inheritance

##### 4.2.6 Mendelian Inheritance

**Materials:** Many beans and maize seeds

**Procedure:** Provide many of each seed to each student or group. Beans represent a dominant allele (Z) and maize seeds represent a recessive allele (z). Have students cross two heterozygotes (e.g. Zz × Zz) by making a mixture of Zz (50% beans and 50% maize) for both the mother and father. To make an offspring, take one seed from each pile. Repeat at least 20 times and record each offspring and its genotype.

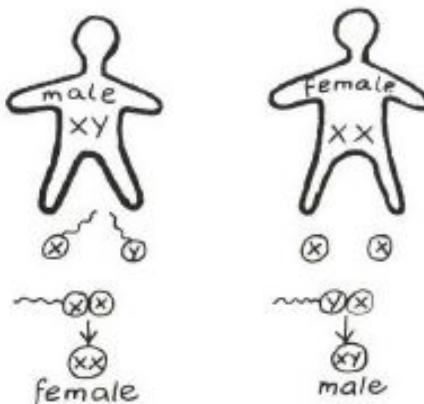
**Observations:** Several combinations are possible: ZZ, Zz, zZ and zz

**Theory:** In sexual reproduction, each parent gives the offspring one copy of each gene. If the offspring has even one dominant allele (ZZ, Zz or zZ), it will show the dominant trait Z. A combination of zz reveals the recessive trait.

**Applications:** Repeat the activity for different heterozygotes (e.g. ZZ × zz, Zz × zz, etc.). Have students calculate the probability of an offspring carrying each combination and exhibiting each genotype.

#### Sex Determination

##### 4.2.7 Determining Sex of a Child



**Materials:** Card/paper

**Procedure:** Cut out 2 shapes, one to represent a male (labeled XY), the other a female (labeled XX). Cut out 4 small circles. Label 3 of them X and label the other Y. These shapes represent the gametes. Move sperm and eggs together to represent fertilisation and sex determination.

**Theory:** An offspring having 2 X gametes will be a female, while a Y gamete results in a male.

## 4.3 Evolution

### 4.3.1 Natural Selection Game

**Materials:** Rice, beans, 3 bottles, 6 clothespins, 6 plastic forks, 6 plastic spoons

**Procedure:**

1. Split participants into groups of 6. Give 2 participants forks, 2 participants spoons, and 2 participants clothespins. Each group will have one beaker, so 3 beakers total will be needed.
2. Spread the beans and rice in the middle of the table.
3. Each team has 20 seconds to collect beans and rice and place them into the

beakers. The two teams with the most beans and rice in their beakers will advance to the next round.

4. Continue with round 2 for 20 seconds. The team with the most beans and rice in their beaker wins.

**Observations:** Students using spoons should be able to gather the most beans and rice.

**Theory:** There is always competition or struggle between organisms for limited resources such as food, space, etc. Only well adapted organisms survive while the less adapted are eliminated (survival of the fittest).

# **Materials and Equipment**

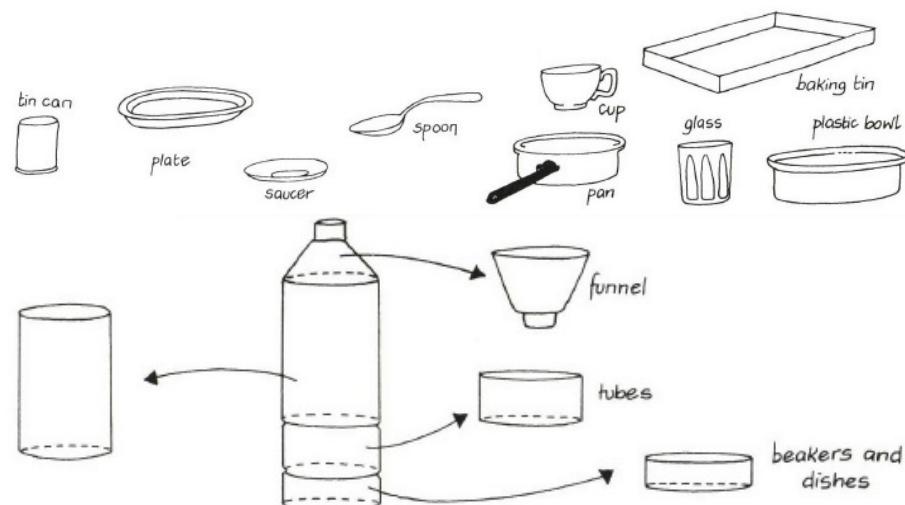
# Local Materials List

In order to gain a thorough understanding of science, students must be able to make a connection between classroom learning and the outside world. The following is a list of locally available materials which may be used to substitute conventional materials and apparatus for various activities. These materials have the following advantages:

- They are readily available in the village or a nearby town;
- They are cheaper than conventional materials;
- They may safely substitute the conventional materials without fear of losing accuracy or understanding;
- They help students to draw a connection between science education and the world around them.

Imagination and innovativeness is encouraged on the part of the student and teacher to find other suitable local substitutions.

How many experiments can be carried out with everyday items?



Below are common apparatus you might order from a laboratory supply company, and comments about which have good if not superior alternatives available in villages and towns. Given equal quality, it is generally better to use local materials, because these help connect classroom learning to students' lives.

The apparatus listed in this section are the following:

- |                       |                  |                        |
|-----------------------|------------------|------------------------|
| 1. Balance            | 11. Droppers     | 21. Masses             |
| 2. Beakers            | 12. Electrodes   | 22. Measuring Cylinder |
| 3. Blowpipe           | 13. Filter Paper | 23. Metre Rule         |
| 4. Bunsen Burner      | 14. Flasks       | 24. Microscope         |
| 5. Burettes           | 15. Funnel       | 25. Mortar and Pestle  |
| 6. Crucible           | 16. Gloves       | 26. Optical Pins       |
| 7. Containers         | 17. Goggles      | 27. Pipettes           |
| 8. Deflagrating Spoon | 18. Heat Sources | 28. Retort Stand       |
| 9. Delivery Tube      | 19. Indicator    | 29. Scale Pans         |
| 10. Drawing Board     | 20. Iron Filings | 30. Scalpels           |

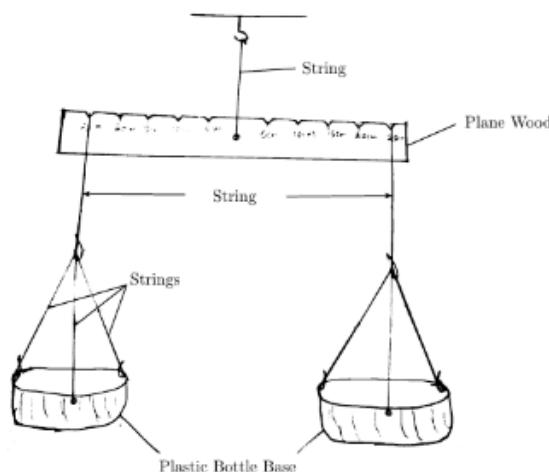
- |                            |                              |                 |
|----------------------------|------------------------------|-----------------|
| 31. Slides and Cover Slips | 36. Test Tube Brush          | 41. Wash Bottle |
| 32. Spatula                | 37. Test Tube Holder / Tongs | 42. Water Bath  |
| 33. Stoppers               | 38. Test Tube Racks          | 43. Weights     |
| 34. Stopwatches            | 39. Tripod Stands            | 44. White Tiles |
| 35. Test Tubes             | 40. Volumetric "Glass" ware  | 45. Wire Gauze  |

## A.1 Balance

**Use:** Measuring mass

**Materials:** Ruler or wooden bar 30 cm × 2 cm, nails, razor/knife, string/wire, pen, 2 Scale Pans

**Procedure:** Find the balancing point of the ruler/wood block and mark it with a pen. Use a heated nail to make a hole through this point. Make notches at 5 cm intervals on either side of the center hole using a razor/knife to suspend scale pans. Use a string/wire tied through the center hole to suspend the balance.



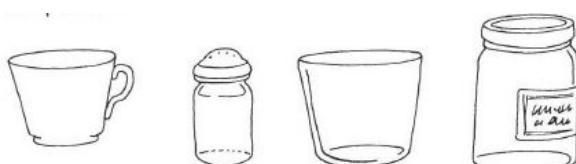
## A.2 Beakers

**Use:** To hold liquids, to heat liquids

**Materials:** Water bottles, jam jars, metal cans, knife/razor

**Procedure:** Take empty plastic bottles of different sizes. Cut them in half. The base can be used as a beaker. Jam jars made of glass, cut off metal cans and aluminum pots may be used when heating.

**Safety:** Glass containers may shatter if heated too much. Use standard laboratory equipment if extreme heating is needed.

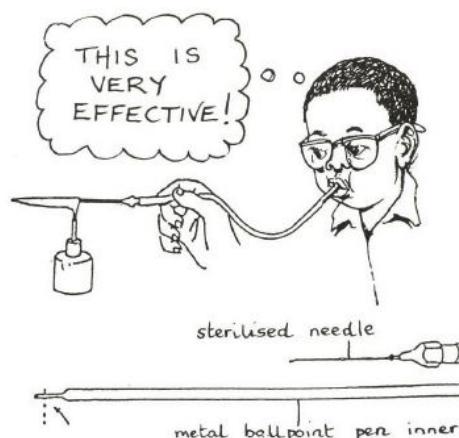


## A.3 Blowpipe

**Use:** Increasing temperature of flames

**Materials:** Syringe needle, tube/straw/pen tube

**Procedure:** For sterilisation heat the needle in open fire for a longer time before using it. A drinking straw or a clean plastic tube can be used as a connection to the mouth.



## A.4 Bunsen Burner

See [Heat Sources](#) (p. 54).

## A.5 Burettes

**Use:** Titration

**Materials:** 10 mL syringes

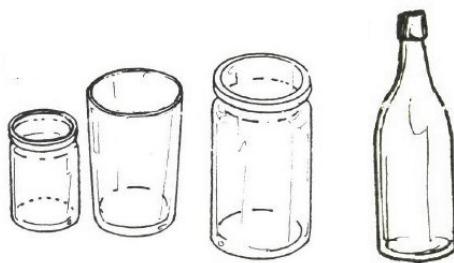
**Procedure:** Use 10 mL disposable plastic syringes with 0.2 mL gradations. Students can estimate between the lines to at least 0.05 mL. If you must buy, buy plastic. Note that broken burettes can often be repaired – see ?? (p. ??).

## A.6 Containers

**Use:** Measuring large volumes (100 mL – 2 L) of solution, titration, storage

**Materials:** Plastic water bottles, jars, tin cans

**Procedure:** Identify the volume of useful marks on the bottles and combine to measure accurate volumes.

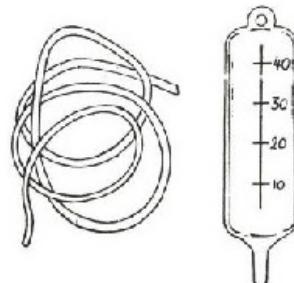


ballpoint casing  
also bent by  
heat



flexible and other  
drinking straws

inner ink tube of  
ballpoint refill

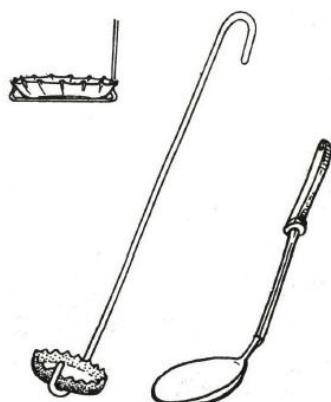


## A.8 Deflagrating Spoon

**Use:** For heating chemicals to observe melting, decomposition, or other changes on heating

**Materials:** Metal spoons, galvanised wire, soda bottle cap

**Procedure:** Bend 30 cm of galvanised wire as shown. The wire should hold the bottle cap firmly.



## A.9 Delivery Tube

**Use:** Movement and collection of gases, capillary tubes, hydraulic press

**Materials:** Straws, pen tubes, IV tubing (giving sets) from a pharmacy, bicycle tubing

## A.10 Drawing Board

**Use:** Dissection, reflection, refraction of light

**Materials:** Thick cardboard

## A.11 Droppers

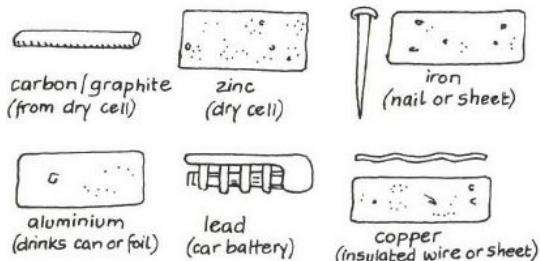
**Use:** To transfer small amounts of liquid

**Materials:** 2 mL syringes, straws

**Procedure:** Take a syringe. Remove the needle to use as a dropper. Or insert a straw into a liquid and then plug the free end with a finger to remove a small amount and use as a dropper.

## A.12 Electrodes

**Use:** Electrolysis



### A.12.1 Graphite

**Materials:** Old dry cell batteries

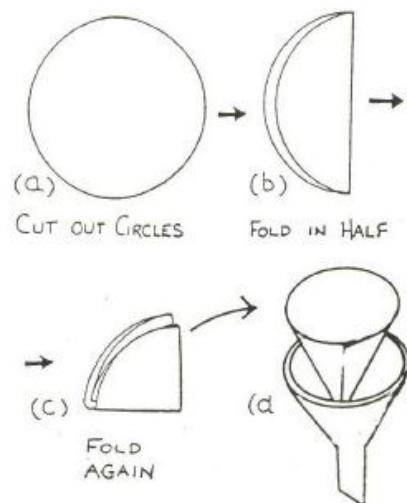
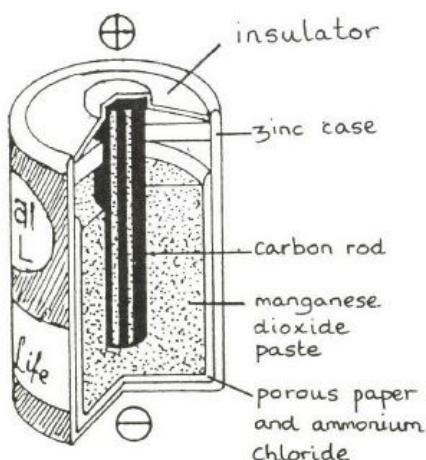
**Procedure:** Gently smash an old battery (D size) with a rock and pull out the electrode with pliers. DO NOT do this with alkaline batteries (most AA size) as they contain caustic liquids.

### A.12.2 Zinc

**Materials:** New dry cell batteries

**Procedure:** Carefully open up a NEW dry cell

(D size) battery by peeling back the steel shell and slicing the plastic inside. You should find a cylindrical shell of zinc metal. Empty out the black powder inside (manganese dioxide mixed with zinc chloride and ammonium chloride; wash your hands after) and keep the graphite electrode for another day. The zinc shell should then be cut into strips, scraped clean, and boiled in water or washed with soap to remove any residual chemicals that might affect your experiment.



### A.12.3 Iron

**Materials:** Ungalvanized nails from a hardware store

### A.12.4 Copper

**Materials:** Thick wire stripped of its insulation, also from a hardware store. Note that copper earthing rods have only a thin surface layer of copper these days.

### A.13 Filter Paper

**Use:** Filtration, separating mixtures, solutions

**Materials:** Cement bag paper, toilet paper, cloth

### A.14 Flasks

**Use:** Titrations, mixing solutions

**Materials:** Clean used liquor bottles, small water bottles

**Procedure:** When using these flasks for titrations, students must practice swirling enough that the solution remains well mixed.

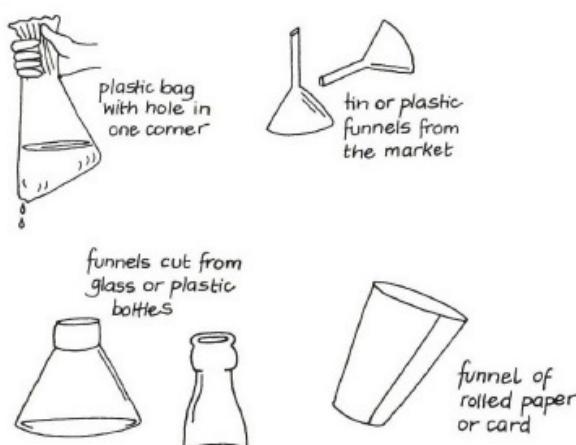
**Safety:** When heating glass liquor bottles, make sure the cap is off.

### A.15 Funnel

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

**Materials:** Empty water bottles, knife

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



## A.16 Gloves

### A.16.1 Latex gloves

**Use:** First aid, when one has open cuts on hands, handling specimens. They are worthless to the chemist because they make the hands less agile and give the user a false sense of security.

**Safety:** Concentrated acids and organic chemicals burn straight through latex.

### A.16.2 Thick gloves

**Use:** For working with organic solvents. Remember that the most dangerous organic solvents (benzene, carbon tetrachloride) should never be used in a school, with or without gloves.

**Materials:** Thick rubber gloves from village industry supply companies and some hardware stores

**Safety:** In general, avoid using chemicals that would make you want to wear gloves.

## A.17 Goggles

**Use:** Handling concentrated acids

**Materials:** 1.5 L plastic water bottles, cardboard, sunglasses

**Procedure:** Cut a strip of plastic from a water bottle. Attach around your head with string or by using stiff cardboard as a frame. Goggles do not need to be impact resistant – they just need to stand between hazardous chemicals and your eyes.



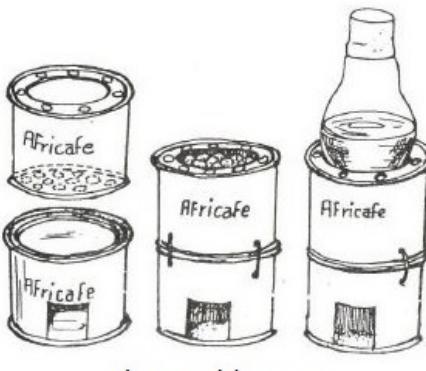
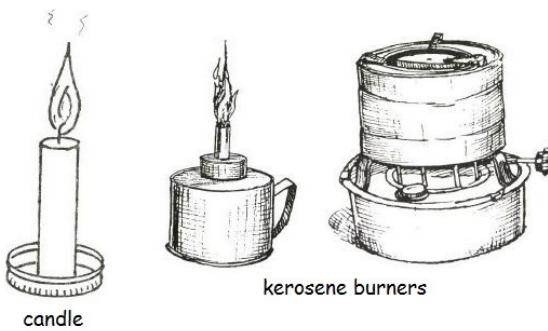
## A.18 Heat Sources

**Use:** Heating substances

**Materials:** Candles, kerosene stoves, charcoal burners, Motopoa (alcohol infused heavy oil), butane lighters, spirit burners, metal can, bottle caps Motopoa provides the best compromise heat source - it is the easiest to use and safest heat source with locally available burners.

**Procedure:** Cut a metal can in half or use a bottle cap and add a small amount of Motopoa.

**Safety:** Always have available fire-fighting equipment that you know how to use. Remember that to put out a Bunsen burner safely, you need to turn off the gas.



charcoal burner



spirit burner

### A.18.1 Heating Solutions

The ideal heat source has a high heat rate (Joules transferred per second), little smoke, and cheap fuel, i.e. Motopoa. A charcoal stove satisfies all of these but takes time to light and requires relatively frequent re-fueling. Kerosene stoves have excellent heat rates but are smoky.

### A.18.2 Heating Solids

The ideal heat source has a high temperature and no smoke, i.e. a Bunsen burner. For heating small objects for a short time (no more than 10-20 seconds), a butane lighter provides a very high temperature. Motopoa will provide a flame of satisfactory temperature for as long as necessary.

### A.18.3 Flame Tests

The ideal heat source has a high temperature and produces a non-luminous flame, i.e. a Bunsen burner. Motopoa is next best hot and non-luminous. Spirit burners produce a non-luminous flame at much greater cost, unless methylated spirits are used as fuel in which case the flame is much cooler. A butane lighter produces a very hot flame of sufficient size and time for flame tests although the non-luminous region is small. Kerosene stoves will work for some salts.

### A.19 Indicator

**Use:** Determine presence of acid or base, determine pH

**Materials:** Rosella leaves, hot water, bottle

**Procedure:** Place some coloured leaves into a bottle of warm water to extract the colour. Use a straw to drop onto solutions or prepare indicator paper by dipping thin strips into the coloured solution. Rosella turns red for acids and greenish blue for bases.



### A.20 Iron Filings

**Use:** To map magnetic fields

**Materials:** Steel wool / Iron wool used for cleaning pots

**Procedure:** Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

### A.21 Masses

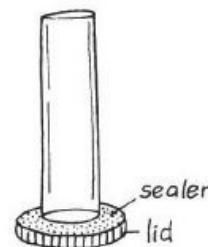
See [Weights](#) (p. 58).

### A.22 Measuring Cylinder

**Use:** Measuring volume

**Materials:** Plastic bottles of different sizes, syringes (10 mL - 50 mL), fluorescent light tubes, marker pen, ruler, bucket of water

**Procedure:** Using the syringe, transfer a known volume of water from the bucket to the empty bottle. Use the marker pen to mark the level of water on the bottle. Repeat for a range of volumes, using a ruler to complete the scale.



### A.23 Metre Rule

**Use:** Measuring length

**Materials:** Slabs of wood, ceiling board, permanent pen

**Procedure:** Buy one, take it and a permanent pen to a carpenter, and leave with twenty. Measure each new one to the original rule to prevent compounding errors.

### A.24 Microscope

See [Low Tech Microscopy](#) (p. 60).

### A.25 Mortar and Pestle

**Use:** To powder chemicals

**Materials:** 2 metal spoons, glass bottle

**Procedure:** Place chemicals between two nested metal spoons and grind down. Alternatively, crush chemicals on a sheet of paper by pressing on them with the bottom of a glass bottle.



### A.26 Optical Pins

**Use:** Compass needles, making holes, dissection, mirror practicals

**Materials:** Office pins, sewing needles, needles from syringes

## A.27 Pipettes

**Use:** Transferring small amounts of liquid  
**Materials:** Disposable plastic syringes (1, 2, 5, 10, 20, 25, 30 and 50 mL sizes)  
**Procedure:** Suck first 1 mL of air and then put the syringe into the solution to suck up the liquid. There should be a flat meniscus under the layer of air.  
**Safety:** Avoid standard pipettes to eliminate danger of mouth pipetting.



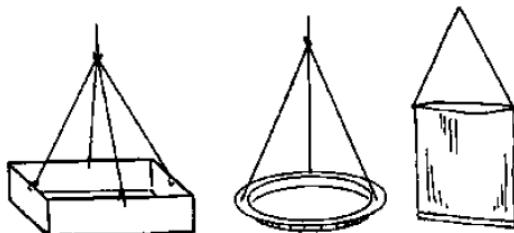
## A.28 Retort Stand

**Use:** To hold springs, burettes, pendulums or other objects  
**Materials:** Filled 1.5 L water bottle, straight bamboo stick, tape, marker  
**Procedure:** Tape the bamboo stick across the top of the water bottle so that it reaches out 20 cm to one side. Attach a small clamp if required or hang the object directly from the bamboo stick.

Alternatively, place a 1 cm piece of reinforcing rod in a paint can full of wet cement and let it dry. Then attach a boss head and clamp.

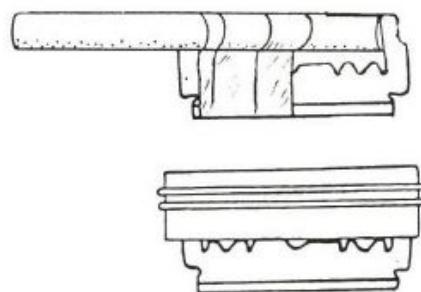
## A.29 Scale Pans

**Use:** Beam balance  
**Materials:** Plastic bottle, cardboard box, string  
**Procedure:** Cut off the bottom of a plastic bottle or cardboard box. Poke 3 or more holes near the top and tie string through each hole. Join strings and tie at the top to hang from a single point.



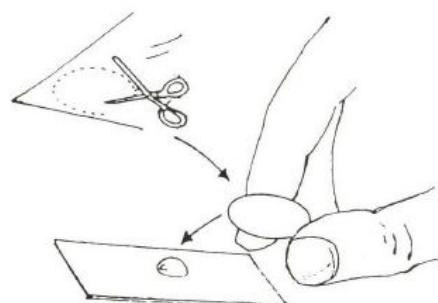
## A.30 Scalpels

**Use:** Dissection  
**Materials:** Razor blades, tongue depressors, super glue  
**Procedure:** Add a handle by gluing a tongue depressor on either side of the razor blade. Hold together with a rubber band until dry.  
**Safety:** Dull blades should be discarded. Because students need to apply more pressure when using them, there is a greater risk of slipping and thus of cuts. Sharp tools are much safer.



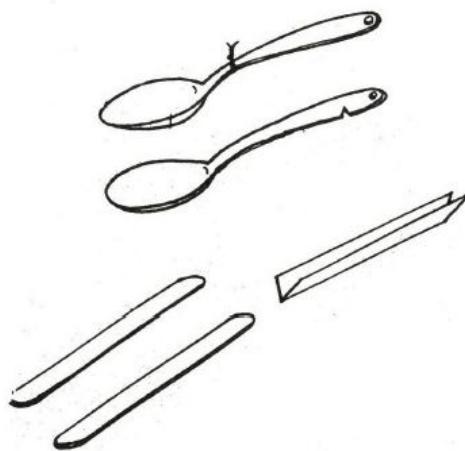
## A.31 Slides and Cover Slips

**Use:** Microscopy  
**Materials:** Small pieces of glass, stiff plastic  
**Procedure:** Small piece of glass provides a slide for mounting the specimen. Cover slips can be made from thin (but stiff) transparent plastic from display packing or bottles. Cut into small squares or circles.



## A.32 Spatula

**Use:** Transferring salts  
**Materials:** Stainless steel spoons  
**Procedure:** Use the handle end to remove salts from containers.  
**Safety:** Clean all metal tools promptly after using with hydroxide, potassium manganate (VII), or manganese (IV) oxide. If the spoon corrodes, scrape with another spoon or steel wool.



### A.33 Stoppers

**Use:** To cover the mouth of a bottle, hold a capillary tube

**Materials:** Rubber from old tires or sandals, cork, plastic bottle cap, pen tube, super glue

**Procedure:** Cut a circular piece of rubber. If the stopper is being used to hold a capillary tube, a hole can be melted in a plastic cap or rubber stopper. Alternatively, super glue a pen tube to a plastic bottle cap and connect to rubber tubing.



### A.34 Stopwatches

**Use:** Simple pendulum, velocity, acceleration

**Materials:** Athletic and laboratory stopwatches from markets, digital wristwatches

### A.35 Test Tubes

#### A.35.1 Plastic Test Tubes

**Use:** To heat materials without a direct flame, to combine solutions

**Materials:** 10 mL syringes, matches

**Procedure:** Remove the needle and plunger from 10 mL syringes. Heat the end of the shell with a

match until it melts. Press the molten end against a flat surface (like the end of the plunger) to fuse it closed. If the tube leaks, fuse it again. Test tubes made this way may be heated in a water bath up to boiling, hot enough for most experiments.



#### A.35.2 For Thermal Decomposition

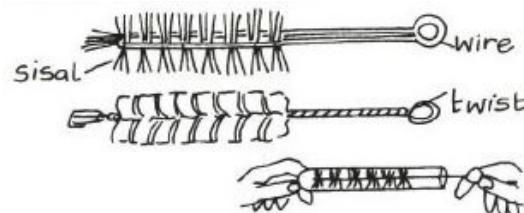
See [Deflagrating Spoon](#) (p. 52).

### A.36 Test Tube Brush

**Use:** Cleaning test tubes

**Materials:** Sisal, wire

**Procedure:** Twist the wire around the sisal as shown or put a little sand in the test tube as an abrasive.

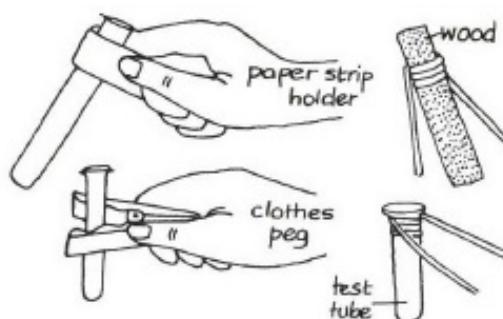


### A.37 Test Tube Holder / Tongs

**Use:** To handle test tubes

**Materials:** Wooden clothespins, stiff wire, strip of paper or cloth

**Procedure:** Use clothespins or stiff wire for prolonged heating, or strips of paper or cloth for short-term heating.

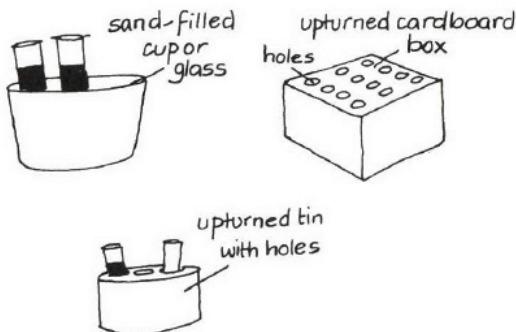


### A.38 Test Tube Racks

**Use:** To hold test tubes vertically in place

**Materials:** Wire grid from local gardening store, styrofoam block, plastic bottle, sand, knife

**Procedure:** Fold a sheet of wire grid to make a table; punch holes in a piece of styrofoam; cut a plastic bottle in half and fill it with sand to increase stability. Or cut a plastic bottle along its vertical axis and rest the two cut edges on a flat surface. Cut holes into it for the test tubes.

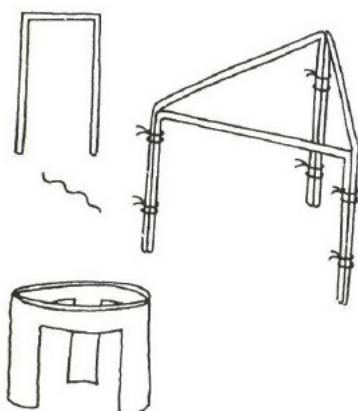


### A.39 Tripod Stands

**Use:** For supporting containers above heat sources, for elevating items

**Materials:** Stiff wire, metal rods, tin can

**Procedure:** Join bent pieces of thick wire together. Or cut the sides of a tin can to leave 3 legs.



### A.40 Volumetric “Glass”ware

See [Containers](#) (p. 51).

### A.41 Wash Bottle

**Use:** Washing hands after experiments

**Materials:** Water bottle, detergent, needle

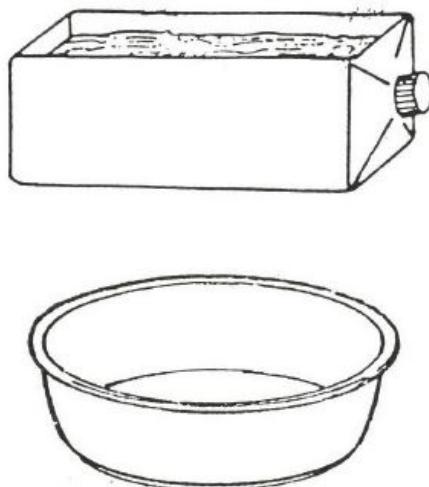
**Procedure:** Put a hole in the cap of a water bottle using a syringe needle.

### A.42 Water Bath

**Use:** To heat substances without using a direct flame

**Materials:** [Heat Sources](#), water, cooking pot

**Procedure:** Bring water to a boil in a small aluminum pot, then place the test tubes in the water to heat the substance inside the test tube. Prevent test tubes from falling over by clamping with clothespins or placing parallel wires across the container.



### A.43 Weights

#### A.43.1 Crude Weights

**Use:** Concept of units, mass, weight

**Materials:** Batteries, coins, glass marbles from town, etc.

**Procedure:** Use objects of unknown mass to create new units and impart the concept of unit measure.

#### A.43.2 Adding Weight in Known Intervals

**Use:** Hooke's Law practical

**Materials:** Water bottles, syringe

**Procedure:** Consider “zero added mass” the displacement of the pan with an empty water bottle. Then add masses of water in g equal to their volumes in mL (e.g. 50 mL = 50 g).

#### A.43.3 Precise Weights

**Materials:** Plastic bags, sand, stones, 250 mL water bottles (all identical), tape, pen

**Procedure:** Use a beam balance and known masses at a market or nearby school to measure exact masses of bags of sand or stones. Use a marker pen to mark the masses on the bags.

If using water, use a beam balance from a nearby school to measure the exact mass of an

empty water bottle. Add a volume of water in mL equal to the mass in g needed to reach a desired total mass. (The density of water is 1.0 g/mL.) This can be done precisely by using a plastic syringe. Label the bottle with tape and a pen.

#### A.44 White Tiles

**Use:** Titration

**Materials:** White paper

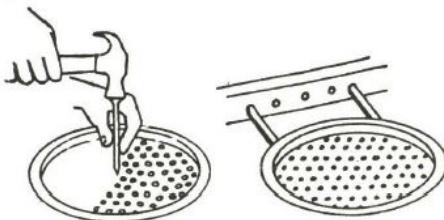
**Procedure:** If students are using syringes as burettes, they can also hold their flask up against a white wall.

#### A.45 Wire Gauze

**Use:** Placing objects over heat

**Materials:** Tin can lid

**Procedure:** Poke holes in a tin can lid.



# Low Tech Microscopy

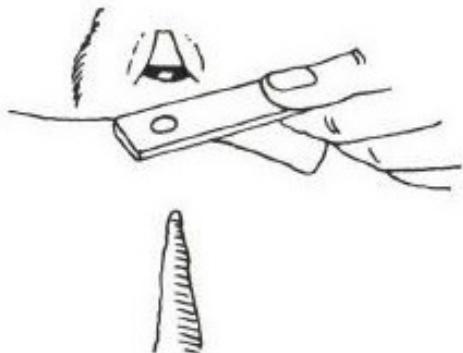
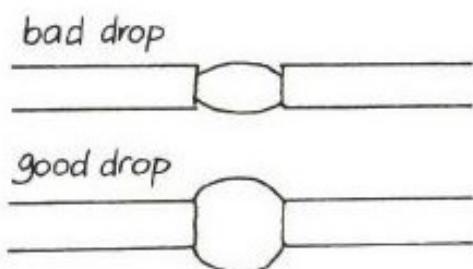
Microscopes are powerful tools for teaching biology, and many of their benefits are hard to replace with local fabrications. However, simple materials can be used to achieve sufficient magnification to greatly expand students' understanding of the very small. They may view up close the anatomy of insects and even see cells.

## B.1 Water as a lens

Water refracts light much the way glass does; a water drop with perfect curvature can make a powerful lens. A simple magnifier can be made by twisting a piece of wire around a nail and dipping the loop briefly into some water. Students can observe the optical properties of the trapped drop of water.

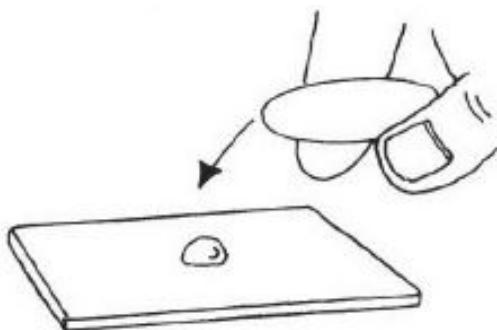
## B.2 Perfect circles

Better imaging can be had if the drop is more perfect in shape – the asymmetry of the wire twisting distorts the image. Search for a piece of thin but stiff plastic – water bottles work well. Cut a small piece of this plastic, perhaps  $1 \times 2$  centimeters. Near one end, make a hole, the more perfect the better. The best hole-cutting tool is a paper hole punch, available in many schools. With care, fine scissors or a pen knife will suffice; remove all burrs.



## B.3 Slides

A slide and even cover slip may be made from the same plastic water bottles, although being hydrophobic they will not have the same properties of glass when making wet mounts. Improvise a method for securing the punctured plastic over the slide; ideally the vertical spacing can be closely adjusted to focus.



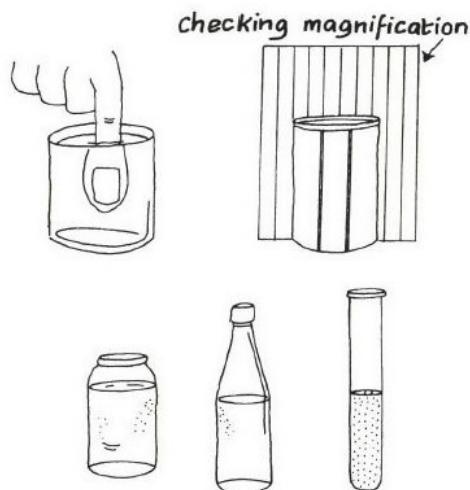
## B.4 Backlighting

On a bright day, there may not be any need for additional lighting, but in most classrooms the image will be too dim to be easily seen. The sun is a powerful light source, though not always convenient. Flashlights are generally inexpensive and available; many cell phones have one built in the end. To angle the light into the slide, find either a piece of mirror glass, wrinkle-free aluminum foil, the metalized side of a biscuit wrapper, etc.

Experiment with a variety of designs to see what works best given the materials available to your school. If you use a slide of onion cells stained with iodine solution, your students should be able to see cell walls and nuclei.

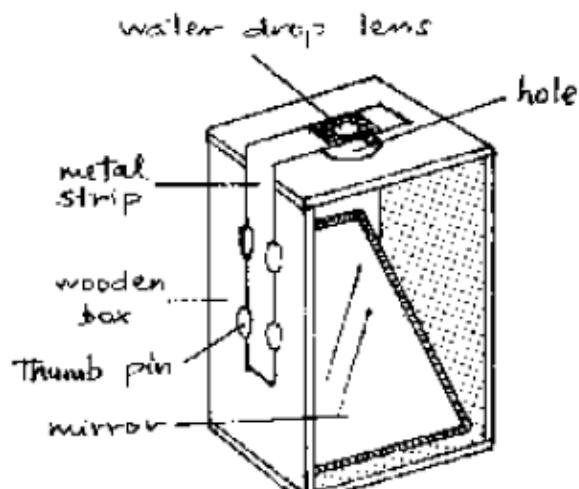
## B.5 Simple Microscopes and Magnifiers

### B.5.1 Clear-Container Magnifiers



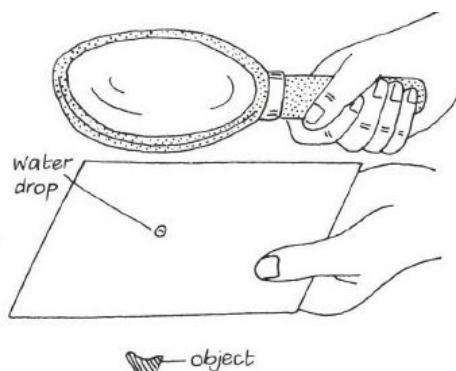
Any of these containers filled with water will make good magnifiers.

### B.5.2 Simple Microscope



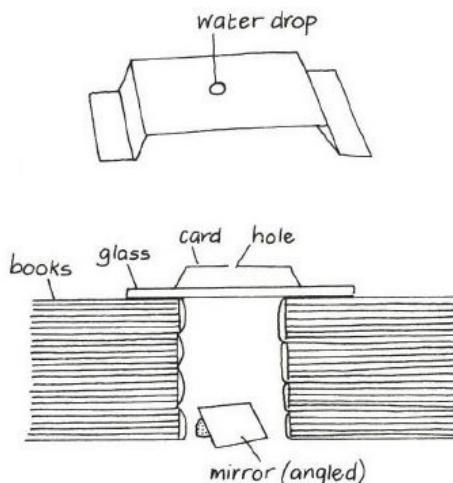
Construct a small wooden box from plywood as shown (or use a small cardboard carton such as a light bulb box). Make a round hole of 2 cm diameter, at the top. Fit a small mirror (glass or polished metal) in the box, angled to reflect light up through the hole. Make a small hole (about 6 mm) in a strip of metal. Remove the round top from a pen-torch bulb and secure it in the strip using adhesive tape. Carefully cut off the tape where it may cover the lens. Bend the strip, then fix it to the side of the box, so that it can be moved up and down. Drawing pins or nails could be used for this. The object is focused by moving this strip. Note the eye should be placed as near as possible to the lens when viewing.

### B.5.3 Simple Compound Microscope



- Using 2 lenses together allows much greater magnification.
- Use a hand lens to make a water drop into a more powerful magnifier.
- Try using a hand lens with a lens from a torch bulb to make another simple compound microscope.

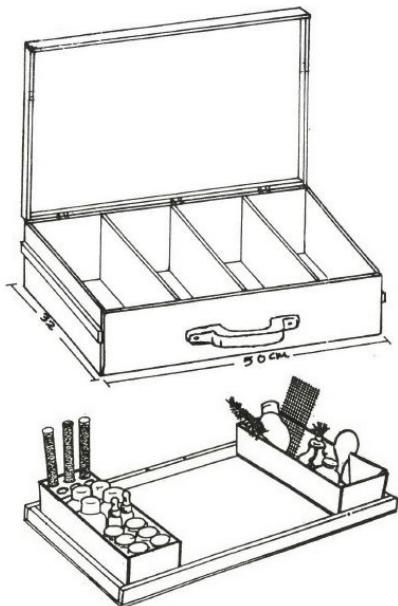
### B.5.4 Card Bridge Microscope



- Place a water drop in the card 'bridge'.
- Place this on a sheet of glass as shown.
- Place the object you are looking at on the glass. This arrangement is most suitable for thin items, e.g. sections of leaves.
- Experiment with the angle of the mirror so that light shines up through the specimen.
- Use this arrangement with a hand lens to produce a compound microscope.

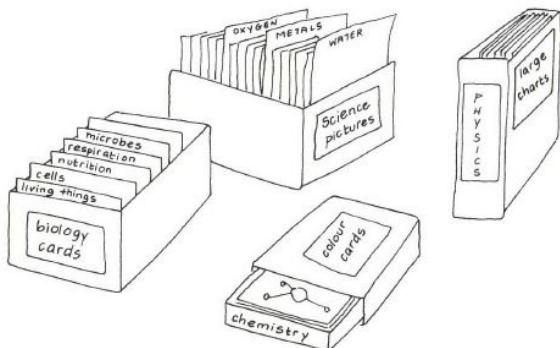
# Storage of Materials

## C.1 The Science Box



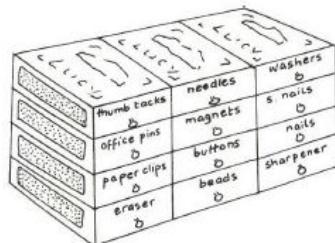
- Use a metal storage trunk to organize all of your new, locally-made science equipment.
- Metal or cardboard sheets can be used as dividers. Tape firmly in place.
- Use the lid as a science tray for safely and easily moving liquids and chemicals.

## C.2 Card and Picture Boxes



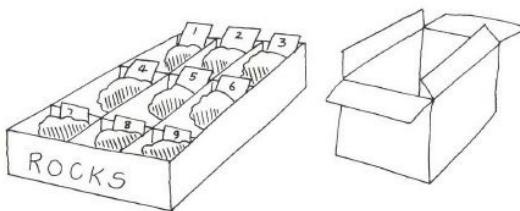
- Cards and pictures can be stored in all sorts of boxes. Store according to syllabus topic or alphabetically.
- Dividers and compartments can be made from cardboard.

## C.3 Matchbox Drawers



- Drawers to store small items can be made from matchboxes glued together as shown.
- Small pieces of string, wire or buttons can be used as handles.

## C.4 Dividing Boxes



- Cut down the sides of boxes for displays.
- Samples can be sorted, then displayed or stored in cardboard boxes as shown.
- The flaps from the top of the box may be cut off and used as dividers for the same box.

## C.5 Envelopes and Bags



- Envelopes and bags of different sizes can be used for storage. Clearly label all containers.

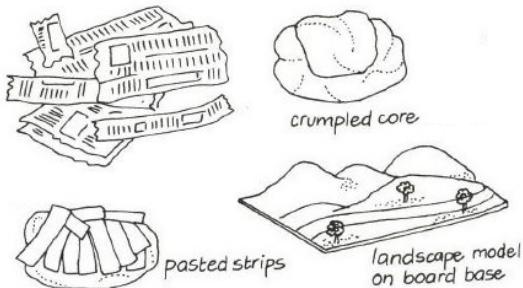
# Pastes and Modeling Materials

## D.1 Papier Mâché



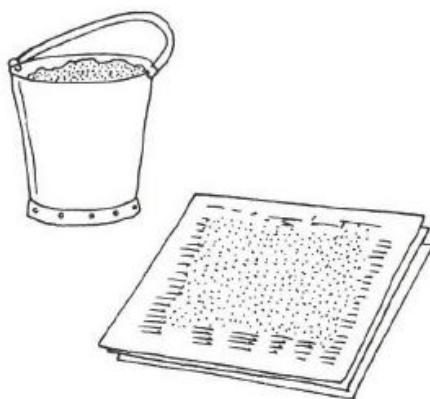
- Soak pieces of paper or card in water for half a day.
- Mash, grind, stir or pound the mix to a smooth fine pulp.
- Squeeze or press out excess water.
- Mix in a little flour paste and work the material into a sticky modeling consistency.

## D.2 Papier Mâché Layering



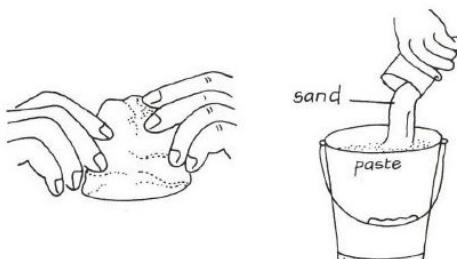
- Soak small pieces, or narrow strips, of newspaper in paste.
- Use crumpled newspaper as a core or skeleton for the model.
- Build up the model in layers of strips and pieces.
- After drying, sandpaper smooth and paint or varnish.

## D.3 Modeling Clay



- Dig out or collect your clay. Seek local advice on where to find suitable deposits.
- Add water and stir to a creamy consistency.
- Filter through cloth or a sieve.
- Allow the filtered material to settle.
- Decant excess water.
- Dry the filtered material on newspaper until it becomes a powder.
- Mix in glycerine to give a plastic texture.
- Knead well and add Vaseline to soften if necessary.
- Adding paste (see page 118) to the clay helps stop it cracking as it dries.

## D.4 Paste and Sand Cement



- Mix evenly together dry sand and flour paste or commercial glue.
- The wet cement moulds very easily and dries hard.

## D.5 Flour Paste



- Sift flour to remove lumps. Maize, wheat and cassava flours are all suitable.
- Mix the flour with water a little at a time to avoid lumps. It should be the consistency of thin cream.
- Cook the mixture gently until it thickens. Keep stirring to ensure the paste remains smooth and of even texture.
- Allow the paste to cool.
- Add insecticide to the paste if needed.
- Store in a clearly labeled container with a good lid, preferably in a cool place.
- Cold method paste is made by simply stirring sifted flour into water.

## D.6 Casein Glue



- Mix milk with vinegar or lemon juice. Add just enough vinegar or lemon juice to curdle the milk. The amounts will vary according to the type of milk used.
- Heat while stirring continuously. Soft lumps will form.
- Strain out the lumps using a cloth.
- Add a teaspoon of sodium hydrogen carbonate (bicarbonate of soda) to the lumps and mix with a little water to produce casein glue.

# Making Biology Solutions

Activities in the topics of Nutrition and Respiration require specific analytical solutions. In this section you will find materials 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.

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.

Note: 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 CO<sub>2</sub>

Result: This liquid will change from clear to cloudy if CO<sub>2</sub> 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<sub>4</sub> crystals in 1/2 litre of water. Dissolve the CuSO<sub>4</sub> 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<sub>4</sub> 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.

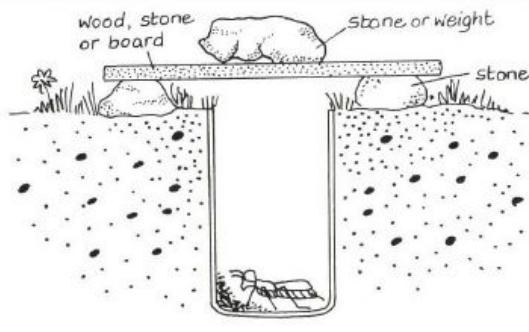
Local manufacture: Burn dry grass and collect the ash. Dissolve 3 spoonfuls of ash into a litre of water. Stir the solution and let it settle. Decant the solution, then place the solution in a labelled reagent bottle.

Note: Local manufacture is not very practical because it will make a very dilute solution. This can be performed just to demonstrate the nature of ashes. It is best to buy industrial caustic soda.

# Collecting Specimens

## F.1 Methods of Collecting and Displaying

### F.1.1 Pitfall Traps



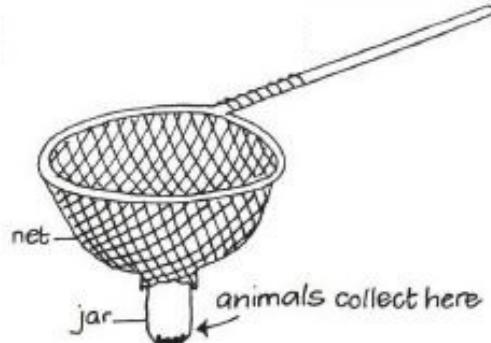
- Make a few holes in the bottom of a tin to let water escape.
- Bury the tin up to its rim in the soil.
- Cover the tin to keep out rain.
- Try out different types of food as bait.
- Check the trap regularly and remove it when finished with!

### F.1.2 Worm Jar



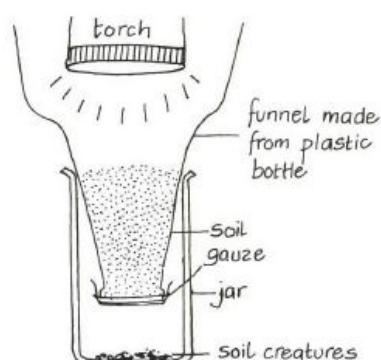
- Fill a plastic or glass vessel with soil and add the worms.
- Wrap black or dark paper around the jar to keep light away from the burrowing worms.
- Remove the paper to reveal the burrows.
- Make sure the soil is kept moist and never dries out.

### F.1.3 Collecting Nets



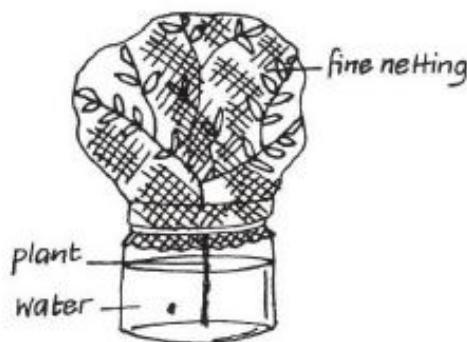
- Collecting nets can be made easily from sticks, some wire and mosquito netting.
- For collecting small water creatures use a fine net with a small jar attached to the blind end as shown.
- River nets can be used to catch small animals disturbed from stones and mud by a stick.

### F.1.4 Soil Life



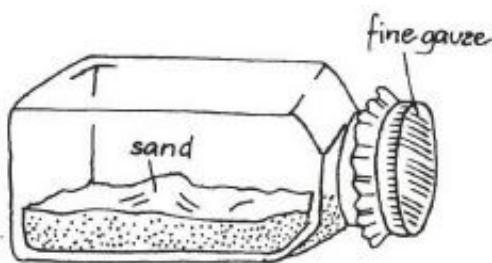
- Collect a sample of soil and place it in a funnel with a piece of gauze across its neck.
- Shine a bright light down onto the soil.
- Soil organisms usually prefer dark, damp and cool conditions so the heat and light drives them downwards until they drop into the collecting jar.
- Return organisms to the soil after examination, as many may dehydrate and die.

### F.1.5 Flying Insect Cage



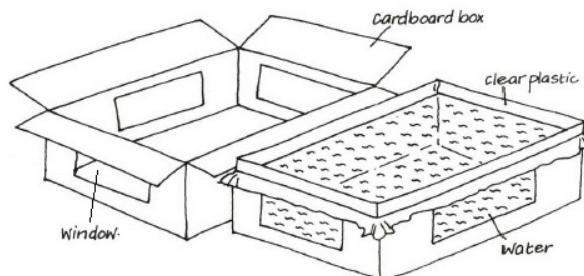
- Insects can be kept in many types of cage.
- Mosquitoes and other insects benefit from having water, vegetation and room to fly. The cage shown provides all these.

### F.1.6 Reptile Cage



- What would you need to add to this jar to make it suitable for keeping and observing lizards or other reptiles?

### F.1.7 Aquarium Box



- Cut viewing windows in the sides of a box.
- Line the box with a large sheet of transparent plastic and fill it with water.
- Attach the plastic firmly, making sure it does not slip down from around the rim of the box.

### F.1.8 Caring for Animals



- Always treat animals with care.
- Some animals are dangerous, some scare easily.
- After study return animals to the place you found them.

## F.2 O-Level Biology Specimens

When teaching Classification, we will need a variety of organisms that may not always be available. Below is information about each Kingdom, Phylum, and Class on the O-level syllabus and how to collect, preserve, kill, and dissect examples in each.

### F.2.1 Kingdom Fungi

The following are features of Kingdom Fungi:

1. They have no roots, stems, or leaves.
2. They lack chlorophyll, are non-photosynthetic and have to get their own food by feeding on dead plants or animals. (Notice the lack of green colour, because of lack of chlorophyll).
3. Most fungi have cell walls made of chitin, which is a polysaccharide.
4. Their body is made of a network of small, tube-like filaments called hyphae.
5. Fungi store carbohydrates as glycogen.
6. Fungi reproduce asexually by small structures called spores.

There are 3 major phyla in Kingdom Fungi. These are Phylum Basidiomycota, Zygomycota, and Ascomycota.

#### F.2.1.1 Phylum Basidiomycota

##### Mushrooms and Toadstools (Uyoga)

Basidiomycota is the most common division of the Fungi Kingdom. Mushrooms and toadstools are in this division. The part of the mushroom that grows above the ground is the reproductive body and is divided into a stem, cap, and gills. Spores are released from the gills and are dispersed by wind.

**Collection** Mushrooms should be collected during the rainy season. Mushrooms can be found on dead and decaying materials like logs in the forest. Mushrooms may also be purchased in supermarkets.

**Preservation** Dry mushrooms in sunlight or preserve them in alcohol (a clear methylated spirit that is 70 % alcohol and 30 % water).

**Dissection** For the dissection of a mushroom, remove the cup of the mushroom and observe the gills. Cut the stem vertically with a razor blade and observe the inside.

#### F.2.1.2 Phylum Zygomycota

##### Bread Mould and Mucor (Ukungu wa mkate, ukungu wa muhogo)

Zygomycota grows on rotting material and looks like small white thread. An example of Zygomycota is bread mould or mucor.

**Collection** Bread mould may be cultured by exposing some slices of bread to moisture. If you live in a dry area, add a few drops of water to the bread and close in a clear bag. For mucor culture from fruits like tomatoes, keep in warm and moist conditions. In dry areas, enclose in clear bags.

#### F.2.1.3 Phylum Ascomycota

##### Yeast (Hamira)

Ascomycota are single-celled organisms called yeast that grow on the surface of rotting fruit and reproduce by budding. Yeast is used to bake bread and create alcohol.

**Collection** Yeast can be purchased at any shop.

**Preservation** Keep yeast in an air-tight container.

## F.2.2 Kingdom Plantae

Organisms in Kingdom Plantae are eukaryotic. Kingdom Plantae is very large and contains many plants. Although organisms in this group look very different, they all get their nutrition from a process called photosynthesis. Photosynthesis is a way to manufacture food from simple materials with the help of the sun. The following are features of Kingdom Plantae:

1. In all plants, the cell walls are made up of cellulose.
2. They demonstrate autotrophic nutrition – they manufacture their own food through photosynthesis.
3. They have chlorophyll.
4. They are multicellular and the plant body is separated into tissues, organs, and systems.

There are 4 major divisions in Kingdom plantae. These are Division Bryophyta, Filicinophyta, Coniferophyta, and Angiospermophyta.

### F.2.2.1 Division Bryophyta

#### Mosses and Liverworts

Bryophyta are mosses and liverworts. They live on the land, but can only grow in wet places because they have no way to carry water. They also need water to reproduce.

These are the features of Division Bryophyta:

1. They have no true roots, stems, or leaves.
2. They have no vascular tissue.
3. They reproduce by using spores.

**Collection** In dry places, moss should be collected during the rainy season. Moss and liverwort can be found on rocks or trees in moist climates or in rocky riverbanks.

**Preservation** Once moss or liverwort has been collected, it can be kept for several days on a rock placed in a container with water.

### F.2.2.2 Division Filicinophyta

#### Ferns

Division Filicinophyta are ferns. Ferns grow in moist, shady environments like ground beds of forests.

The following are the features of Division Filicinophyta:

1. They have true roots, stems, and leaves.
2. They have vascular tissue (xylem and phloem).
3. The leaves make sori which will later produce spores so the fern can reproduce.
4. The leaves are called fronds.
5. They grow in damp and shady places.

**Collection** Ferns can be found in shady and humid environments, usually in forests.

**Preservation** Ferns can be dried inside a book for future use. Place a fern between two pieces of paper and then place them into a book. Add more weight on top of the book and wait a few weeks. These specimens will be very delicate but will last a long time.

### F.2.2.3 Division Coniferophyta

#### Pine Trees (Mivinje)

Coniferophyta is a division of Kingdom Plantae. Coniferophyta are cone bearing plants with needle-shaped leaves. The male cones are smaller and produce a yellow powder called pollen. The female cones are larger and have small seed-like structures called ovules.

The following are the features of Division Coniferophyta:

1. They are mostly shrubs and trees with needle shaped leaves.
2. Their reproductive structures are cones.
3. The ovule are not enclosed inside an ovary wall.
4. The majority are evergreens, which means they keep their leaves all year round.

**Collection** Coniferophyta can be found in cooler, higher climates like Mbeya, Iringa, and Lushoto. Choose a branch that includes both needle shaped leaves and a cone.

**Preservation** Coniferophyta can be dried in the sun and stored in a dry place for future use.

#### F.2.2.4 Division Angiospermophyta

##### Flowering Plants (*mimosa itoayo maua*)

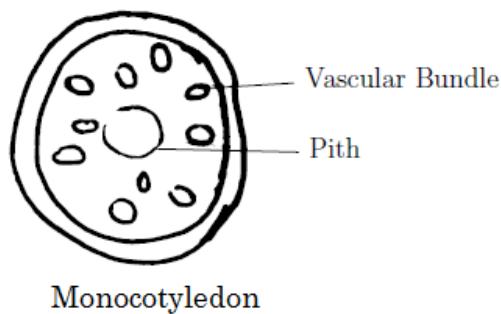
Division Angiospermophyta consists of all flowering plants.

The following are the features of Division Angiospermophyta:

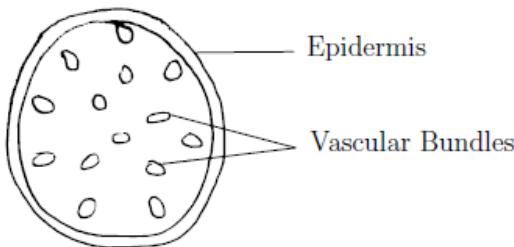
1. Their reproductive structures are flowers.
2. Ovules are enclosed in an ovary and seeds are enclosed in a fruit.

Division Angiospermophyta can be divided into two classes; Monocotyledons and Dicotyledons.

**F.2.2.4.1 Monocotyledons** Monocotyledon seeds have only one cotyledon. Monocots have a fibrous root system, leaves with parallel venation, three part floral systems, and vascular bundles which are scattered. Examples of monocotyledons are maize and grasses.



Monocotyledon



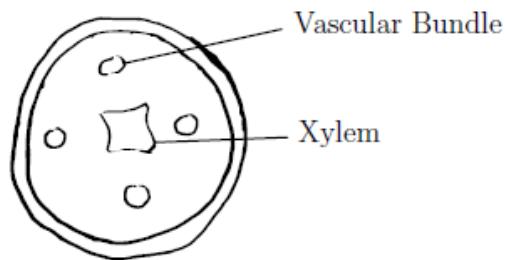
Monocotyledon Stem

**F.2.2.4.2 Dicotyledons** Dicotyledons seeds have two cotyledons. They also have a tap root system, leaves with net-like veins, floral parts in four or fives, and vascular bundles which form a ring in the stem. Examples of dicotyledons are mangoes, cashews, beans, and okra.

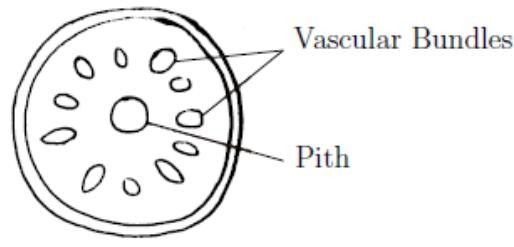
**Collection** Angiosperms are easily found in your surrounding environment. Monocotyledons are organisms like maize plants and grasses. Dicotyledons are organisms like mango trees, cashew nut trees, and okra.

**Preservation** Flowers and leaves can be dried in a book. Place the flower or leaf between two sheets of paper and then press these in the centre of a book. Place the book in a safe place and add more books on top. Leave for a few weeks and then remove.

**Dissection** Hibiscus flowers can be easily dissected using a razor blade to identify the reproductive parts.



Dicotyledon Root



Dicotyledon Stem

### F.2.3 Kingdom Animalia

Organisms in Kingdom Animalia are eukaryotic. There are many organisms and phyla in Kingdom Animalia. However, for practical purposes, students will only study Phylum Platyhelminthes, Annelida, Nematoda, Arthropoda, and Chordata.

The following are the features of Kingdom Animalia:

1. Animals are multicellular.
2. Animals are differentiated into tissues.
3. Animals are heterotrophic feeders.
4. Animals are capable of locomotion.
5. Animals have a nervous system (with the exception of sponges.)

#### F.2.3.1 Phylum Platyhelminthes

##### Flatworms

Phylum Platyhelminthes defining characteristic is that their bodies are dorso-ventrally flattened and most are parasitic and feed off other organisms.

This phylum is divided into three classes: Trematoda (Flukes), Cestoda (Tapeworms), and Turbellaria.

1. Class Trematoda or flukes (minyoo bapa) are parasitic. They are flat and use suckers to feed.
2. Class Cestoda or tapeworms (minyoo yenye pingili) are flat, tape-like and have segmented or divided bodies. They are parasitic and use suckers and hooks to feed. Tapeworms live in the human intestines and affect humans by absorbing partly digested food. They can cause disease as well as malnutrition.
3. Class Turbellaria are flat and have cilia which help them move.

**Collection** Flukes can be collected when a cow, pig, or sheep is slaughtered by examining the liver or intestines. There are some species of flatworm that can be found in shallow tide pools along the beach.

**Preservation** Organisms in Phylum Platyhelminthes can be kept in labelled air-tight containers with formaldehyde solution.

**Killing** Place the Platyhelminthes into a formaldehyde solution.

**Dissection** You can observe the unbranched gut of a Plathelminthes by making a lateral cut along the body and observing the internal structure of the organism.

#### F.2.3.2 Phylum Nematoda or Aschelminthes

##### Roundworms

Phylum Nematoda, also known as Aschelminthes, includes round parasitic worms that cause infections in humans.

The following are the features of the Phylum Nematoda

1. They have unsegmented, cylindrical bodies with pointed ends.
2. Their body is covered in a cuticle of protein.
3. They have an unbranched gut from mouth to anus.

**Collection** Roundworms can be found in the stomach of fish, in soil or stagnant water, or in the intestines of locally raised chicken.

**Preservation** Organisms in Phylum Nematoda can be kept in labelled air-tight containers with formaldehyde solution.

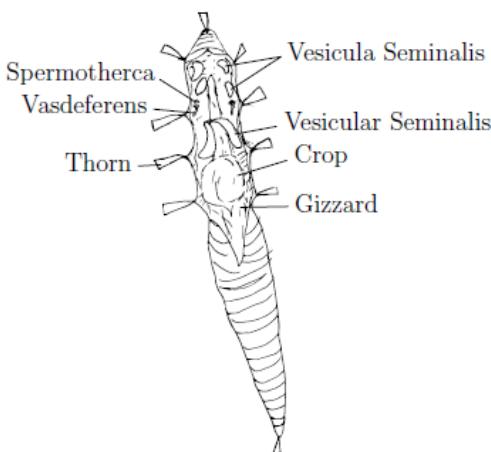
**Killing** Place the Nematoda into a formaldehyde solution.

**Dissection** You can observe the unbranched gut of a Nematoda by making a lateral cut along the body and observing the internal structure of the organism.

#### F.2.3.3 Phylum Annelida

##### Earthworms (Chambo) and Leeches (Ruba)

Phylum Annelida are eukaryotic organisms. Earthworms have a mouth at their anterior end and anus at the posterior end with a bulge called a clitellum in the middle that holds eggs. The earthworm uses bristles (small hair like structures) to burrow through the dirt.



The following are the features of the Phylum Annelida:

1. They are segmented. They have separate internal organs and body walls.
2. They have a thin, moist, non-chitinous cuticle.
3. Their body has external bristles.

**Collection** Earthworms can be found after a rain by digging under rocks or in other damp places. Leeches can be found in a river.

**Preservation** You can keep earthworms in a container with fresh soil to preserve live specimens. If killed, these organisms can be preserved in ethanol alcohol for a few months.

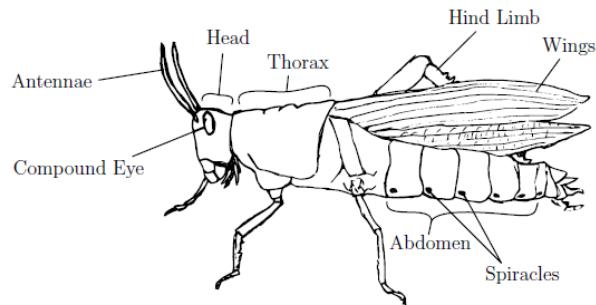
**Killing** Place the Annelida into a closed bottle in which is suspended a ball of cloth or mosquito net soaked in methylated spirits. Avoid direct contact with the spirit

**Dissection** You can observe the internal structures of an earthworm by making a lateral cut along the body.

#### F.2.3.4 Phylum Arthropoda

Organisms in this phylum have jointed appendages and an exoskeleton made of chitin. There are 5 classes in this phylum: Insecta, Crustacea, Arachnida, Diplopoda, and Chilopoda.

#### F.2.3.4.1 Class Insecta Beetles, Houseflies (Nzi), Grasshoppers (Panzi), Ants (Sisimizi), and Termites (Mchwa)



The following are the features of Class Insect:

1. Insects have a head, thorax, and abdomen.
2. They have one pair of antennae.
3. They have three pairs of jointed legs.
4. Most adult insects have wings.

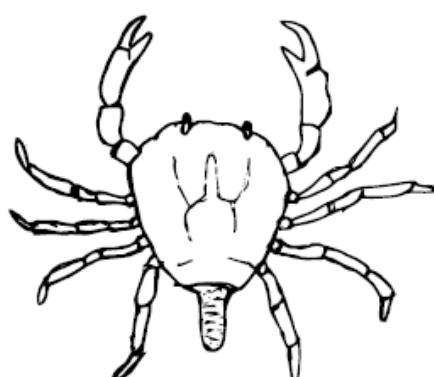
**Collection** Many insects can be caught in a field using a sweep net.

**Preservation** Live insects can be kept in a clear bottle and fed grass clippings. Dead insects can be preserved for a few months by placing them in methylated spirits.

**Killing** Seal in an airtight container until the insect suffocates.

**Dissection** First remove wings, antennae, and legs of the insect. Then cut down the sides of the insect to open the body cavity and observe the digestion and reproductive systems.

#### F.2.3.4.2 Class Crustacea Crabs (Kaa), Prawns (Kamba), and Lobsters (Kamba Kochi)



The following are the features of Class Crustacea:

1. Crustacea have bi-forked appendages.
2. They have 2 pairs of antennae.

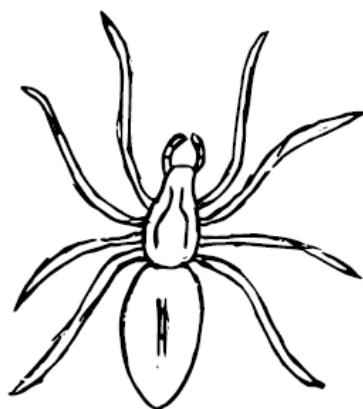
**Collection** Fresh water crabs, prawns, and shrimp can be found in most rivers, lakes, dams and swamps. Otherwise, they can be purchased in many markets.

**Preservation** Crustacea can be preserved in methylated spirits. Crustacea can also be dried for preservation purposes.

**Killing** Crustacea can be killed by being left in an airtight container or boiled in water.

**Dissection** For crabs, turn it so that its abdomen is facing up. Wedge a knife under the triangular abdomen and twist, so that the abdomen opens. Examine the internal organs.

#### F.2.3.4.3 Class Arachnida Spiders (Buibui) and Scorpions (Nge)



The following are the features of Class Arachnida:

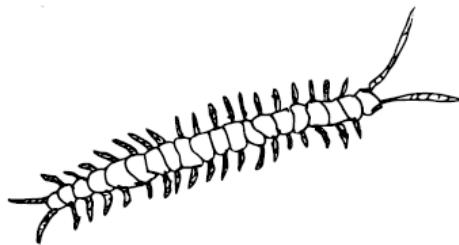
1. Arachnids have four pairs of jointed legs.
2. Arachnids have a cephalothorax (head and thorax) and abdomen.

**Collection** Spiders can be found in almost any environment. Scorpions can be found in dark, dry and cool areas, usually at night.

**Preservation** Arachnida can be dried or preserved in methylated spirits.

**Killing** To kill Arachnida, place them in an airtight container for a few days or use insecticide.

#### F.2.3.4.4 Class Chilopoda Centipedes (Tandu)



The following are the features of Class Chilopoda:

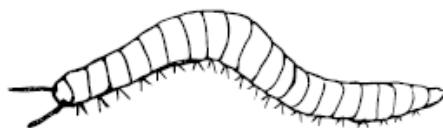
1. Chilopoda have long bodies consisting of many segments.
2. Each segment contains a pair of legs.

**Collection** Centipedes can be found under rocks, in tree bark, and in leaf litter.

**Preservation** Chilopoda can be dried or preserved in methylated spirits.

**Killing** To kill Chilopoda, place them in an airtight container for a few days or use insecticide.

#### F.2.3.4.5 Class Diplopoda Millipedes (Jongoo)



The following are the features of Class Diplopoda:

1. Diplopoda have long bodies consisting of many segments.
2. Each segment contains 2 pair of legs.

**Collection** Millipedes can be found under rocks, in tree bark, and in leaf litter.

**Preservation** Diplopoda can be dried or preserved in methylated spirits.

**Killing** To kill Diplopoda, place them in an airtight container for a few days or use insecticide.

### F.2.3.5 Phylum Chordata

Chordata are eukaryotic organisms that contain a backbone. These organisms have 4 distinct features:

1. They have a notochord in the embryonic stage. In most chordates this will be replaced with a vertebral column.
2. They have a nerve chord.
3. They have gill slits during the embryonic stage.
4. They have a tail which is behind the anus.

In this phylum, there are 6 classes: Chondrichthyes, Osteichthyes, Amphibia, Aves, Reptilia, and Mammalia.

#### F.2.3.5.1 Class Chondrichthyes

##### **Sharks (Papa), Skates (Taa), and Rays**

Chondrichthyes are also known as cartilaginous fish. Chondrichthyes include sharks, skates, and rays.



The features of Class Chondrichthyes are:

1. The skeleton is made of cartilage.
2. The body is covered with placoid scales.
3. The tail fin is asymmetrical.
4. The gill slits are visible.
5. The mouth and two nostrils are centrally placed.
6. They are cold blooded or ectothermic. This means their body temperature changes with the environment.

**Collection** Chondrichthyes can be found in most fish markets by the ocean.

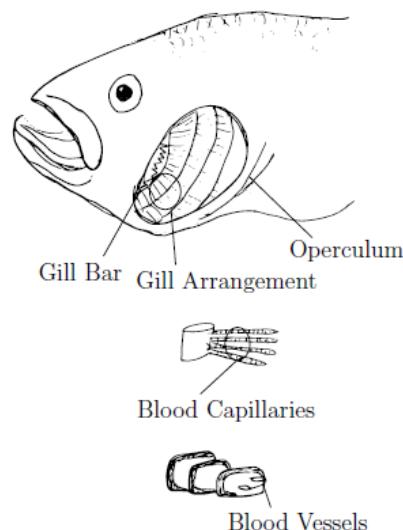
**Preservation** Chondrichthyes can be preserved in a formaldehyde solution.

**Killing** Chondrichthyes can be killed by removing them from water.

**Dissection** For sharks, make a lateral cut from the mouth down to the anus. Make another cut from the left pectoral fin to the right. Peel back the layer of skin and examine the internal organs. You can also examine the brain by shaving off thin layers from the top of the head until you reach the brain.

### F.2.3.5.2 Class Osteichthyes

##### **Tilapia (Sato) and small fish (Dagaa)**



Osteichthyes are also known as bony fish. The following are the characteristics of Class Osteichthyes:

1. The skeleton is made of bone.
2. The body is covered with scales.
3. The gills are covered by an operculum.
4. The tail fin is symmetrical.
5. Most have an air sac or swim bladder.
6. They are cold blooded or ectothermic. This means their body changes temperature with the environment.

**Collection** Osteichthyes can be found in both fresh water and the ocean. Fresh killed fish can also be purchased at the fish market.

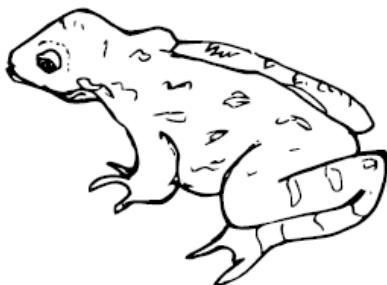
**Preservation** Osteichthyes can be preserved in a formaldehyde solution. Osteichthyes can also be dried and smoked. To smoke a fish, make a fire and put fish on a rack over the fire. Smoke the fish until it is dry. This takes from hours to days depending on the size of the fish.

**Killing** Osteichthyes can be killed by removing them from water.

**Dissection** Make a lateral cut from the mouth to the anus of the fish. Open the cut and observe the digestive system. Then, peel back the gill cover, operculum, and observe the structure of the gills.

#### F.2.3.5.3 Class Amphibia

**Frog (Chura wa majini), Toad (Chura wa nchi kavu), and Salamander (Boromondo au Tunutunu)**



The features of this class are:

1. They have to spend part of their life in water during the larva stage.
2. Their skin is always moist and without scales.
3. Their life cycle involves a form called a tadpole.
4. They are cold-blooded or ectothermic.

**Collection** These organisms can be found near rivers or ponds. Toads can also be collected at night during the rainy season. Use cages or sweep nets to capture amphibians.

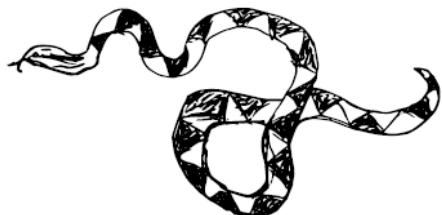
**Preservation** Make an aquarium or pond for live specimens, providing small insects for food and a source of water. For the preservation of dead specimens inject formaldehyde or leave in the sun for a few days until they are dried.

**Killing** To kill Amphibians, keep them in an airtight container or prick their head with a nail or pin.

**Dissection** For frogs, make a lateral cut from the mouth to the anus. Then make two intersecting cuts, one that is under the arms and one that is above the legs. Peel back the layer of skin and observe the internal organs.

#### F.2.3.5.4 Class Reptilia

**Lizards (Mjusi), Crocodiles (Mamba), Snakes (Nyoka), Turtles (Kasa), and Tortoise (Kobe)**



The following are the features of Class Reptilia:

1. They have dry skin with horny scales.
2. They are cold blooded or ectothermic.
3. They lay their eggs on land and the eggs have a soft shell.

**Collection** Reptiles can be found on rocks or in caves, inside cracks in the wall, forests, and in or nearby rivers and lakes. They can be collected by using sweep nets, traps, or fishing nets.

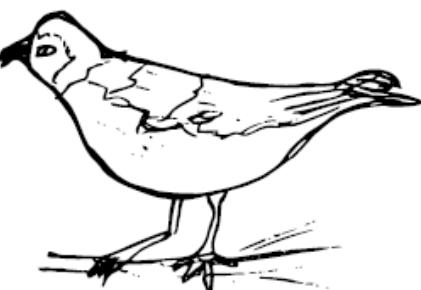
**Preservation** Live specimens can be held inside a cage or aquarium. Snakes should be fed small rodents and turtles can be given grass or leaves. For dead specimens, preserve them by placing them in an airtight container with formaldehyde solution.

**Killing** Reptiles can be killed by placing them in an airtight container, submerging them in bucket of water, or hitting the back of their head with a pin or nail.

**Dissection** For dissection, follow the same guidelines as amphibian dissection.

#### F.2.3.5.5 Class Aves

**Eagle (Tai), Owl (Bundi), Crow (Kunguru), and Chicken (Kuku)**



Class Aves contains the organisms commonly known as birds. The following are the features of Class Aves:

1. Their body is covered with feathers.
2. They have wings.
3. They have a bill or beak.
4. They lay hard-shelled eggs.
5. They are warm blooded or homothermic, which means they maintain a constant body temperature.

**Collection** Chicken are kept domestically and can be easily purchased or raised. Wild birds usually live in the forest and can be killed using a sling shot or captured live with the use of a sweep net or fishing net.

**Preservation** To preserve dead specimens, place them in an airtight container with formaldehyde solution. You can also keep and dry bones of dead bird for studying.

**Killing** To kill birds, break their neck, drown them in water, or use a slingshot.

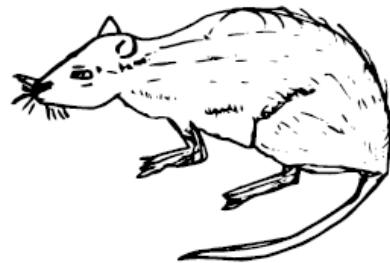
**Dissection** Make a lateral cut starting at the lower abdomen up to the sternum. Cut through the rib cage and pin it back to the dissection tray to examine the heart, respiratory system, and digestive system.

#### F.2.3.5.6 Class Mammalia

**Rats (Panya), Cats (Paka), Goats (Mbuzi), Bats (Popo), Whale (Nyangumi), and Humans (Binadamu)**

The following are the features of Class Mammalia:

1. They have a developed brain.
2. They have hair or fur on their body.
3. They have mammary glands which in females, produce milk.
4. They have teeth.
5. They have a diaphragm.
6. They are viviparous, which means the fetus develops inside the mothers body.
7. They have sweat glands.
8. They are warm blooded or homoeothermic.

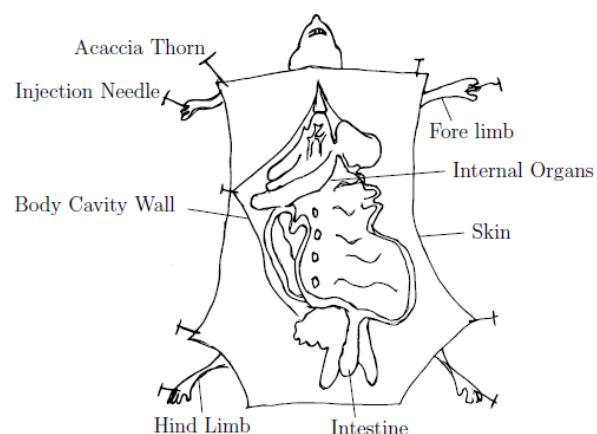


**Collection** Rats can be captured overnight using a trap. Bats can be collected during the day, when they are sleeping, by using a sweep net.

**Preservation** Mammals can be preserved in a formaldehyde solution.

**Killing** Specimens should be killed by drowning. Place the mammal inside a cage or trap and submerge in a bucket of water. Wait at least 10 minutes. After the animal is dead, add one cap full of bleach for every five litres of water in the bucket (e.g. 2 caps of bleach for a 10 litre bucket). Stir the contents of the bucket. Wait 20 minutes. The bleach will kill harmful organisms on the outside of the specimen.

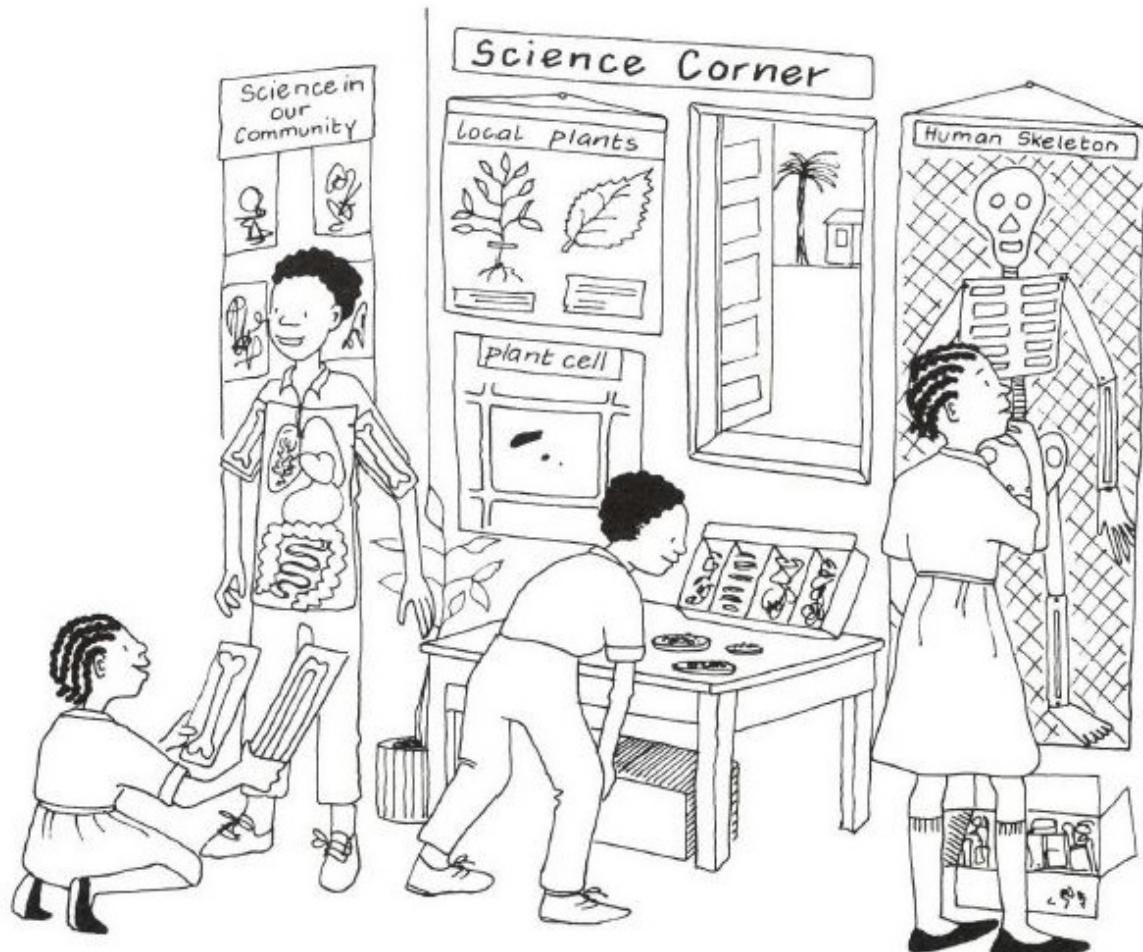
**Dissection** Make a lateral cut from the mouth to the anus. Then make 2 cuts, one from hand to hand and another from foot to foot so that both cuts cross the first lateral cut. Separate the skin and pin it to the dissection tray to examine the internal organs.



# Interactive Learning

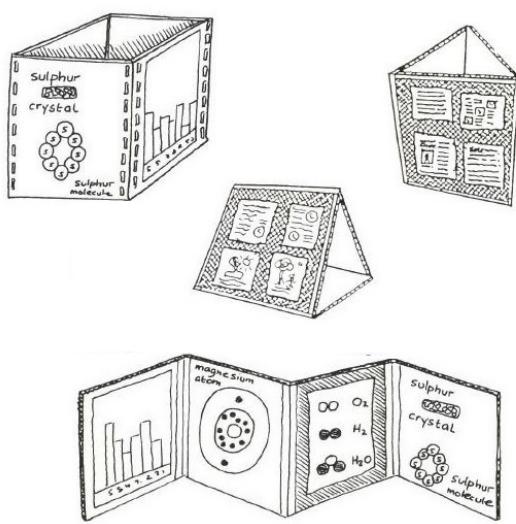
# Visual Aids and Displays

## G.1 Science Corner



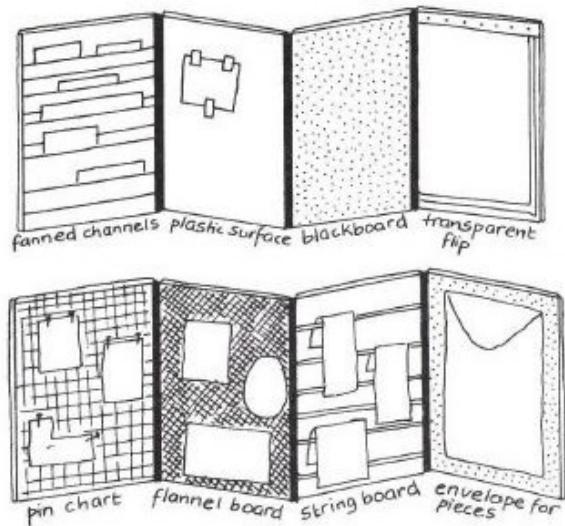
- A table pushed into a corner can be the start of a science corner in the classroom.
- A few nails or strips of wood can be added above the table to hang posters and specimens.
- The corner could be the focus for science club or science fair activities.

## G.2 Cardboard Box Displays



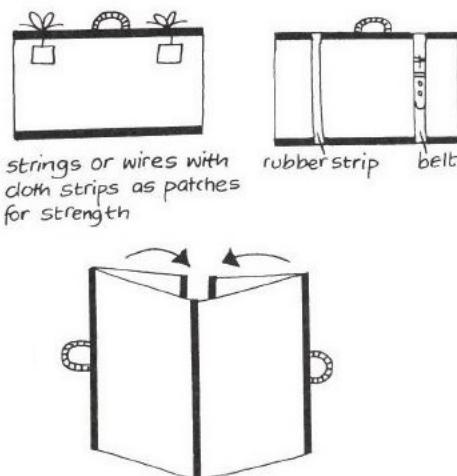
- Pin display work on the sides of the box.
- Sew or tape cardboard sheets together to make a box.
- A box can show 8 sides.

### G.2.1 Zigzag Multiboards



- A portable zigzag board can hold and display many items.

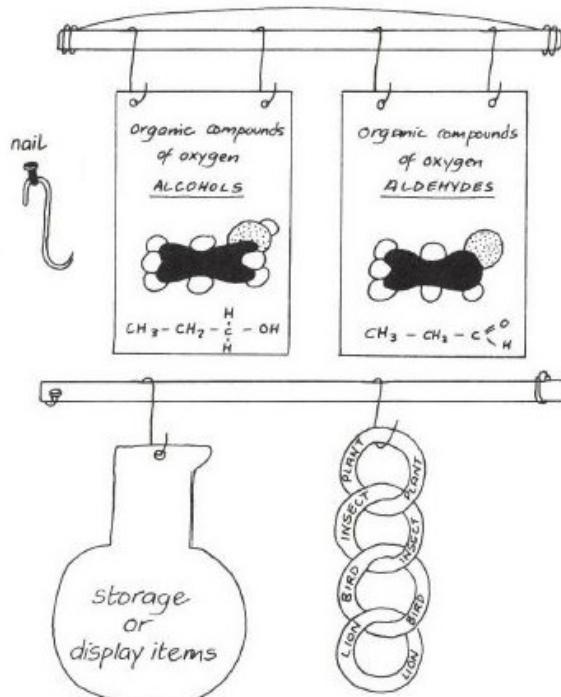
## G.2.2 Portability



- Fold the outer wings in, close the board.
- The boards can be made from plywood, hard-wood or cardboard.
- Fastenings can be made from many materials.

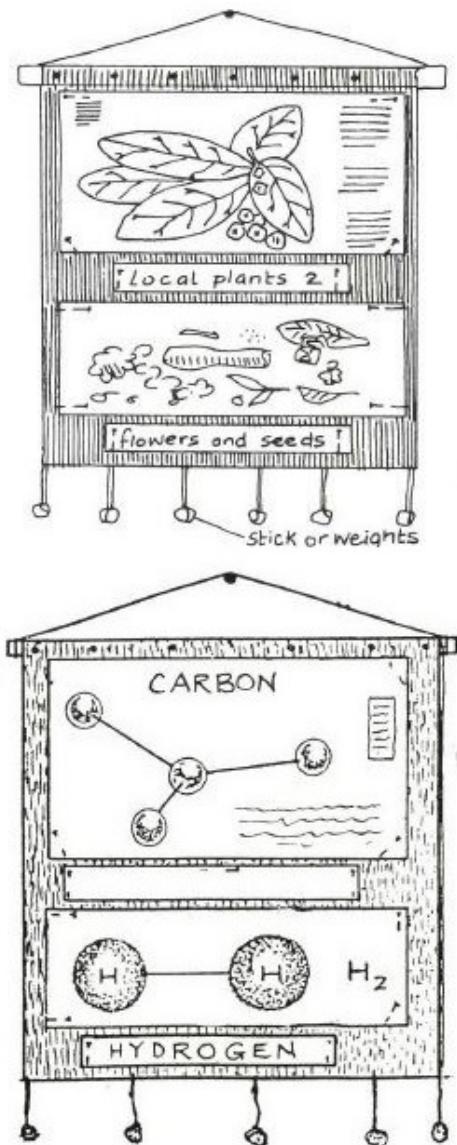
## G.3 Hanging Displays

### G.3.1 Display Beams and Hooks



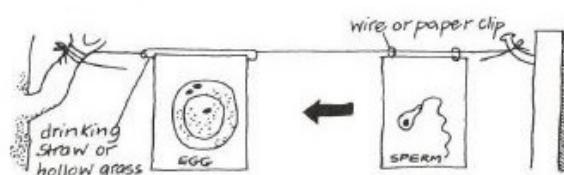
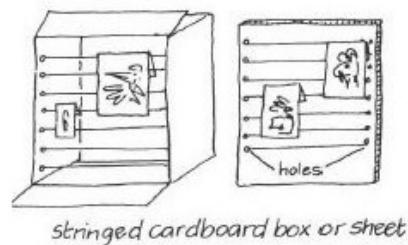
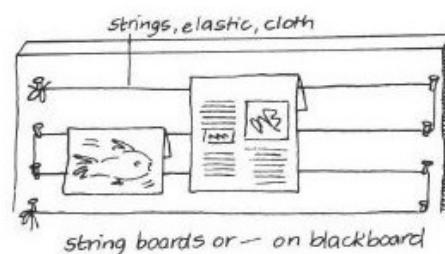
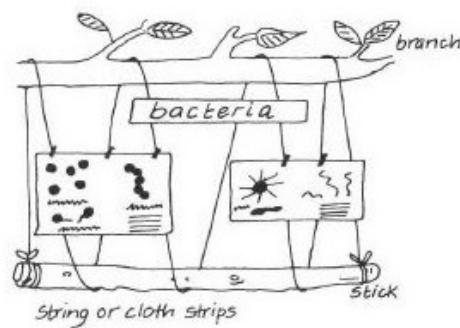
- Make a beam supported by 2 nails or loops of wire. It can be hung on the wall, or suspended from a beam.
- Hooks of wire allow easy and swift display.

### G.3.2 Display Charts



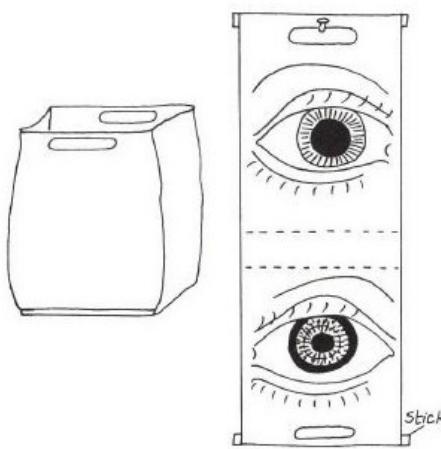
- Display charts can be made from durable cement bags, cloth, cardboard boxes, sleeping mats and blankets.
- To make the chart hang flat, attach a strip of wood to the top and either another strip of wood or weights to the bottom.
- Strips at top and bottom will strengthen the chart and make it last longer.
- Attach items to be displayed to the chart with office pins, cactus needles or sharpened matchsticks.

### G.3.3 String Display Lines



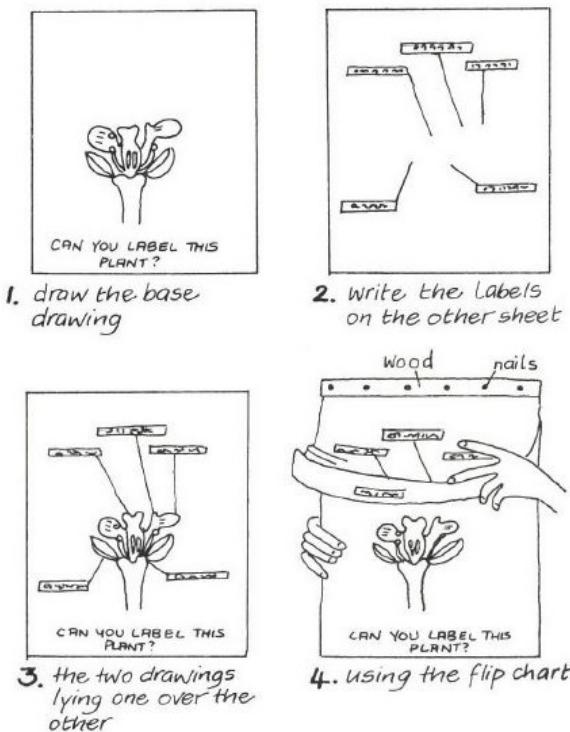
- String can be used in many ways to display items. Some ideas are given here.
- Hollow tubes, e.g. drinking straws, or paper clips will allow the display to slide up and down the string.

### G.3.4 Carrier Bag Display



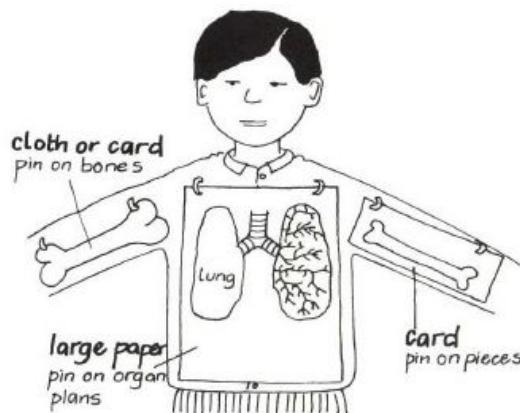
- Attaching a wooden stick at the top and bottom of the carrier bag adds strength and makes it hang flat.
- Permanent or temporary marker pens can be used to draw onto the plastic.
- Use Sellotape tabs to attach pieces to the display chart. These can be movable pieces.

### G.4 Transparent Flip-Sheets



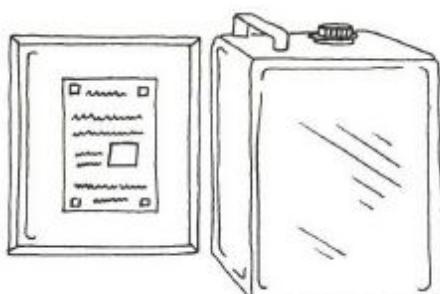
- You will need plastic sheets (from a stationery store), a bar of wood and some nails or pins.
- Lift up different sheets to show the combinations you want.

### G.5 Clothing Posters



- Body organs could be drawn, painted or pinned onto gloves, T-shirts or trousers.

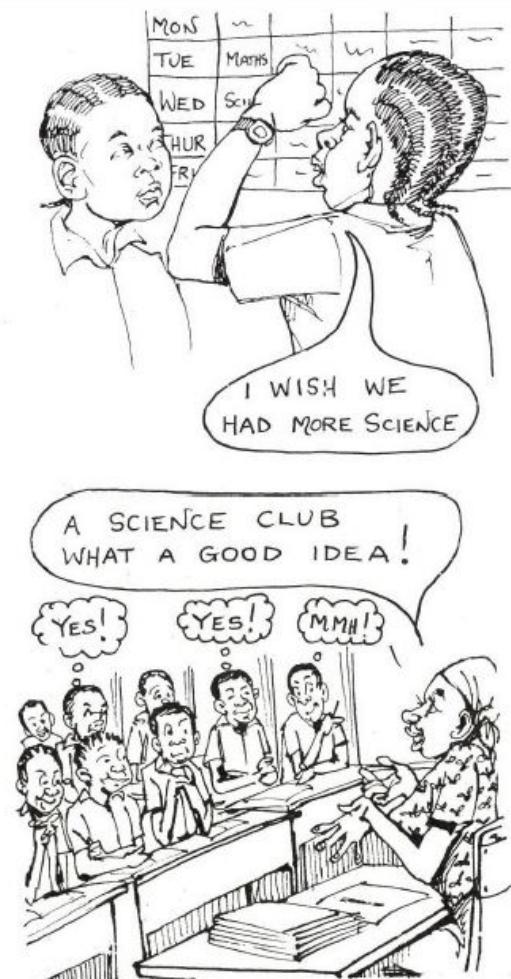
### G.6 Magnet Boards



- Use a thin metal sheet. Paint it black to act as a blackboard too.
- Metal could come from old cans or car panels, fridge doors, filing cabinets, steel shelves, flattened corrugated sheet, storage trunks.
- Tape over the edges of the sheet, or hammer the edges over for safety.
- Magnetize small pieces of metal to attach pictures to the metal sheet.
- Painting the metal pieces white makes them less noticeable. Glue the magnetic pieces to the back of pictures used regularly.

# Science Outside the Classroom

## H.1 Science Clubs



A science club is an association of young people, with one or more adult sponsors, organised to carry out extra-curricular science activities. The nature of this out-of-school science education should be such that it both complements and supplements science education in school.

It should include those activities that are not easily provided at school, and also those that the constraints of the curriculum or time usually exclude. Out-of-school science education can emphasize the role of science in the community or encourage creativity among young people and be a valuable means of linking education with productive work.

### H.1.1 Organizing a Club



The ideas for a new science or JETS (Junior Engineers, Technologists and Scientists) club may come from students or the teacher. Before rushing into establishing the club the following questions must be considered:

- Is it for science alone or could it include other areas (engineering and technology)?
- Are there any other clubs/ Has there been a science club in the past? If so, why did it fail?
- Are there any regulations (school or elsewhere) which might affect the formation of the club?
- Does the constitution have to be approved?
- Where and when can the club meet?
- Does the club need funds to operate? Where will this money come from?
- What do other staff members think? Do others want to be involved?

The teacher or sponsor should call the first meeting to establish the structure and scope of the club. It is better to start off with a small club with modest aims than to be over ambitious. While the adult sponsor is vital to the success of a club, she/he cannot and should not be expected to do all the work. She/he should act as an adviser helping when needed. Nevertheless sponsors must be willing to give generously of her/his time. A real interest and enthusiasm are the keys to success! Enthusiasm is contagious, but so is lack of enthusiasm!

### H.1.2 Activities Record Book



The club should keep a detailed record of the science activities carried out at each meeting. These should include judgments on the success or failure of an activity. Many teachers keep their own personal note book record of successful activities, which they are able to add to throughout their teaching career. Most of the activities described in the *Shika Express* companion manuals are ideal for use as out-of-school activities.

### H.1.4 Science in the News Book



Keep up with current scientific affairs and general knowledge by keeping all selected newspaper and magazine cuttings in a permanent album. Build up a library of cuttings over your school years.

Newspaper cuttings are an ideal source of information for essays or quiz questions.

### H.1.3 Science Notice Board



Display newspaper and magazine articles on a science notice board. Notices giving dates and times of regular meetings and special events can be included. Why not hold a poster competition to see who can create the most attractive or imaginative work. Why not ask club members to write essays on science topics for the board?

### H.1.5 Personal Science Kits



Students could start to collect items for their own science kits. Why not hold a science kit competition? Ask groups of students to collect low or no cost materials from the local environment which could be used for science activities.

### H.1.6 Collections and Research



Students can make collections of a wide variety of objects. Here are some ideas: rocks and minerals; shells; types of wood; leaves; flowers; bones; natural and artificial fabrics; metals; stamps; types of paper and card. Collections can be mounted labeled and displayed in the science corner.

### H.1.7 Additional Practicals



Students get the opportunity to do interesting science practicals which may not be in their text books or syllabus.

### H.2 Science Fairs

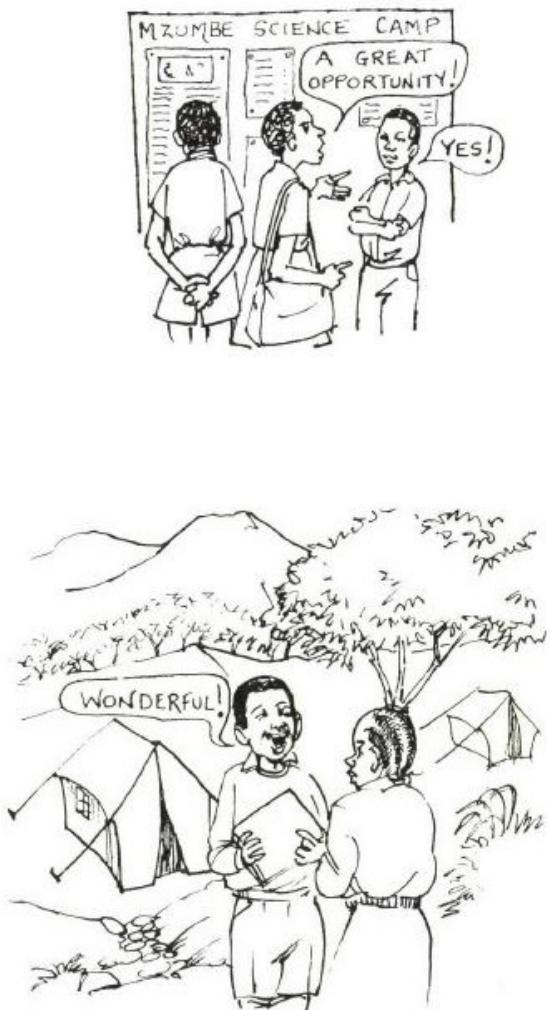


Science fairs can be an excellent motivation for science club activities. These could involve exhibitions of projects, essay writing competitions (a), project presentations (b), debates (c), with certificates for prize winners. Organisers should note that the presentation of certificates, prizes or awards may increase the basic running costs of the club. A sponsor from local industry, business or community group could be sought.

### H.3 Science Competitions

Students love to compete and show their knowledge of math and science! Organize a small competition among interested students or create a multi-day competition using a variety of activities. See the *Shika na Mikono* resource manuals for plenty of great competition activities.

## H.4 Science Conferences and Camps



Science camps can be organised during the holidays. These can be for a few days or several weeks. As well as giving students the opportunity to gain first hand knowledge it also gives youngsters the chance to live and work together with their peers and supportive adults.

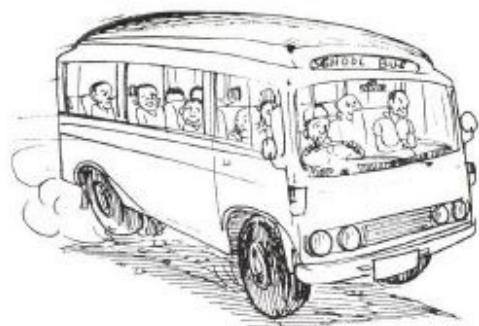
There are two main types of camp:

- (a) held in an established institution like a school, college, university, or special study centre.
- (b) may involve outdoor camping often in a remote setting, to carry out a set research project.

If a camp is located at an institution the activities may be more laboratory based and involve the design, construction and testing of apparatus in order to study specific topics. The nature of the activities at an outdoor camp will depend on the location chosen.

See the *Shika na Mikono* resource manual for more information on holding math and science conferences and other events.

## H.5 Field Trips



A scientific excursion may have a variety of objectives, but it is very important that the major objectives are known before the visit starts. If possible an initial planning visit is made by the teacher (or sponsor) to the excursion site, in order to familiarise themselves with the local environment and discover any difficulties. Detailed forward planning is often the secret to a successful visit. Meeting local resource persons could lead to an altering of plans. Planning must include the very important topics of finance and safety!

# Science in the Community

## I.1 Science for All



Science clubs and activities are most often school based, but they may be organised at a science centre, community hall, factory or business. In many countries a large proportion of the school age populations are not at school, and never will be. They receive only the barest contact during elementary years and thus may have no real opportunity to learn or experience science and technology.

Therefore, the potential for out-of-school science and technology education is enormous, ranging from the vast numbers of adults to the large numbers of school-age leavers who have had no formal education or inadequate contact with science education.

How can your school and community help spread and share science for all? A community science club may be the answer - a joint venture between school and community.

## I.2 Science Target Groups



"All out-of-school science activities and programmes should be planned and developed according to the identified needs, interests real-life problems and concerns of the various target groups." (UNESCO)

(a) The formal school populations, who need out-of-school activities to enrich, supplement and complement school science education curricula.

(b) Out of school youth and adults (early dropouts from school, illiterates, general work force), who need activities designed to develop a basic scientific literacy, to create interest and to form an appropriate, relevant scientific climate of opinion.

(c) Educated youths and adults for whom out-of-school activities should be part of a lifelong education, designed to clarify changing socioeconomic and cultural conditions and rapid changes in the applications and relevance of scientific and technological ideas and developments.

### I.3 Environmental Awareness



A vital role of a science club or group is to raise environmental awareness in the school and community. Millions of people are very concerned about what is happening to our world and looking for ways to change things for the better. Perhaps you think that means you don't have to get involved, or that the environment is getting enough attention. Nothing could be further from the truth - the battle is nowhere near won!

This can take the form of surveys, plays, studies, posters, discussions and debates. Many socially beneficial environmental protection activities can be undertaken, such as the creation of specific miniature reserves or patches, tree and shrub planting to prevent erosion and provide shade; protecting newly planted trees from animals; beautifying ones home and greening of street and courtyards.

One of the most important roles of the club in the community is to look-out for environmental hazards like water pollution which may affect everyone's health and happiness.

### I.4 Wildlife Conservation



Out-of-school activities give an excellent opportunity for students to collect and study small wild creatures. The teacher must instruct the students to be careful not to distress the animals while the study is being carried out.

Wherever possible living things should be studied in their own habitats. If this is not possible and they have to be captured, the students MUST try to return the animals to their original home. Students must be made aware that by destroying wildlife habitats they destroy the wildlife. By protecting habitats Tanzania's precious wildlife resources will be conserved for future generations.

## I.5 Science and Health



Health education is part of school science, but can also be a major focus for out-of-school activities. Good science teaching and scientific thinking can improve health. Health education is concerned with skills for life: skills which can save and improve lives; skills which go out of the classroom and are used in daily life and which, when thoroughly learnt, last for life.

Pollution of the environment is the major cause of health problems in a community. Students need to be able to identify polluting health hazards in the local environment. Health is one of the areas which confirms to students that scientific thinking need not be confined to the laboratory but should be applied in many different situations.

# HIV/AIDS Awareness

This section was originally prepared for the Biology Sourcebook of the Mzumbe Book Project by Mr. M. Sawaya of the Inspectorate, Ministry of Education and Culture, Dar es Salaam.

## J.1 Introduction

The purpose of this material is to provide a guide or basis for the school AIDS education program. On the grounds that the future of our nation and progress is based on the on going generation - the student. Hence the aim is to promote behaviour which will reduce transmission of HIV among young people.

The main mode of HIV transmission is through unprotected sexual intercourse. Open talk on sex is difficult in our society, thus making discussions on AIDS education a sensitive issue which has to touch on personal, religious cultural and moral perspectives. Initial and continuous communication on all aspects of education is expected and requires time, cooperation and participation of many people from the school, the home and the community. Teachers who are going to do much of the education have to change their attitudes towards students. They have to treat students as individuals and with respect. They have to make students become comfortable and confident to talk about sexuality and related issues freely with them. It is advised that interpersonal relationship between teacher and student is fostered as it is the basis for preventive education and counselling.

The AIDS education provided in this material considers it as part of integrated health education program. AIDS or HIV infection is not treated as a set of isolated disease, but understanding it as disease that needs action to prevent or limit its development through learning and practising positive health behaviour, skills and attitudes. Likewise importance, is linked to Family life Education were self-esteem, respect for self and others, decision making nurturing relationships. That will help students to understand the immediate and long term benefits of abstaining from sexual activity.



## J.2 AIDS - Current Information

This brief overview provides teachers with a general understanding of AIDS. It should be supplemented as needed with other texts on the subject. Knowledge about the disease and its effects on individuals is constantly being updated.

**Teachers should periodically review and update this information to assure that is accurate.**

### J.3 Description and Cause of AIDS

- Acquired Immune Deficiency Syndrome (AIDS) is a disease caused by a virus that attacks the body's immune system, making infected people vulnerable to opportunistic infections, cancer, and neurological disorders.
- The AIDS virus (called Human Immunodeficiency Virus-HIV) primarily attacks certain white blood cells (called T-Lymphocytes or T-4 helper cells) that are part of the body's internal defense against disease. The virus may also attack the central nervous system.
- An infected person's immune system responds by developing antibodies to fight off the invading virus. It is these antibodies to HIV, and not the virus itself, that can be identified by a blood test before a person has any signs of illness. However, the body's ability to produce disease-fighting antibodies eventually becomes limited in HIV-infected persons as the virus reproduces and multiplies, killing the critical T-4 cells it has infected.

### J.4 Clinical Manifestations

- HIV infection may lead to disease which can take many forms. It ranges from the complete absence of symptoms to mild illness, to debilitating neurological disorders, and to fatal disease.
- The condition called AIDS represents a syndrome of late-stage diseases in which the immune system is unable to fight off other viruses, bacteria, protozoa, and fungi, resulting in infections and diseases that eventually cause the death o
- The condition called AIDS Related Complex (ARC) refers to individuals who have a suppressed immune system and symptoms of AIDS but no specific opportunistic infections. For an unknown percentage of individuals, ARC is a precursor to AIDS.
- The onset of symptoms associated with either ARC or AIDS may take from six months to five or more years to appear after the virus has entered the body. At this time most individuals exposed to HIV do not develop either ARC or AIDS, although they are carriers of the virus and are capable of infecting others.
- Symptoms related to ARC include:
  - loss of appetite
  - weight loss
  - fever
  - night sweats
  - skin, rashes
  - diarrhoea
  - tiredness
  - lack of resistance to infection
  - swollen lymph glands

The symptoms are likely to be milder than those found in person with AIDS and generally are present in a cyclic fashion with illness followed by periods of wellness.

- The symptoms that individuals with AIDS develop are related to the opportunistic diseases that have taken advantage of the compromised immune response due to HIV infection. These symptoms are usually persistent and difficult to treat, and they progressively debilitate the person to the point of death. They may include:
  - extreme tiredness, sometimes combined with headaches, dizziness, or lightheadedness
  - continued fever or night sweats
  - weight loss of more than 10 pounds that is not due to dieting or increased physical activity

- swollen glands in the neck, armpits, or groin
  - purple or discoloured growths on the skin or the mucous membranes (inside the mouth, anus, or nasal passages)
  - heavy, continual dry cough that is not from smoking or that has lasted too long to be a cold or flu
  - continuing bouts of diarrhoea
  - thrush (a thick whitish coating on the tongue or in the throat), which may be accompanied by sore throat
  - unexplained bleeding from any body opening or from growths on the skin or mucous membranes
  - bruising more easily than usual
  - progressive shortness of breath
  - confusion, lethargy, forgetfulness, lack of coordination, general mental deterioration.
- Specific diseases that generally don't affect healthy adults are linked with HIV infection.
  - The incubation period before any symptoms of HIV disease appear varies significantly from person to person. Many infected people develop symptoms within two years of exposure. Others, infected up to seven years ago, have not yet shown any signs of illness. Since AIDS is a new disease, only recognized in 1981, the maximum incubation period has not yet been identified. Extensive research is in progress to identify potential internal or external co-factors that may cause some infected people to become fatally ill, while others have milder symptoms or remain symptom-free.

## J.5 Transmission

Unlike flu or measles, HIV is not transmitted through the air; it must get into the bloodstream to cause infection. For this reason, HIV-infected people do not pose a risk to others through any form of casual contact. There is no evidence that AIDS is transmitted through coughing, sneezing, food preparation, drinking fountains, toilet seats, being around an infected person on daily basis, or donating blood.

HIV is carried in blood, semen, vaginal secretions, and other body fluids including tears and saliva of an infected person. It is transmitted from one person to another by three routes:

1. through sexual intercourse (physical sexual contact between individuals that involves the genitalia of at least one person-includes vaginal intercourse, oral intercourse, and anal intercourse),
2. through parenteral exposure to infected blood, and
3. from infected women to their infants during the perinatal period.

Sexual transmission of the AIDS virus occurs during intercourse. It is thought that it happens through abrasions or tiny, unfelt tears that may occur in delicate tissues. Such tissue breaks can allow infected semen, blood, or vaginal fluid to enter the bloodstream of a sex partner. Anal intercourse is most risky, since tissue tearing and bleeding are likely to occur. Transmission through parenteral exposure to infected blood occurs in persons sharing contaminated needles, syringes, and works during intravenous (IV) drug use. Small, even invisible, particles of infected blood can remain in the drug paraphernalia and can be injected into the bloodstream of the next user.

The risk of AIDS transmission through blood transfusions has been almost eliminated since all blood banks began testing donated blood for antibodies to HIV in 1985. There may be some risk to receiving blood if it was too early for the virus to show up when donor blood was tested. Blood-donor testing has been so effective it has reduced the risk of AIDS from blood transfusion to one in a million. There is no risk of AIDS from donating blood; blood collection centers use new transfusion equipment for each donor.

All infected people, whether or not they have any symptoms, are presumed capable of transmitting the virus to others through blood-to-blood or semen-to-blood exchange, or through vaginal secretions-to-blood exchange.

An individual can be infected with the virus that causes AIDS without having symptoms of AIDS or appearing ill. Infected individuals without symptoms can transmit the infection to others. Once infected, a person is presumed infected for life, but actual symptoms may not develop for many years. A single exposure to the AIDS virus may result in infection.

### J.5.1 How the virus is NOT known to be spread

- There is no evidence that the virus is spread through casual social contact (shaking hands, social kissing, coughing, sneezing; sharing swimming pools, bed linens, eating utensils, office equipment; being next to or served by an infected person in ordinary social contact). There is no reason to avoid an infected person in ordinary social contact.
- It is not spread by the process of giving blood; new transfusion equipment is used for each donor.
- HIV is not transmitted by insects.
- It is not spread by sexual intercourse between individuals who have maintained a sexual relationship exclusively with each other, assuming that they have not been infected through contaminated blood, blood factors, IV drug use, or a previous sexual partner.

### J.5.2 Major Risk Factors

Persons at increased risk for being infected with the AIDS virus include:

- homosexual and bisexual men
- sex partners of IV drug abusers
- male or female prostitutes and their sex partners
- sex partners of infected persons
- all persons with haemophilia who received blood-clotting factor and transfusions prior to 1985
- Children born to infected mothers.

## J.6 Prevention

There is no vaccine against AIDS or any treatment so far that can reverse AIDS damage to the immune system. People must learn how to protect themselves and their loved ones from this infection. It is essential that students gain knowledge and skills to protect themselves before they reach an age at which they might experiment with sex or illegal drugs. Following are some basic elements of AIDS information related to prevention.

### J.6.1 How to Prevent Infection

- Infection through sexual contact can be avoided by practicing abstinence or having a mutually monogamous marriage/relationship with no known risk factors in either partner. Young people can stay safe from AIDS by not having sex. They need to know it is all right to say **NO**. In addition to the risk of AIDS, there are other health reasons to postpone sex, including the risk of gonorrhea, syphilis, and herpes, and unplanned pregnancies.
- Do not use IV drugs; do not share needle or works. Young people can stay safe from AIDS by not using IV drugs. They need to know it is all right to say NO not only to IV drugs but to alcohol and drugs of any kind, as these impair judgment. In addition to the risk of AIDS, there are many other health reasons for abstaining from illegal drug use.
- If already sexually active:
  - Until you ask a lot of questions about his or her past sexual experience and drug use, don't have sex with anyone.
  - The more people you have sex with, the greater the chance you may get infected, so don't have sex with multiple partners.
  - With infected persons, using a condom during sex may help keep the virus from getting into your body. A condom is a thin rubber covering that is slipped over the penis before any sexual contact. (See [Condoms](#).)

- The chance of blood or semen entering your bloodstream is very high during anal sex, since it can cause tearing of delicate tissues, so avoid anal sex.
- Drugs and alcohol can lead you to do things you wouldn't do drug-free, so don't drink alcohol or use drugs of any kind.

### J.6.2 If There is Suspicion of Infection

- Abstain from sexual intercourse.
- Seek counseling and AIDS virus antibody testing to be sure of infection status. Be aware that weeks to months may elapse from the time of infection to the time that antibodies to the AIDS virus appear in the blood. During this time persons may be infectious but the test may be negative.
- Obtain counseling and testing if pregnancy is being considered.

### J.6.3 Information which will emphasize the seriousness of the problem, yet reduce inappropriate fear

- AIDS is a national emergency requiring attention from all citizens.
- If people change their behaviours, the spread of the AIDS virus can be reduced.
- Blood for transfusion in Tanzania is screened for antibodies to the HIV and is now essentially safe, but some risks cannot be eliminated.
- Everyone who engages in high-risk behaviour is at risk for AIDS, regardless of age, race, or socio-economic status.

## J.7 Research and Treatment

Researchers in the Tanzania and other countries are working diligently to develop a vaccine to protect people from HIV. Vaccine development is made more difficult because the virus can alter its form in the human body. There is no cure for AIDS at this time, nor is there any treatment that can restore the function of the immune system. A number of antiviral drugs including AZT (Azidothymidine) are being tested on patients. While AZT has shown some promise in curbing the ability of the virus to reproduce itself inside human cells, the drug is highly toxic and has serious side effects. Some drugs used in cancer control, such as Interferon, are also being tried with AIDS patients.

## J.8 Societal Issues

When a disease epidemic threatens society, the needs of all people must be considered: those already infected with the disease, those threatened by the disease, and those who will provide support for others.

In the past, once treatment or medical prevention for an epidemic infection was easily available, society sought to protect itself by providing information to as many people as possible through school-based courses and educational campaigns and, in some cases, by requiring mass strategies such as immunization (polio) or premarital blood tests (syphilis). As the number of AIDS cases mounts, this epidemic will have a significant and long-term impact on interpersonal and family relationships, medical care delivery, public policies, and health care resources. Because there is no available treatment, tremendous fears exist. Education must be used to curb those fears that can lead to discriminatory behaviour against people with AIDS. The rights of people with AIDS must be weighed and protected within the framework of disease prevention and with relation to the rights of those not infected.

## J.9 Condoms

A condom is a thin sheath that is placed over the erect penis to retain semen upon ejaculation. A condom is a safe and effective device in the prevention of pregnancy and somewhat effective in the prevention of sexually transmitted diseases, such as gonorrhoea, syphilis, and HIV. When properly used, a condom is theoretically 90 percent effective. However, it should be clear that, the use of condom is not an

ABSOLUTE DEFENSE AGAINST HIV INFECTION. YET, YOU WILL BE RESPONSIBLE TO USE SKILL STUDIED TO PREVENT YOURSELF FROM HIV INFECTION.

NOT HAVING SEX IS ONE SURE WAY TO AVOID HIV INFECTION.

### **J.9.1 How to Use the Condom**

Buy condoms that are stored out of the sun and not yet expired. MAKE SURE that the packet with the condom is intact. Do not use brittle, damaged condoms. Keep condoms in a cool place, away from the body's heat.

1. Wait for the penis to be fully erect before putting on the condom.
2. Take the condom out of the packet carefully so that it does not get torn by finger nails.
3. Pinch the end of the condom with the thumb and finger of one hand (do not let nails tear it!) The purpose is to remove air from the tip. Place the condom on tip of the penis
4. With the other hand-roll the condom all the way down to the base of the penis.
5. Now its' ready. Only use water-based lubricants. Lubricants containing oil such as grease, vaseline will damage condoms.
6. After ejaculating, take the penis out of the vagina before it goes soft, carefully holding the condom onto the penis so that no sperms spills. Direct the penis downwards and remove the condom gradually.
7. Dispose the condom in the latrine or in a way that children cannot play with it. Do not use condoms more than once.