Shika Express - Physics
Version 1.0 TZ

Hands-On Activities Companion Guide

Tanzania

Teacher's Guide

May 31, 2014

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Part I

Hands-On Activities

Materials and Equipment

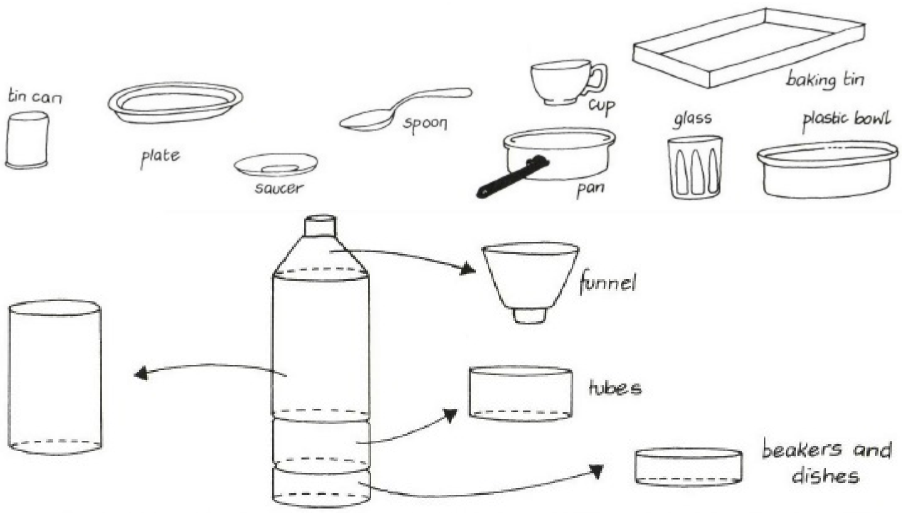
Local Materials List

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. Alligator Clips
2. Balance
3. Beakers
4. Bulbs
5. Bunsen Burner
6. Circuit Components
7. Containers
8. Deflagrating Spoon
9. Delivery Tube
10. Drawing Board
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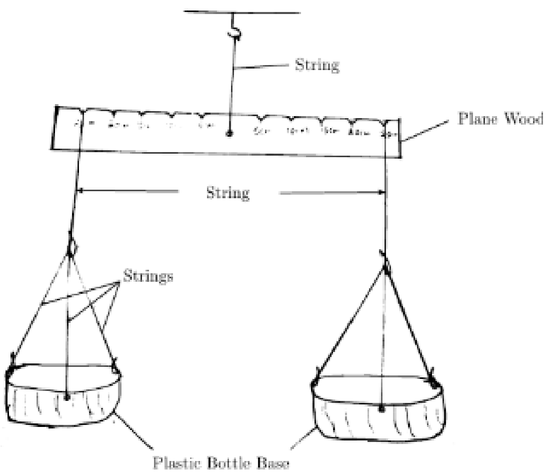
44. Volumetric “Glass”ware
45. Wash Bottle
46. Water Bath
47. Weights
48. Wire
49. Wire Gauze

A.1 Alligator Clips

Use: Connecting electrical components
Materials: Clothespins, aluminum foil, glue
Procedure: Glue aluminum foil around the clamping tips of a clothespin.

A.2 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.3 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.4 Bulbs

Use: Electrical circuits, diodes
Materials: Broken phone chargers, flashlights, other electronic devices
Procedure: Look for LEDs from broken items at hardware stores, local technicians, or small shops.

A.5 Bunsen Burner

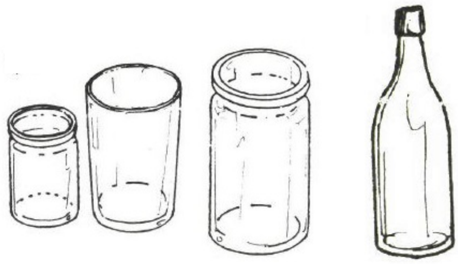
See Heat Source (p. 9).

A.6 Circuit Components

Use: Building simple circuits, Ohm’s Law, amplifier, wave rectifiers
Materials: Broken radio, computer, stereo, other electrical devices
Procedure: Remove resistors, capacitors, transistors, diodes, motors, wires, transformers, inductors, rheostats, pulleys, gears, battery holders, switches, speakers and other components from the devices. Capacitors tend to state their capacitance in microFarads on their bodies.

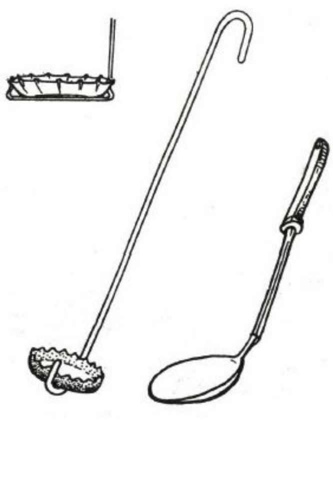
A.7 Containers

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.



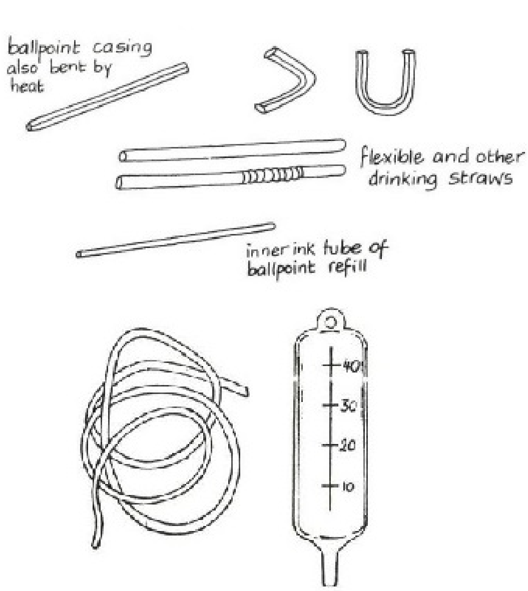
A.8 Deflagrating Spoon

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

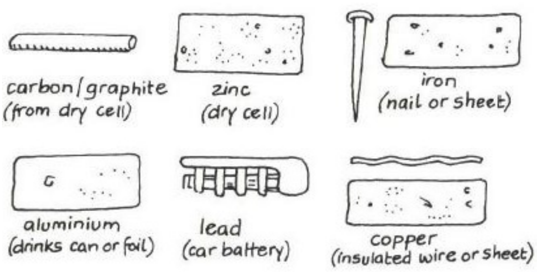
Use: Movement and collection of gases, capillary tubes, hydraulic press
Materials: Straws, pen tubes, IV tubing (giving sets) from a pharmacy, bicycle tubing



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.

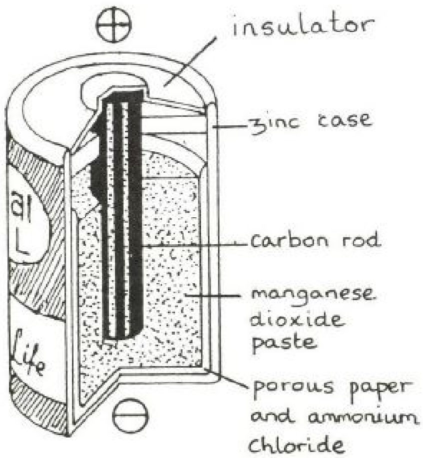
A.12 Electrodes
Use: Electrolysis



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

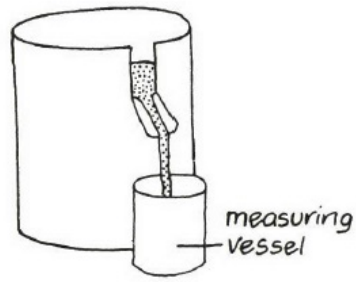
Materials: Ungalvanized nails from a hardware store

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.

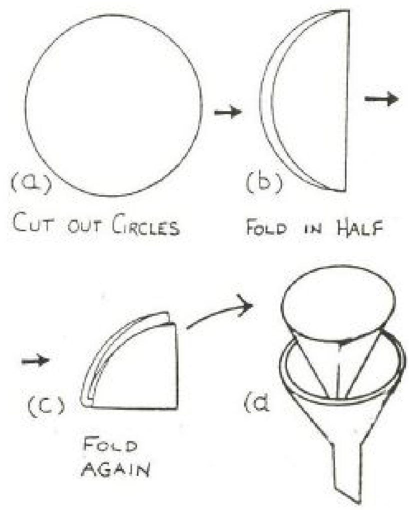
A.13 Eureka Can

Use: To measure volume of an irregular object, Archimedes' Principle, Law of Flotation
Materials: Plastic bottle, knife, Optional: super glue, straw, nail, candle
Procedure: Cut the top off of a 500 mL plastic bottle. Then cut a small strip at the top (1 cm wide by 3 cm long) and fold down to make a spout. Alternatively, heat a nail using a candle and poke a hole near the top of a cut off bottle. Super glue a straw so that it fits securely in the hole without leaking.



A.14 Filter Paper

Use: Filtration, separating mixtures, solutions
Materials: Cement bag paper, toilet paper, cloth

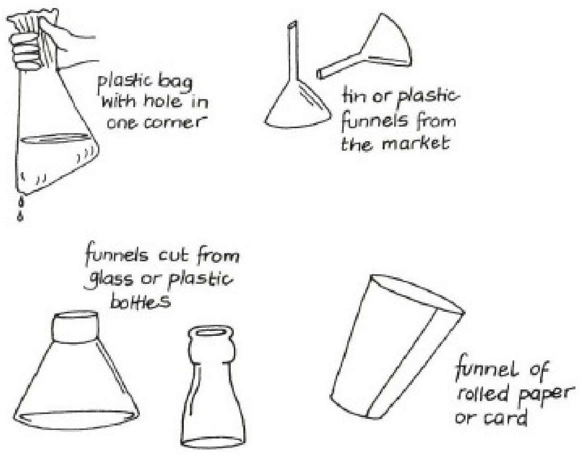


A.15 Flasks

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.16 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.17 Glass blocks

Use: Refraction of light
Materials: 8 mm - 15 mm slabs of glass
Procedure: Have a craftsman make rectangular pieces of glass with beveled edges, so students do not cut themselves. Glass blocks from a lab supply company are generally 15 mm thick. 8 mm and 10 mm glass is relatively common in towns. 12 mm and thicker glass exists though is even more difficult to find. Stack several pieces of thinner glass together and turn them on their edge.

A.18 Gloves

A.18.1 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.18.2 Thick gloves

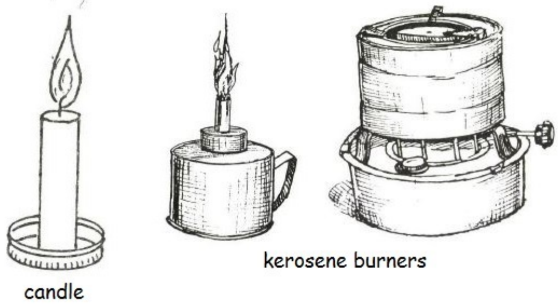
Use: For working with organic solvents. Remember that the most dangerous organic solvents (benzene, carbon tetrachloride) should never be used in a school, with or without gloves.
Materials: Thick rubber gloves from village industry supply companies and some hardware stores
Safety: In general, avoid using chemicals that would make you want to wear gloves.

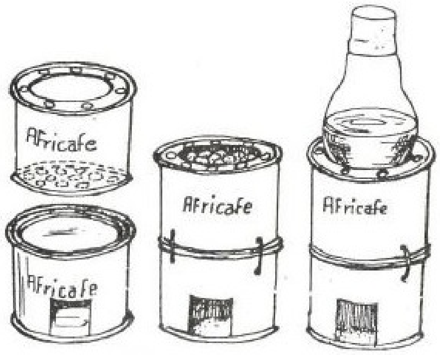
A.19 Goggles

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.

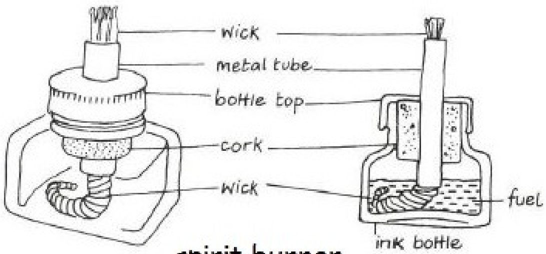
A.20 Heat Source

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.20.1 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.20.2 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.20.3 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.21 Iron Filings

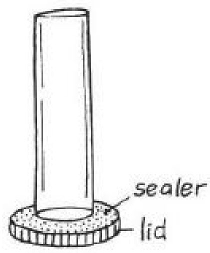
Use: To map magnetic fields
Materials: Steel wool / Iron wool used for cleaning pots
Procedure: Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

A.22 Masses

See Weights (p. 14).

A.23 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.24 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.25 Microscope

See Low Tech Microscopy (p. 16).

A.26 Mirrors

A.26.1 Plane Mirrors

Use: Microscope, Laws of Reflection
Materials: piece of thin glass, kibatari, super glue, small wooden blocks

Optional: Small pieces of mirror glass are cheap or free at a glass cutter's shop
Procedure: Light the kibatari so that it creates a lot of smoke. Pass one side of the glass repeatedly over the kibatari until that side is totally black.

The other side acts as a mirror. Super glue to small wooden blocks to stand upright.

A.26.2 Curved Mirrors

Use: Curved mirror practicals
Materials: Spoons
Procedure: Inside surface is a concave mirror; back surface is a convex mirror.

A.27 Nichrome Wire

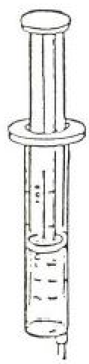
For flame tests in chemistry, you can use a steel wire thoroughly scraped clean with iron or steel wool. For physics experiments, see Wire (p. 15).

A.28 Optical Pins

Use: Compass needles, making holes, dissection, mirror practicals
Materials: Office pins, sewing needles, needles from syringes

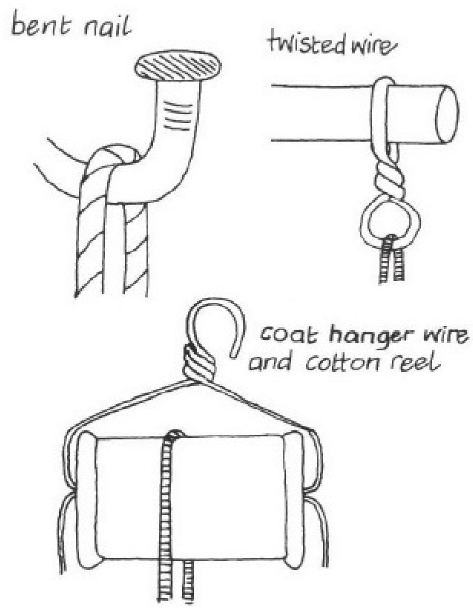
A.29 Pipettes

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.30 Pulleys

Use: Simple machines
Materials: Bent nail, twisted wire, thread reel, water bottle, string, coat hanger
Procedure: Cut off the top of a water bottle just below the lip where the top screws on. Run string or stiff wire through the centre to hang from a table or chair.



A.31 Resistors

Use: Electrical components
Materials: Old radios, circuit boards, soldering iron
Procedure: Remove resistors from old radios and circuit boards by melting the solder with a soldering iron or a stiff wire heated by a charcoal stove. If you need to know the ohms, the resistors tell you. Each has four strips (five if there is a quality band) and should be read with the silver or gold strip for tolerance on the right. Each color corresponds to a number:

black = 0	yellow = 4	violet = 7
brown = 1	green = 5	gray = 8
red = 2	blue = 6	white = 9
orange = 3		

and additionally for the third stripe: gold = -1 and silver = -2.

The first two numbers should be taken as a two digit number, so green-violet would be 57, red-black 20, etc. The third number should be taken as the power of ten (a 10^n term), so red-orange-yellow would be $23 \times 10^4 = 230000$, red-brown-black would be $21 \times 10^0 = 21$ and blue-gray-silver would be $68 \times 10^{-2} = 0.68$. The unit is always ohms. The fourth and possibly fifth bands may be ignored.

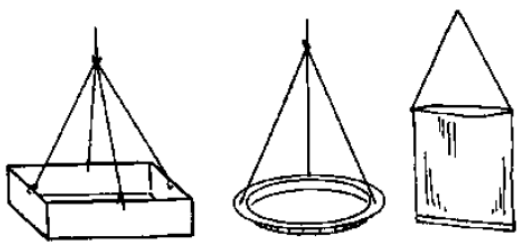
A.32 Retort Stand

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.

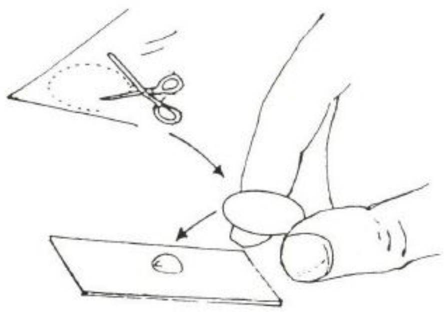
A.33 Scale Pans

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.



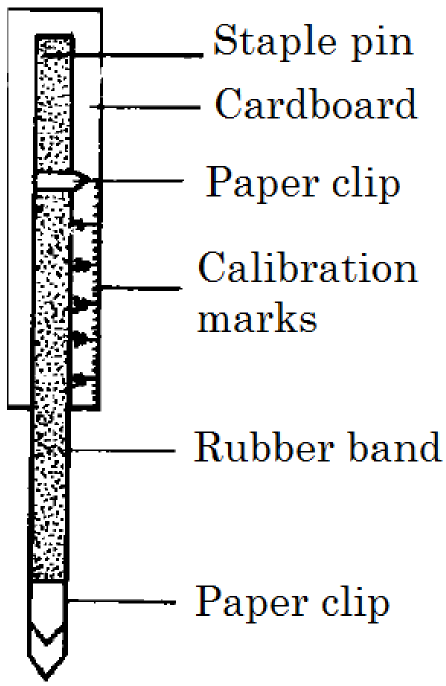
A.34 Slides and Cover Slips

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.35 Spring Balance

Use: To measure force applied on an object
Materials: Strip of cardboard, rubber band, 2 paper clips, staple pin, pen
Procedure: Cut a rubber band and fix one end to the top of a cardboard strip using a staple pin. (A stronger rubber band allows for a greater range of forces to measure.) Attach one paper clip near the top as a pointer. Attach the other paper clip as a hook at the bottom of the rubber band. Calibrate the spring balance using known masses. Write the equivalent force in Newtons on the cardboard. (A 1 g mass has a weight of 0.01 N, 100 g has a weight of 1 N, etc.)



A.36 Springs

Use: Hooke's Law, potential energy, work, spring balance
Materials: Springs from hardware stores, bike stores, junk merchants in markets, window blinds; stiff wire; rubber bands; strips of elastic
Procedure: Remove plastic covering if necessary and cut to a desired length (5 cm). Alternatively wind a stiff wire around a marker pen or use rubber bands or elastic from a local tailor.

A.37 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.

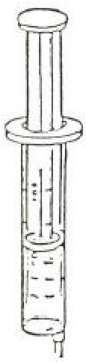
A.38 Stopwatches

Use: Simple pendulum, velocity, acceleration
Materials: Athletic and laboratory stopwatches from markets, digital wristwatches

A.39 Test Tubes

A.39.1 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.

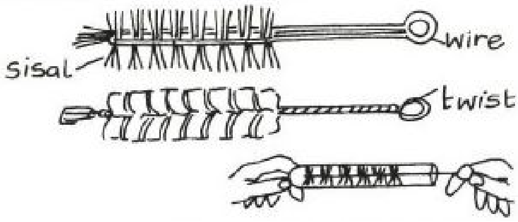


A.39.2 For Thermal Decomposition

See Deflagrating Spoon (p. 7).

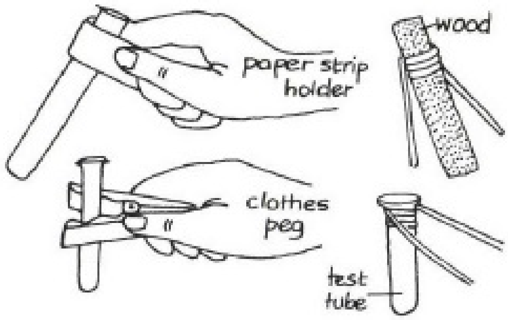
A.40 Test Tube Brush

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.



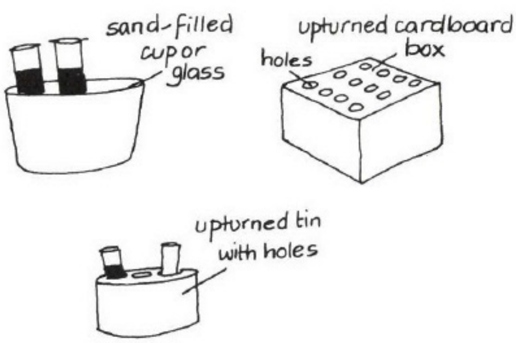
A.41 Test Tube Holder / Tongs

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.



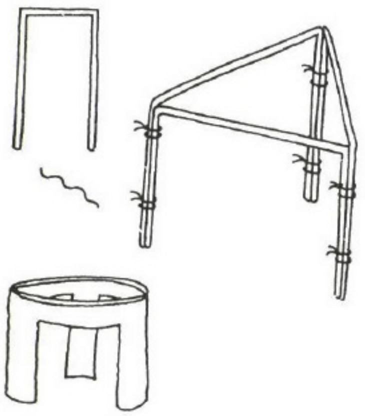
A.42 Test Tube Racks

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.43 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.44 Volumetric "Glass"ware

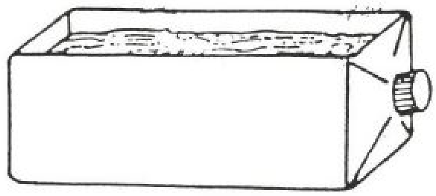
See Containers (p. 6).

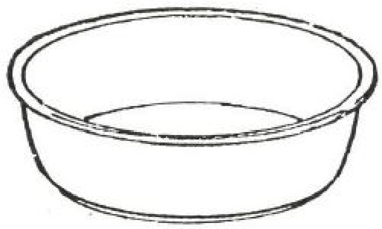
A.45 Wash Bottle

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.46 Water Bath

Use: To heat substances without using a direct flame
Materials: Heat Source, 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.47 Weights

A.47.1 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.47.2 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.47.3 Precise Weights

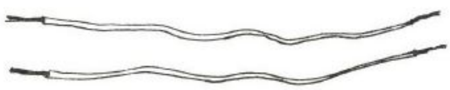
Materials: Plastic bags, sand, stones, 250 mL water bottles (all identical), tape, pen
Procedure: Use a beam balance and known masses at a market or nearby school to measure exact masses of bags of sand or stones. Use a marker pen to mark the masses on the bags.

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.48 Wire

A.48.1 Connecting Wires

Use: Connecting circuit components, current electricity
Materials: Speaker wire, knife
Procedure: Speaker wire can be found at any hardware store or taken from old appliances - the pairs of colored wires brained together. Strip using a knife, scissors or a wire stripper.

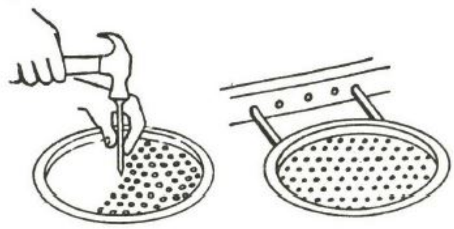


A.48.2 Specific Gauge Wire

Use: Electrical components, motors, transformers, simple generators
Materials: Copper wire without plastic covering (transformer wire), knife/scissors, matches
Procedure: Scrape or burn off the insulating varnish at any points you wish to make electrical contact. These wires come in a variety of diameters (gauges). A useful chart for converting diameter to gauge may be found at http://www.dave-cushman.net/elect/wiregauge.html. If the wire is sold by weight, you can find the length if you know the diameter - the density of copper metal at room temperature is 8.94 g/cm^3. For example, with 0.375 mm wire, 250 g is about 63 metres.

A.49 Wire Gauze

Use: Placing objects over heat
Materials: Tin can lid
Procedure: Poke holes in a tin can lid.



Low Tech Microscopy

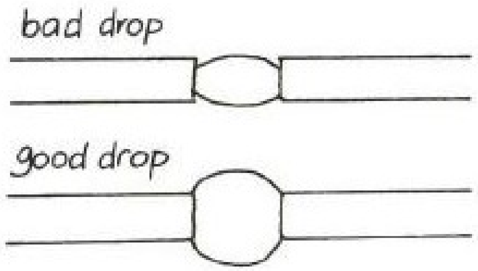
Microscopes are powerful tools for teaching biology, and many of their benefits are hard to replace with local fabrications. However, simple materials can be used to achieve sufficient magnification to greatly expands students' understanding of the very small. They may view up close the anatomy of insects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

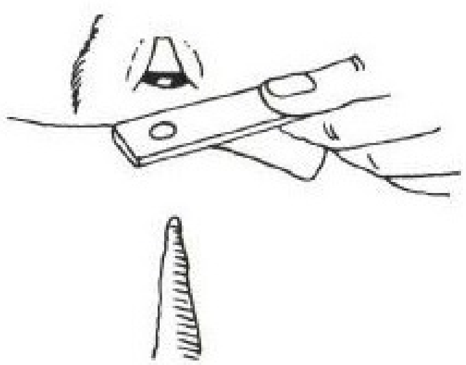
B.1 Water as a lens

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

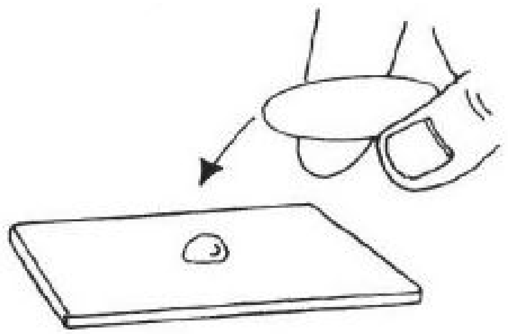
Better imaging can be had if the drop is more perfect in shape – the asymmetry of the wire twisting distorts the image. Search for a piece of thin but stiff plastic – water bottles work well. Cut a small piece of this plastic, perhaps 1×2 centimeters. Near one end, make a hole, the more perfect the better. 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.



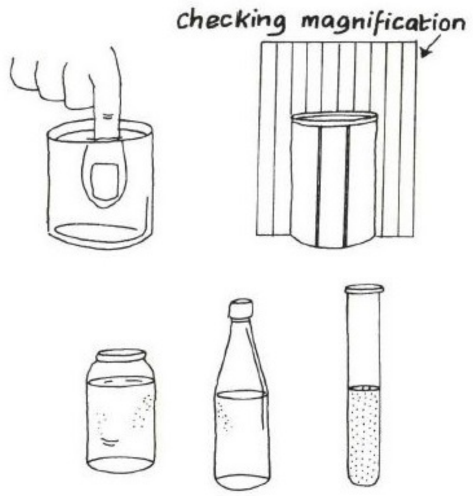
B.4 Backlighting

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.

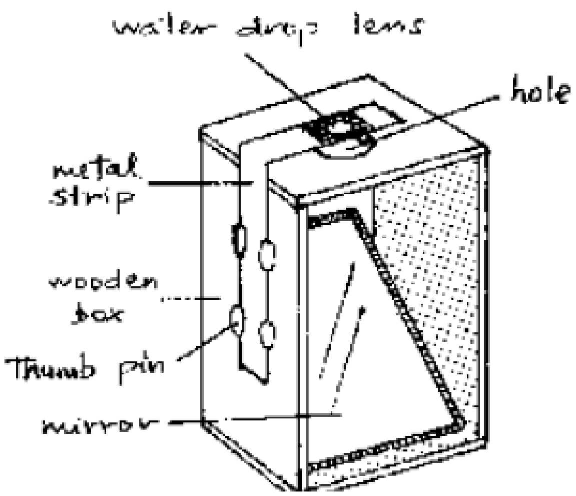
B.5 Simple Microscopes and Magnifiers

B.5.1 Clear-Container Magnifiers



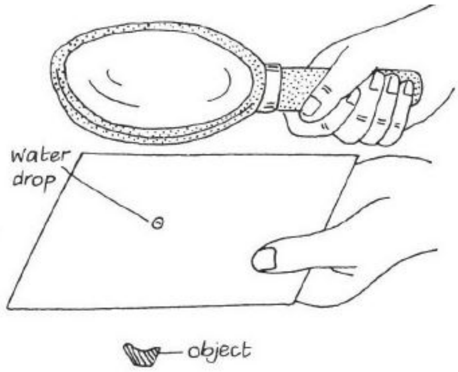
Any of these containers filled with water will make good magnifiers.

B.5.2 Simple Microscope



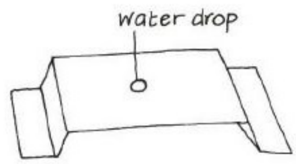
Construct a small wooden box from plywood as shown (or use a small cardboard carton such as a light bulb box). Make a round hole of 2 cm diameter, at the top. Fit a small mirror (glass or polished metal) in the box, angled to reflect light up through the hole. Make a small hole (about 6 mm) in a strip 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.

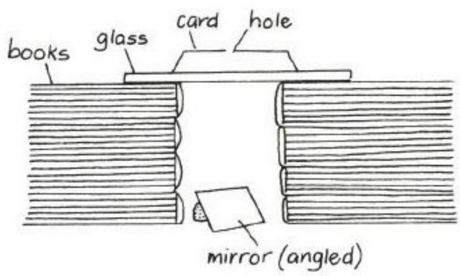
B.5.3 Simple Compound Microscope



- 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

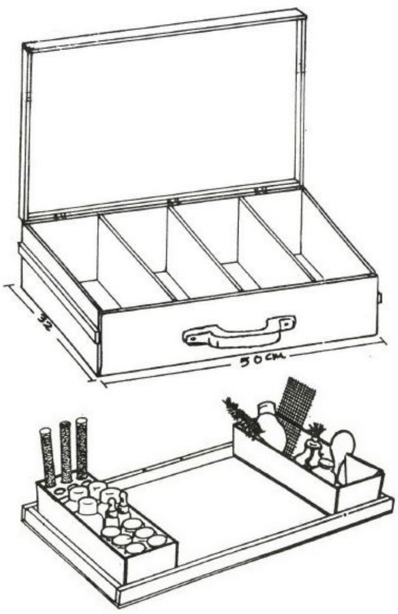




- Place a water drop in the card 'bridge'.
- Place this on a sheet of glass as shown.
- Place the object you are looking at on the glass. This arrangement is most suitable for thin items, e.g. sections of leaves.
- Experiment with the angle of the mirror so that light shines up through the specimen.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

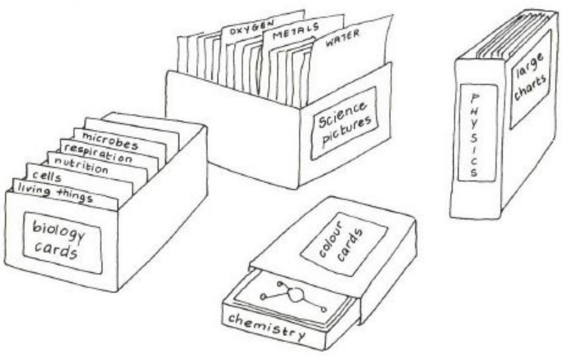
Storage of Materials

C.1 The Science Box



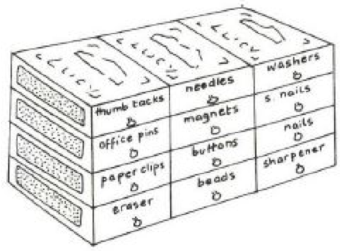
- Use a metal storage trunk to organize all of your new, locally-made science equipment.
- Metal or cardboard sheets can be used as dividers. Tape firmly in place.
- Use the lid as a science tray for safely and easily moving liquids and chemicals.

C.2 Card and Picture Boxes



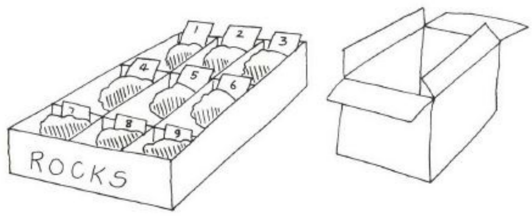
- Cards and pictures can be stored in all sorts of boxes. Store according to syllabus topic or alphabetically.
- Dividers and compartments can be made from cardboard.

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

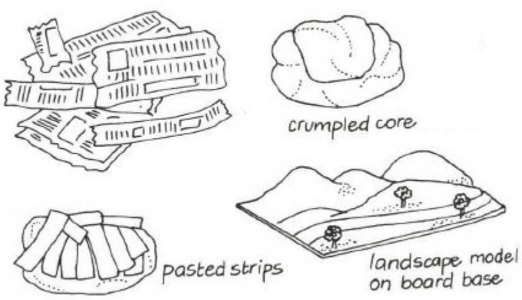
- Envelopes and bags of different sizes can be used for storage. Clearly label all containers.

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

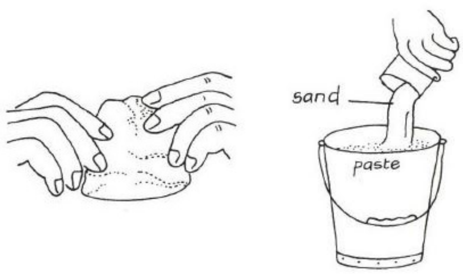


- Soak small pieces, or narrow strips, of newspaper in paste.
- Use crumpled newspaper as a core or skeleton for the model.
- Build up the model in layers of strips and pieces.
- After drying, sandpaper smooth and paint or varnish.

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

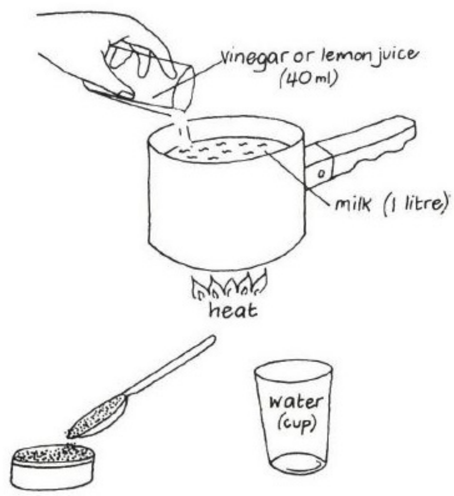


- Mix evenly together dry sand and flour paste or commercial glue.
- The wet cement moulds very easily and dries hard.

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

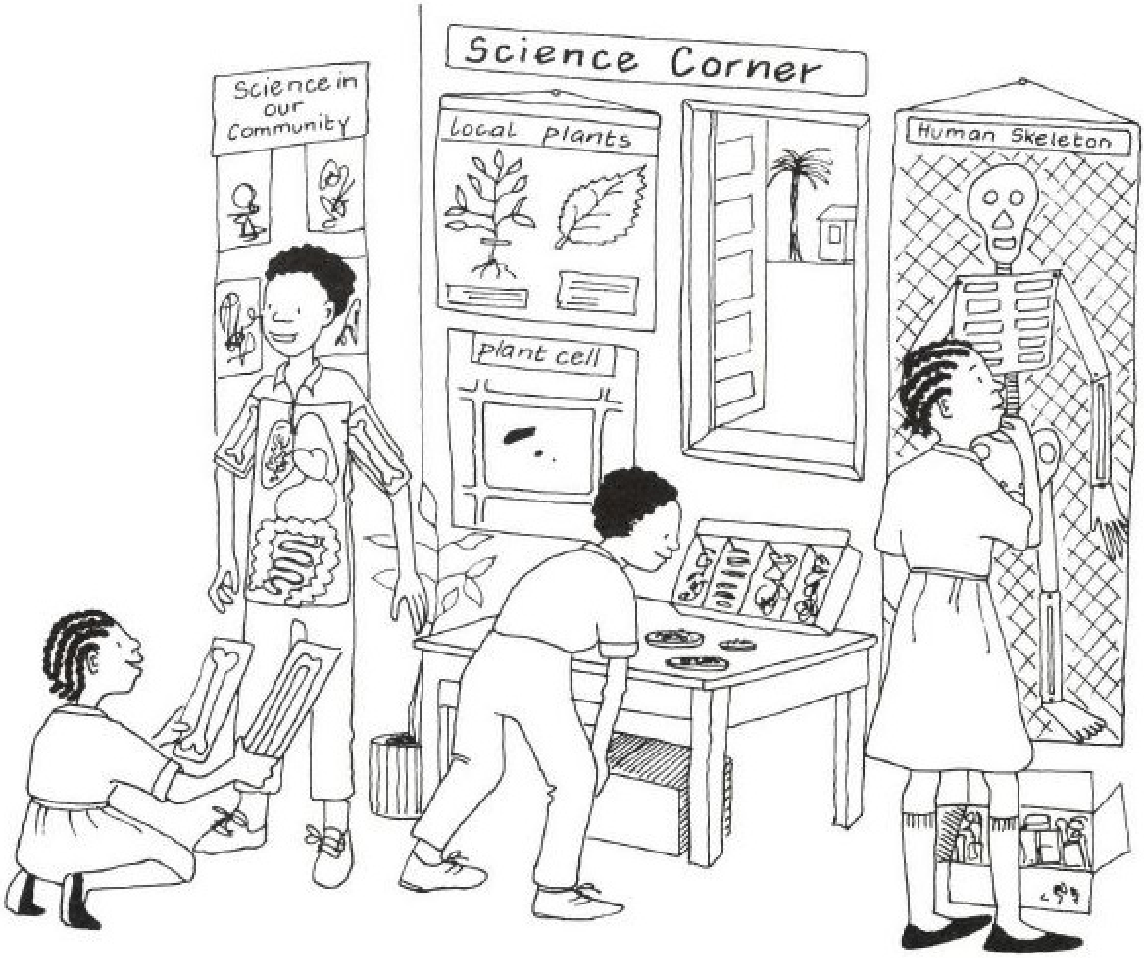


- Mix milk with vinegar or lemon juice. Add just enough vinegar or lemon juice to curdle the milk. The amounts will vary according to the type of milk used.
- Heat while stirring continuously. Soft lumps will form.
- Strain out the lumps using a cloth.
- Add a teaspoon of sodium hydrogen carbonate (bicarbonate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

Interactive Learning

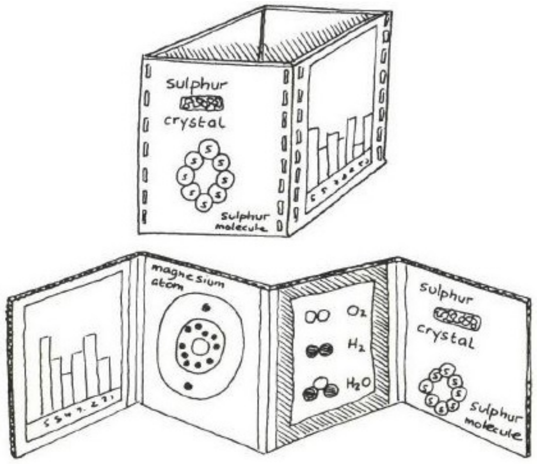
Visual Aids and Displays

E.1 Science Corner



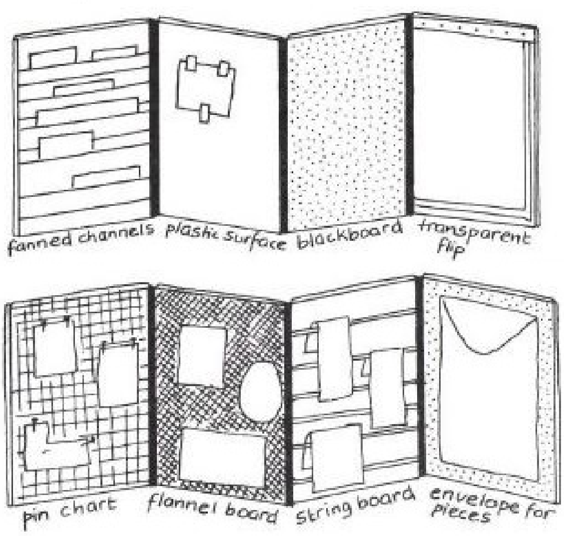
- A table pushed into a corner can be the start of a science corner in the classroom.
- A few nails or strips of wood can be added above the table to hang posters and specimens.
- The corner could be the focus for science club or science fair activities.

E.2 Cardboard Box Displays



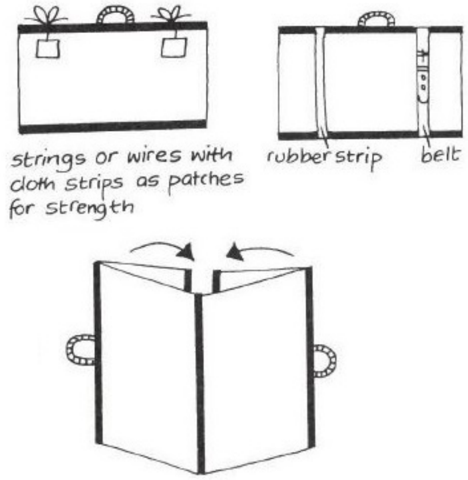
- Pin display work on the sides of the box.
- Sew or tape cardboard sheets together to make a box.
- A box can show 8 sides.

E.2.1 Zigzag Multiboards



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

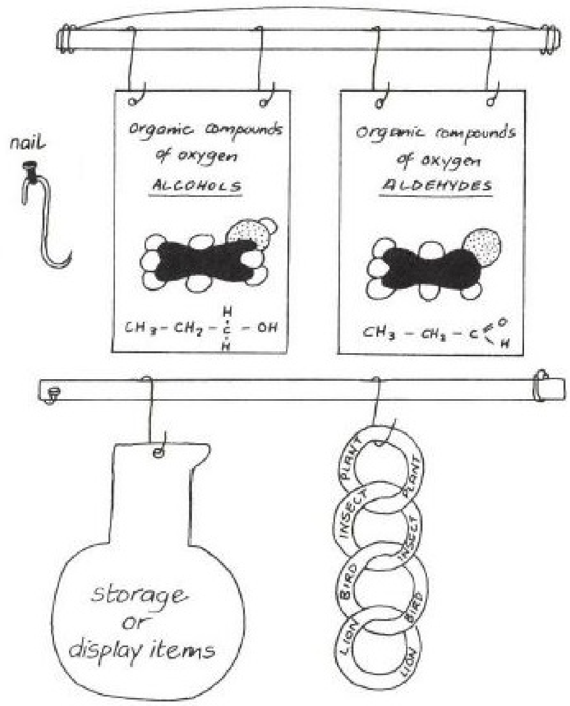
E.2.2 Portability



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

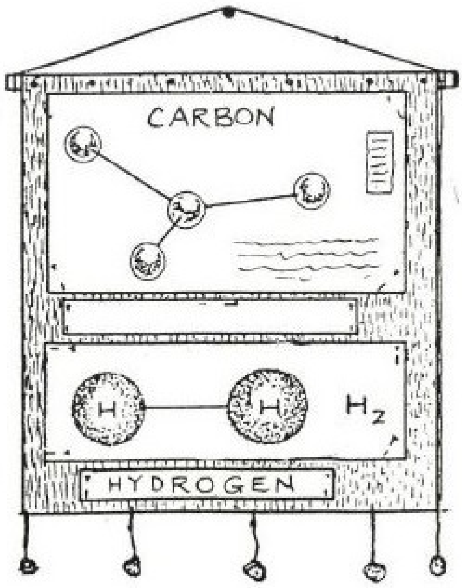
E.3 Hanging Displays

E.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.

E.3.2 Display Charts



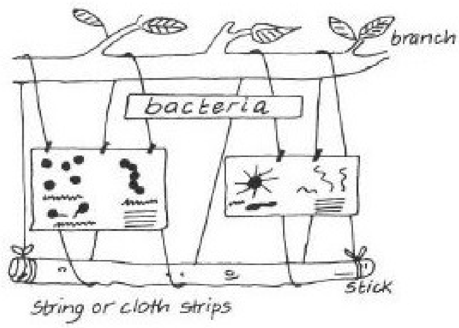
- Display charts can be made from durable cement bags, cloth, cardboard boxes, sleeping mats and blankets.

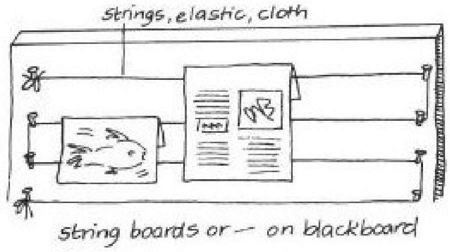
- To make the chart hang flat, attach a strip of wood to the top and either another strip of wood or weights to the bottom.

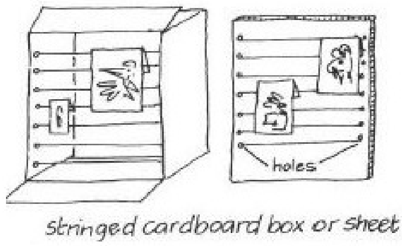
- Strips at top and bottom will strengthen the chart and make it last longer.

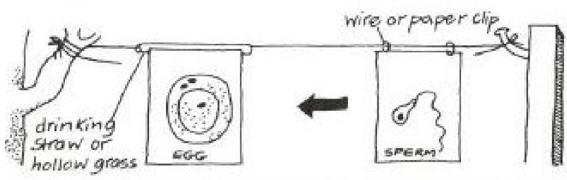
- Attach items to be displayed to the chart with office pins, cactus needles or sharpened matchsticks.

E.3.3 String Display Lines





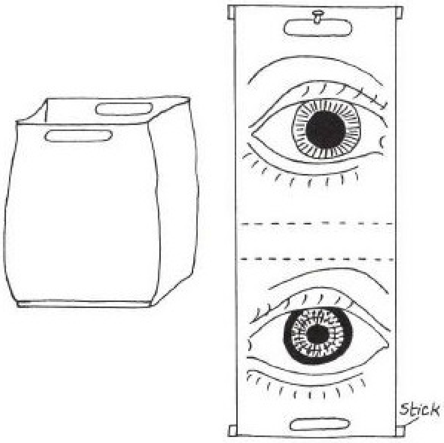




- String can be used in many ways to display items. Some ideas are given here.

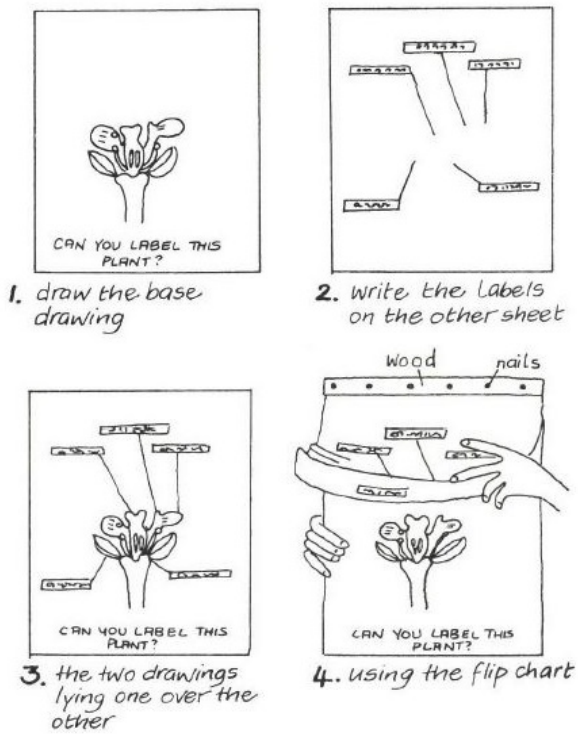
- Hollow tubes, e.g. drinking straws, or paper clips will allow the display to slide up and down the string.

E.3.4 Carrier Bag Display



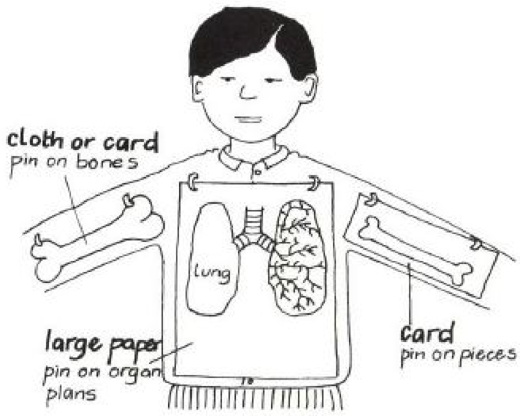
- Attaching a wooden stick at the top and bottom of the carrier bag adds strength and makes it hang flat.
- Permanent or temporary marker pens can be used to draw onto the plastic.
- Use Sellotape tabs to attach pieces to the display chart. These can be movable pieces.

E.4 Transparent Flip-Sheets



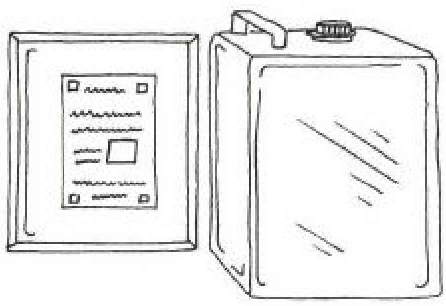
- You will need plastic sheets (from a stationery store), a bar of wood and some nails or pins.
- Lift up different sheets to show the combinations you want.

E.5 Clothing Posters



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

E.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

F.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.

F.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:

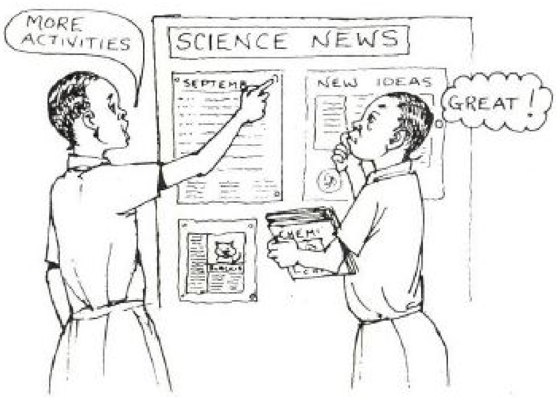
- Is it for science alone or could it include other areas (engineering and technology)?
- Are they any other clubs/ Has there been a science club in the past? If so, why did it fail?
- Are there any regulations (school or elsewhere) which might affect the formation of the club?
- Does the constitution 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!

F.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.

F.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?

F.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.

F.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.

F.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.

F.1.7 Additional Practicals

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

F.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.

F.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 multiday competition using a variety of activities. See the *Shika na Mikono* resource manuals for plenty of great competition activities.

F.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:

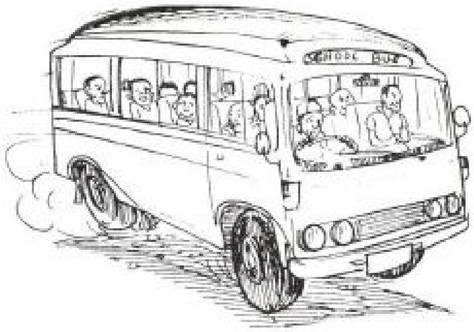
(a) held in an established institution like a school, college, university, or special study centre.

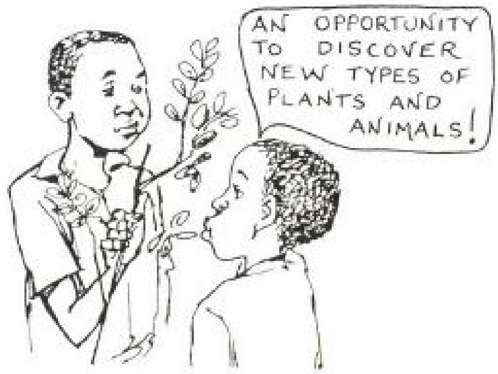
(b) may involve outdoor camping often in a remote setting, to carry out a set research project.

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.

F.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

G.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.

G.2 Science Target Groups

"A1l 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.

G.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 mini-nature 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.

G.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.

G.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.