Shika Express - Biology
Version 2.0 TZ

Hands-On Activities Companion Guide

Tanzania

Teacher's Guide

May 6, 2018

Questions or Comments?

Thank you for using the *Shika Express - Biology* manual! If you have any questions, comments, or would like to request a copy of this manual, please use the contact information given below.

Shika na Mikono Primary Contact (shika.mikono.tz@gmail.com)

You may also contact any of the current members of the Shika na Mikono team directly using the following contact information.

Ed. 2017
Kyle Golden (kylegldn@gmail.com)
Kayla Huffman (kaylarhuffman@gmail.com)
Iain Laufer (iainlaufer360@gmail.com)
Mara McKown (marasmckown@gmail.com)
Brandi Rajala (brajala@mtu.edu)
Emily Slater (eslater6@gatech.edu)

Ed. 2016
Kalvin Croto (kmcroto@gmail.com)
Marguerite Daw (margueritedaw@gmail.com)
Katharine Kobylt (kat.kobylt@gmail.com)
Jonathan McClure (jonathanmcclure37@gmail.com)
Cailin McLaughlin (cailin_mac@yahoo.com)
Paige Van de Vuurst (paigevandevurrst29@gmail.com)

To download a digital version of this manual, please visit the digital download page at the following address: http://pctanzania.org/shika

Feedback and requests for revisions to the content of any of the manuals can be made using the primary contact information above, or by visiting the Shikamikonotz Project Page at GitHub: https://github.com/shikamikonotz/

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Part I

Laboratory Development

Starting School Laboratories

A science laboratory is any place where students learn science with their hands. It might be a room, or just a box. The goal is to develop a space that facilitates hands-on learning.

1.1 Benefits of a School Laboratory

There are many benefits of having a laboratory:

- Students learn more and better science
- Students get more excited about science class
- Students have to go to the lab for class, thus eliminating those too lazy to walk over
- Practical exams are easier than the alternative-to-practical exams
- Everyone thinks practicals are important, and that science without practicals is silly.

1.2 Challenges of a School Laboratory

There are some challenges with having a laboratory:

- They are places where people can get hurt
  This is true. Please see the sections on Classroom Management in the Laboratory (p. 18) and Laboratory Safety (p. 10) to mitigate this risk.
- Many teachers do not know how to use a laboratory
  Then use the lab to teach them how to use it, thus spreading skills.
- Laboratories are far too expensive for poor schools to build and stock
  This is simply incorrect. Any room will work for a lab, and any school can afford the materials required to stock it. The rest of this book is dedicated to this point.

So you want to build a laboratory?

1.3 Step one: Location

A permanent location is obviously preferable. If your school has an extra classroom, great. The only requirements of a potential room are that it be well ventilated (have windows that either open or lack glass altogether) and be secure: bars in the windows, a sturdy door, and a lock. If you plan to put fancy equipment in your lab, remember that hack saw blades are cheap and that the latch through which many pad locks pass can be cut quickly regardless of the lock it holds. But if you are just starting, there will probably not be any fancy equipment; a simple lock is enough to keep overly excited students from conducting unsupervised experiments.

If there is no extra space at all, the lab can live in a few buckets and be deployed in a classroom during class time. "There is no lab room," is no excuse for not having a lab.

1.4 Step two: Funding

Yes, some is required. But the amount is surprisingly little – in most countries a single month of a teacher's salary is enough to furnish a basic laboratory. Almost every school can find the amount required to get started, and if not the community certainly can. A single cow in most countries would pay for a basic laboratory many times over. A cow is valuable. So is science education.

We encourage you to resist the temptation to ask people outside of the school community or school system to pay for the lab. There is simply no need to encourage that sort of dependence; this can be done locally, and it should be.

Specific Technical Needs of a School Biology Laboratory

2.1 Basic Biology Laboratory

A basic biology laboratory should allow the following investigations:

- Collection, shelter, and observation of living specimens (plant, insect, fish, reptile, mammal)
- Bacterial and fungal cultures
- Preservation and dissection of dead specimens (plant, insect, fish, reptile, mammal; both whole and parts thereof)
- Assembly and observation of miniature ecosystems
- Low power microscopy
- Diffusion and osmosis
- Chemical tests of basic biological molecules ("biochemical tests" / "food tests")
- Chemical analysis of the products of animal and plant respiration
- Non-invasive investigation of human systems (nervous, sensory, circulatory, muscular, parts of the digestive)

Key materials are:

- Containers, bottles, tubes, super glue
- Plants, insects, fish, (safe) reptiles, and small mammals
- Sugar, starch, protein source, fertilizer, salt, food coloring
- Chemicals for preservation of specimens
- Scalpels and pins
- Low power microscopes (water drop microscopes, locally assembled)
- Reagents for biochemical tests
- Reagents for gas identification
- Stopwatches
- Heat sources

Improving an Existing School Laboratory

If there is already a laboratory at your school, the immediate tasks are to see what it has, make it safe, get it organized, make repairs, and ensure smart use with sound management.

3.1 Inventory

- Making a list of what and how much of everything is in your lab is easy, if time consuming. Difficulties arise when you find apparatus you have never seen before, or containers of chemicals without labels.
- Unknown apparatus are not harmful nor useful until you know what they do. Ask around.

3.2 Organize

Have enough space

The key to organization is having enough space. Usually, this means building shelves. In the long term, find a carpenter to build good shelves. In the short term, boards and bricks, scrap materials, chairs, anything to provide sturdy and horizontal storage space. It should be possible to read the label of every chemical, and to see each piece of equipment.

Apparatus

- Arrange apparatus neatly so it is easy to find each piece.
- Put similar things together.
- Beakers can be nested like Russian dolls.

Make a map and ledger

- Once you have labeled and organized everything in a lab, draw a map.
- Sketch the layout of your laboratory and label the benches and shelves.
- In a ledger or notebook, write down what you have and the quantity. For example, Bench 6 contains 20 test tubes, 3 test tube holders, and 4 aluminum pots.

This way, when you need something specific, you can find it easily. Further, this helps other teachers – especially new ones – better use the lab. Finally, having a continuously updated inventory will let you know what materials need to be replaced or are in short supply. Proper inventories are a critical part of maintaining a laboratory, and they really simplify things around exam time.

3.3 Repair/Improve

Once the lab is organized, it is easy to find small improvements. Here are some ideas:

Build more shelves

You really cannot have too many.

Identify key apparatus needs

Sometimes a few pieces of apparatus can be very enabling, like enough measuring cylinders, for example. Buy plastic!

3.4 What next?

Once the lab is safe and organized, develop a system for keeping it that way. Consider the advice in Routine Cleanup and Upkeep (p. 20). Make sure students and other teachers in involved.

Then, start using the lab! Every class can be a lab class. That is the whole point.

Part II

Laboratory Safety

Guidelines for Laboratory Safety

There is no excuse for laboratory accidents. Students and teachers get hurt when they do something dangerous or when they are careless. If you do not know how to use a substance or a tool safely, do not use it. If your students do not know how to use a chemical or a tool safely, do not let them use it until they do. Adopt a zero tolerance policy towards truly unsafe behavior (running, fighting, throwing objects, etc.) – first infraction gets students kicked out of class for the day. Explain the error to everyone to make sure that it is never repeated. If the same student errs again, expel him for longer. Make it clear that you will not tolerate unsafe behavior.

Remember, the teacher is responsible for everything that happens in the lab. If a student is hurt the teacher is to blame. Either the teacher did not understand the danger present, did not adequately prepare the laboratory or the lesson, did not adequately train the student in safe behavior, or did not offer adequate supervision. As a teacher, you must know exactly the hazards of your chemicals, tools, and apparatus. Explain these hazards clearly and concisely to your students before they touch anything.

The following rules are for everyone in the lab to follow – students, teachers, and visitors alike. We recommend painting them directly on the wall as most paper signs eventually fall down.

4.1 Basic Lab Rules

1. Wear proper clothes. For every practical, wear shoes. Sandals are not acceptable lab ware. If you are pouring concentrated chemicals, you need to wear safety goggles.
2. Nothing enters the mouth in the lab. This means no eating, no drinking, and no mouth pipetting.
3. Follow the instructions from the teacher. Obey commands immediately. Only mix chemicals as instructed.
4. If you do not know how to do something or what to do, ask the teacher.

In addition to these rules, we recommend a variety of guidelines for teachers and lab managers to keep the lab a safe place.

4.2 Specific Guidelines to Reduce Risk

1. Never use the following chemicals:
    1.1. Organic liquids, including:
        1.1.1. Benzene (C_6H_6)
        1.1.2. Chlorobenzene (C_6H_5Cl)
        1.1.3. Dichloromethane (CH_2Cl_2)
        1.1.4. Tetrachloromethane/carbon tetrachloride (CCl_4)
        1.1.5. Trichloroethane (CH_3CCl_3)
        1.1.6. Trichloromethane/chloroform ($CHCl_3$)
    1.2. Anything containing mercury:
        1.2.1. Mercury metal (Hg)
        1.2.2. Mercurous/mercuric chloride ($HgCl/HgCl_2$)
        1.2.3. Million's Reagent ($Hg + HNO_3$)
        1.2.4. Nestler's Reagent ($HgCl_2$ + others)

2. Do not make hazardous substances

    2.1. Chlorine gas - electrolysis of chloride salts, oxidation of chloride salts or hydrochloric acid by oxidizing agents such as bleach or potassium permanganate

    2.2. Chloroamines - ammonia with bleach. People have died mixing ammonia and bleach together when mixing cleaning agents.

    2.3. Hydrogen cyanide - cyanide salts, including ferro- and ferri-cyanide, with acids.

3. Avoid hazardous substances

    3.1. If you have a choice, use non-poisonous substances. To be a good teacher, the only poisons that you have to use are those required by the national exams. For all other activities, use less dangerous substances.

    3.2. Only give students small quantities of required poisons.

    3.3. For advice on handling the various required poisons, see Laboratory Management: Dangerous Chemicals.

4. Avoid explosions

    4.1. Never heat ammonium nitrate.

    4.2. Never heat nitrates in the presence of anything that burns.

    4.3. Never heat a closed container.

    4.4. If performing a distillation or other experiment with boiling or hot gases, make sure that there is always an unobstructed path for gases to escape.

5. Avoid fires

    5.1. Be careful!

    5.2. Keep all flammable materials away from flames. Never have the following very flammable chemicals in the same room as fire: propanone (acetone), ethyl ethanoate (ethyl acetate), diethyl ether.

    5.3. Keep stoves clean and in good working order. Do not douse stoves with water to extinguish them because the metal will corrode much faster (think kinetics). There is never a need for this. If the stove does not extinguish on its own, you should repair it so it does.

    5.4. Only use the appropriate fuel for a given stove. For example, never put petrol in a kerosene stove.

6. Avoid cuts

    6.1. Only use sharp tools when required, and design activities to minimize use of sharp tools.

    6.2. Keep sharp tools sharp. The only thing more dangerous than cutting with a sharp knife is cutting with a dull one.

    6.3. Use the right tool for cutting.

    6.4. Use as little glass as possible.

    6.5. Do not use broken glass apparatus. The last thing you want to deal with during a practical is serious bleeding. It is tempting to keep using that flask with the jagged top. Do not. Do not let anyone else use it either – break it the rest of the way.

    6.6. Dispose of sharp trash (glass shards, syringe needles) in a safe place, like a deep pit latrine.

7. Avoid eye injuries

    7.1. Students should wear goggles during any activity with a risk of eye injury. See the Materials: Apparatus section for suggestions on goggles. If you do not have the goggles necessary to make an experiment safe, do not do the experiment.

    7.2. Keep test tubes pointed away from people during heating or reactions. Never look down a test tube while using it.

7.3. Never wear contact lenses in the laboratory. They have this way of trapping harmful chemicals behind them, magnifying the damage. Besides, glasses offer decent (though incomplete) protection on their own.

8. Avoid chemical spills

8.1. Teach students that if they get chemicals on their hands, they should wash them off immediately, without asking for permission first. Some students have been taught to wait for a teacher's permission before doing anything in the lab, even if concentrated acid is burning their hands. On the first day, give them permission to wash their hands if they ever spill chemicals on them.

8.2. Also, teach students to tell you immediately when chemicals are spilled. Sometimes they hide chemical spills for fear of punishment. Do not punish them for spills - legitimate accidents happen. Do punish them for unsafe behavior of any kind, even if it does not result in an accident.

9. Use adequate protection with hazardous chemicals.

9.1. Wear eye protection (see above). Find goggles or things that will substitute.

9.2. Tie a cloth over your face when using concentrated ammonia or HCl. For the latter chemical, see below.

9.3. Sulfuric Acid, H_2SO_4

9.3.1. There is never any reason to ever use fully concentrated (18 M) sulfuric acid.

9.3.2. For qualitative analysis, 5 M H_2SO_4 is sufficient for "concentrated sulfuric acid."

9.3.3. Do not buy 18 M sulfuric acid. Battery acid will suffice for qualitative analysis and is a much safer (if still quite dangerous) source of sulfuric acid.

9.3.4. If you already have 18 M sulfuric acid in your lab, just leave it. Battery acid is so cheap you can afford to get as much as you need.

9.4. Hydrochloric acid, HCl

9.4.1. Hydrochloric acid is never required.

9.4.2. Do not buy concentrated hydrochloric acid. Use battery acid for all of its strong acid applications.

9.4.3. When you need the reducing properties of HCl, for the precipitation of sulfur from thiosulfate in kinetics experiments for example, make a solution with the proper molarity of chloride and H^+ by dissolving sodium chloride in battery acid and diluting with water.

9.5. Nitric acid, HNO_3

9.5.1. The only time nitric acid is required is to dissolve certain carbonates in qualitative analysis. The first time you need nitric acid, prepare a large volume of dilute acid (e.g. 2.5 L) so that you do not need to handle the concentrated acid again.

9.5.2. If many schools share a single bottle of concentrated acid, they should dilute it at a central location and transport only the dilute acid.

9.5.3. Teach qualitative analysis of insoluble carbonates using copper, iron, or zinc carbonate – these will dissolve in dilute sulfuric acid.

10. Avoid mouth pipetting

10.1. Never do it!

10.2. This is a dangerous activity prohibited in every modern science laboratory.

10.3. Use rubber pipette filling bulbs or plastic syringes.

10.4. For more explanation, see Mouth pipetting in Dangerous Techniques (p. 16).

11. Be prepared

11.1. Set aside a bucket of water for first aid.

11.2. It should not be used for anything else.

11.3. Have materials to fight fires and know how to use them.

11.4. A bucket of sand will work for any lab fire, is available to every school, and can be used by anyone.

12. Use good habits

12.1. Hand washing

12.1.1. Students should wash their hands every time they leave the lab.

12.1.2. Always have water and soap available, ideally in buckets on a desk near the door.

12.1.3. Even if students do not touch any chemicals when they are in the lab, they should still wash their hands.

12.2. Clean all benches and chemicals

12.2.1. Stray chemicals and contaminated apparatus has the potential for danger.

12.2.2. Make sure students do not leave stray pieces of paper.

12.2.3. Ensure all students clean the apparatus they use immediately after use.

12.2.4. Have students to clean apparatus prior to use. It is not always possible to trust the students washed the apparatus after their last use.

12.3. Tasting chemicals

12.3.1. Students should never eat anything in the lab. Ever.

12.3.2. Barium nitrate looks just like sodium chloride. Lead carbonate looks like starch.

12.3.3. Do not bring food into the lab.

12.3.4. If you use domestic reagents (vinegar, salt, baking soda, etc.) in the lab, label them and leave them in the lab.

12.4. Smelling chemicals

12.4.1. Be aware that many chemicals give of fumes that can produce obnoxious odors or be irritating to the respiratory system.

12.4.2. Practicals involving nitrates, chlorides, ammonium compounds, and some sulphates produce harmful gases.

12.4.3. Open the lab windows to maximize airflow.

12.4.4. Kerosene stoves also produce noxious fumes - it is much better to use motopoa.

12.4.5. If students feel dizzy or sick from the fumes, let them go outside to recover.

12.4.6. Many lab reagents – ammonia, hydrochloric acid, nitric acid, ethanoic (acetic) acid – can cause serious damage if inhaled directly.

12.5. Keep bottles and other apparatus away from the edge of the table. Twenty centimeters is a good rule.

12.6. Cap reagent bottles when they are not in use.

12.7. Do not do things you do not want your students to do. They are always watching, always learning.

First Aid

In spite of taking all necessary precautions to avoid dangerous situations in the laboratory, emergencies may still arise which require the immediate use of First Aid techniques. Listed below are various types of possible emergencies, as well as some immediate treatment guidelines to follow until professional medical attention may be given to the victim.

Cuts

1. Immediately wash cuts with lots of water to minimize chemicals entering the blood stream.
2. Then wash with soap to kill any bacteria that may have entered the wound.
3. To stop bleeding, apply pressure to the cut and raise it above the heart. If the victim is unable to apply pressure him/herself, remember to put something (gloves, a plastic bag, etc.) between your skin and their blood.
4. If the cut is deep (might require stitches) seek medical attention. Make sure that the doctor sees how deep the wound really is – you might do such a good job cleaning the cut that the doctor will not understand how serious it is.

Eyes

1. If chemicals get in the eye, immediately wash with lots of water.
2. Keep washing for fifteen minutes.
3. Remind the victim that fifteen minutes is a short time compared to blindness for the rest of life. Even in the middle of a national exam.

First and Second Degree Burns

1. Skin red or blistered but no black char.
2. Immediately apply water.
3. Continue to keep the damaged skin in contact with water for 5-15 minutes, depending on the severity of the burn.

Third Degree Burns

1. Skin is charred; there may be no pain.
2. Do not apply water.
3. Do not apply oil.
4. Do not removed fused clothing.
5. Cover the burn with a clean cloth and go to a hospital.
6. Ensure that the victim drinks plenty of water (one or more liters) to prevent dehydration.

Chemical Burns

1. Treat chemical burns by neutralizing the chemical.
2. For acid burns, immediately apply a dilute solution of a weak base (e.g. sodium hydrogen carbonate).
3. For base burns, immediately apply a dilute solution of a weak acid (e.g. citric acid, ethanoic acid). Have these solutions prepared and waiting in bottles in the lab.

Ingestion

1. If a student ingests (eats or drinks) the following, induce vomiting.
   1.1. Barium (chloride, hydroxide, or nitrate)
   1.2. Lead (carbonate, chloride, nitrate, oxide)
   1.3. Silver (nitrate)
   1.4. Potassium hexacyanoferrate (ferr[i/o]cyanide)
   1.5. Ammonium ethandioate (oxylate)
   1.6. Anything with mercury (see list above), but mercury compounds should just never be used.

2. To induce vomiting:
   2.1. Have the student put fingers into his/her throat
   2.2. Have the student drink a strong solution of salt water (use food salt, not lab chemicals)

3. Do not induce vomiting if a student ingests any organic chemical, acid, base, or strong oxidizing agent.
   3.1. These chemicals do most of their damage to the esophagus and the only thing worse than passing once is passing twice.
   3.2. Organic chemicals may be aspirated into the lungs if vomited, causing a sometimes fatal pneumonia-like condition.

Fainting

1. If a student passes out (faints), feels dizzy, has a headache, etc., move him/her outside until fully recovered.
2. Check unconscious students for breath and a pulse.
3. Perform CPR if necessary and you know how.
4. Generally, these ailments suggest that harmful gases are present in the lab – find out what is producing them and stop it. Kerosene stoves, for example, may emit enough fumes to have this effect.
5. See Sources of Heat in the Materials section for alternatives.
6. Chemicals reacting in drain pipes can also emit harmful gases. See Waste Disposal.

Electrocution – If someone is being electrocuted (their body is in contact with a live wire)

1. First disconnect the power source. Turn off the switch or disconnect the batteries.
2. If that is not possible, use a non-conducting object, like a wood stick or branch, to move them away from the source of electricity.
3. Unless there is a lot of water around, the sole of your shoe is non-conducting.

Seizure

1. If a student experiences a seizure, move everything away from him/her and then let the body finish moving on its own.

Dangerous Techniques

Some common laboratory techniques are actually quite dangerous. Identify practices in your school that seem likely to cause harm and devise safer alternatives. Below are some examples of techniques often performed in the laboratory that can easily bring harm and alternative methods to do the same thing more safely.

Mouth Pipetting

Many schools use pipettes for titrations. Many students use their mouths to fill these pipettes. We strongly discourage this practice. The solutions used in ordinary acid-base titrations are not particularly dangerous. A little 0.1M NaOH in the mouth does not merit a trip to the hospital. Nevertheless, there are two pressing safety issues.

1. First, there are often other solutions present on the same benches the qualitative analysis test reagents for example that can kill if consumed. It seems like it would be a rare event for a student to mix up the bottles, but in the panic of the exam anything is possible.

2. Second, safety issue applies to the best students, those that continue on to more advanced levels. High level secondary and university students must measure volumes of the size fit for pipettes for chemicals that under no circumstances should be mouth pipetted. If a student is trained in mouth pipetting, she will continue with this habit in advanced level, especially in a moment of frustration when a pipette filling bulb seems defective, or if the school has not taught her how to use them, or if they are not supplied. Students have died in many countries from mouth pipetting toxins.

Fortunately, there is no reason to ever use a pipette in secondary school, even if rubber-filling bulbs are present. *Disposable plastic syringes are in every way superior to pipettes for the needs of students.*

- They have no risk of chemical ingestion.
- They are more accurate plastic is much easier to make standard size than glass; the pipettes available generally vary from their true volume, but all the syringes of the same model and maker are exactly the same volume.
- Plastic syringes are easier to use
- They are faster to use
- They are much more durable
- When they do break they make no dangerous shards
- They are much less expensive, by about an order of magnitude

Schools all over are already substituting plastic syringes for glass pipettes.

Shaking Separatory Funnels

Separatory funnels are useful for separating immiscible liquids. They are also made of glass, very smooth, and prone to slipping out of students' hands. The liquids often used in these funnels can be quite harmful and no one wants them splashed along with glass shards on the floor. Much better is to add the mixture to a plastic water bottle, cap it tightly, and shake. After shaking, transfer the contents of the bottle into a narrow beaker. Either layer can be efficiently removed with a plastic syringe.

There are some cases where a separatory funnel remains essential. For secondary school, however, simply design experiments that use other equipment - and less harmful chemicals.

Looking Down into Test Tubes

May blind.

Part III

Laboratory Management

Classroom Management in the Laboratory

In addition to the guidelines recommended in the Laboratory Safety section, we recommend the following strategies to keep lab work safe, productive, and efficient.

Set lab rules

Before the first practical of the year, hold a short session to teach lab rules and lab first aid. Try to set a few clear, basic rules (like the four proposed in the Laboratory Safety section) instead of a long list of rules. Post these rules in the lab, and be consistent and strict in enforcing them with students and teachers.

Train students in basic techniques

For students just beginning laboratory-based education, you can probably teach each specific skill one at a time as they come up in experiments. For more advanced students, especially when they have different backgrounds in terms of laboratory experience, it is wise to spend several sessions practicing basic techniques (e.g. titrations for chemistry, using the galvanometer for physics, etc).

Have students copy the lab instructions before entering the lab

Do not let them into the lab unless they can show you their copy of the procedure, etc. Have a class dedicated to explaining the practical activity before the actual session. Bring a demo apparatus into the classroom.

Demonstrate procedures at the beginning

Do not assume that students know how to use a syringe or measure an object with calipers. If there are many new procedures, hold a special session before the practical to teach them the procedures. For titration, for example, hold a practice session in using burettes and syringes with water and food coloring. For food tests, explain and demonstrate each step to the students before holding a practical. It will save you a lot of trouble during the actual practical.

Have enough materials available

Always prepare 25-50 percent more reagent than you think you will need. Also have spare apparatus in case they fail in use. For example with physics, have extra springs, resistors, weights, etc. That said; do not make all of what you prepare immediately available to the students. As with sugar and salt, an obvious surplus increases consumption. If there is a definite scarcity of resources, it may be necessary to distribute the exact volumes necessary to each student. If you are doing this, make sure students understand that there is no more. In an exam, you might take unique objects, such as ID cards, to ensure each student receives her/his allotment only once.

Have enough bottles of reagent available

Even if only a small quantity of a reagent is needed, divide it into several bottles and put a bottle on each bench. If the volume is sufficiently small, distribute the chemical in plastic syringes. Do not use syringes for concentrated acids or bases because these chemicals can degrade the rubber in the syringe, there is a risk of the syringe jamming and the student squirting chemicals into eyes. The waiting caused by shared bottles leads to frustration and quarrels between groups. The last thing you want are students wandering around the lab and crowding to get chemicals.

Designate fetchers

If students must share a single material source, designate students to fetch materials If a reagent needs to be shared among many students, explain this at the beginning, and have them come to the front of the room to get it rather than carrying it to their benches. This will help to avoid arguments and confusion over where the reagent is. If the students are in groups, have each group appoint one student to be in charge of fetching that chemical. However, it is much better to have the reagent available for each group at their workplace.

Teach students to clean up before they leave

This will save you a lot of time in preparing and cleaning the laband it is just a good habit. Do not let students leave the lab until their glassware is clean and the bench is free of mystery salts and scraps of paper. If they do, consider not letting them in for the next practical. This might take assigned seats if you have many students. When they perform this clean up, make sure they follow whatever guidelines you have set for proper waste disposal.

Allow more time than you think you will need

What seems like a half hour experiment to you may take an hour for your students. Add fifteen minutes to a half hour more than you think will be necessary. If you finish early, you can have them clean up and then do a bonus demonstration.

Know the laboratory policies at the school

What is the policy on replacing broken equipment at the school? As a teacher, you need to know what you are going to do when the student drops an expensive piece of glassware. It is no fun to make up procedure while a student is in tears. What criteria will you use to determine if the student is “at fault?” Of course, this is less of an issue if you do not use glass apparatus.

Routine Cleanup and Upkeep

Like gardens and children, laboratories require constant attention. The Second Law of Thermodynamics does not sleep. The following advice should keep you on the winning side of the struggle against entropy.

Things to do immediately

- Remove broken glass from the floor. Use tools, like pieces of cardboard, not fingers!
- Neutralize and wash up chemical spills
- Replace chemical labels that have fallen off

The person who made the mess should clean it up. Make sure they know how before they are in a position to make a mess. If they are unable (e.g. hurt), have someone else do it. Review the incident with everyone present focusing on how to prevent similar accidents in the future. Avoid blaming other people – as the supervisor the accident is your fault; either you did not train someone well enough or your supervision of their behavior/technique was inadequate.

Things to do right after every lab use

- Return stock containers of chemicals to the store area. Only teachers should move glass bottles of corrosive or toxic chemicals. Remember to carry these with two hands!
- Transfer waste, including chemicals to be reused, into suitable storage containers
- Return apparatus to their proper places
- Put broken apparatus in a special place
- Wash off all benches / tables

The people who used the lab should do these things. If it is a lab class, the students should clean up the lab in that class period. If it is a group of teachers preparing experiments, the teachers should clean up their mess. Mess tends to grow with time, and no one wants to clean up someone else's mess.

Things to do either right after lab use or later that same day

- Transfer chemicals to be reused into more permanent and well labeled storage containers.
- Process all waste for disposal.
- Remove all trash from the laboratory.

If done right after lab use, those who used the lab should do this work. If the work is done later anyone can take out the trash but waste should only be processed by someone who knows what (s)he is doing, and never working alone.

Things to do every week

- Sweep and mop the floor. Note that this should be done with brooms and buckets of water, or long handled mops, not by pushing cloth on the floor directly with hands.
- Wipe down the chemical storage area. Check for broken and leaking bottles.
- Ensure that sinks (if present) are not clogged. If a sink is clogged, either unclog it immediately or prevent use of the sink by physically obstructing the basin and also writing a sign. Signs by themselves are often insufficient. Barriers with signs tend to get moved.

You can do this work or you can train students to do it. Supervise their work while they are learning to make sure they use safe techniques. Ensure that students never work alone – even for mopping at least two students must be present at all times. Students should not work in the chemical storage area without a teacher present.

Laboratory Techniques in Biology

Preservation of Specimens

9.1 Dead Specimens

- Mosses and lichens: Wrap in paper or keep in a closed container.
- Plants and parts thereof: hang in the sun until dry. Alternatively, press the plants using absorbent material and a stack of books.
- Insects: Leave exposed to air but out of reach by other insects until bacteria eat everything except the exoskeleton. If you want to preserve the soft tissue, store under methylated spirits.
- Fish, worms, amphibians, and reptiles: Store in methylated spirits (will makes specimens brittle) or a 10% formaldehyde solution (more poisonous and more expensive).
- Parts of mammals (e.g. pig eyes, bovine reproductive organs): store in 10% formaldehyde solution.

9.2 Skeletons

Skin the animal and remove as much meat as possible. Bury the bones for several months. Exhume and assemble with wire and superglue.

9.3 Living Specimens

Be creative! Figure out what the animal will eat, who will feed it, what it will drink, where it can hide, how it can be observed, etc.

Dissection

10.1 Preparation of Specimens

Unless you want students to observe a beating heart, dead specimens are much easier to work with than unconscious ones. This also removes the problem of stunned animals waking up in the middle of their dissection.

- Flowers and other plant parts: No preparation required as long as the samples are relatively fresh. Store samples in closed plastic bags to minimize drying. If you intend to keep them for more than a day or two, submerge the bags in cold water to slow the rate of molding.
- Insects: Kill with household aerosol insecticide. Use specimens within one day of collection, unless you have refrigeration or freezer.
- Fish: Keep living until the day of the dissection. Then remove from water until they suffocate. Use immediately after death.
- Frogs: Able to breathe above and below water, frogs are hard to starve of oxygen. One option is to seal them in a container of methylated spirits and then rinse the dead bodies with water prior to dissection.
- Reptiles, birds, and mammals: For most organ systems, you can kill the animal by blunt trauma without ruining the lesson. Students can even bring animals caught and killed in homes. Snakes should be decapitated along with enough of the body to remove the fangs and venom sacks. Bury these deeply. Do not use animals killed by poison, or those that were found dead. For completely undamaged specimens, enclose the live animal in a cage (or a tin with adequate holes) and submerge in a bucket of water until drowned.
- Living specimens: If you really want to see that heart beating, use chloroform. This can be transferred from bottle to specimen jar via cotton ball, or perhaps made in situ by the reaction between propanone (acteone) and bleach. We have not yet attempted the latter if you do, remember that the products are poisonous gases; indeed, that is the point. Note that if you use too little chloroform, the animal will feel the blade opening it up. If you use way too little, it may start squirming. If you use too much chloroform, however, you will simply kill the animal you might as well have drowned it.

10.2 Tools

For more, see the section on Local Materials List (p. 78).

- Scalpels can be made using razor blades and tongue depressors. Make sure the razors are very sharp. If the blade is dull or floppy, the students will probably push too hard, and may cut themselves when the skin finally gives and the blade slips.
- Optical Pins from new disposable syringes are an easy option.
- Dissection trays can be prepared using cardboard or by making a 1 cm thick layer of wax on the bottom of a shallow tray or bowl. This surface will readily accept pins and is easy to clean.

10.3 Procedure

This varies by species. The internet has many resources and there are many good books with very detailed instructions alas, this manual is not yet one of them. A crude method follows:

1. Position the specimen on its back and make a clean, symmetric, and shallow incision down the full length of the underside.

2. Make additional perpendicular cuts at the top and bottom of the torso for an overall I shape. These cuts should only just penetrate the body cavity.

3. Open up skin "door" you have created, pinning them back onto the dissection tray.

4. Pick an organ system circulation, digestion, nervous, etc and, with the aid perhaps of a good drawing, remove other material to focus on the target anatomy.

You can teach many systems from one specimen start with the most ventral (front) and move to the most dorsal (back).

Encourage students to sketch at various steps in the process. Also encourage them to identify anatomy for themselves, perhaps with the aid of thought provoking questions and discussion in groups.

10.4 Cleanup and Carcass Disposal

Wash all blades, pins, and trays with soapy water. Rinse all tools to remove the soap and then soak for about fifteen minutes in bleach water. When finished, rinse again in ordinary water.

Bury all carcasses in a deep pit, below the reach of dogs. You may also add kerosene and burn, but this smells bad and costs money.

Preparation of Culture Media

11.1 Introduction

In microbiology, there are two basic types of media: solid agar media and a liquid broth media. From these, many types of media can be made. Generally, exact amounts of ingredients are not needed so if you want to make some agar plates or liquid cultures try with the resources you have. The recipes listed are a guideline to help you get started.

11.2 Media Recipes

11.2.1 Basic Agar (1.5%)

- 15 g/L agar
  it is like gelatin or if you can find seaweed you can grind it up
- 10 g/L nutrient source
  e.g.sugar, starch (potatoes), beans fruits like mango and papaya
- 1-2 g/L salts and phosphates
  this varies with what you want to grow experiment! (table salt is usually fine)
- 1 L water

Add and mix all the ingredients together and heat until boiling. Boil for $\tilde{1}5$ minutes and make sure all the gelatin/agar is dissolved. Pour liquid into Petri plates (15-20 mL each). The plates should solidify $\tilde{4}5$C. Cover and keep agar side up in a cool place if possible. If the plates do not solidify, try adding more gelatin or corn starch to thicken it up. You can also pour agar into test tubes/syringes to do oxygen tests (aerobic vs. anaerobic)

11.2.2 Blood Agar

- 15 g/L agar/gelatin/ground sea weed
- 10 g/L nutrient source
- 15 mL sheeps blood (other organizisms also work)
- 1 L water

Heat and boil agar, nutrient source and water for 15 minutes. After liquid has ceded ($\tilde{4}5$C (when you can leave your hand on the flask for a few seconds) add in blood until the mixture is blood red. Swirl in and pour into plates.

11.2.3 Liquid Broths

- 10 g nutrient source
- 1 L water
- 1-2 g salts/phosphates

  Mix together, heat, and boil. Distribute in test tubes.

11.3 Things you can do after media preparation

- Agar-streaked plates! Swab something (back of throat, nose, belly button, door handle, etc) and gently rub onto the agar. Try not to gouge the agar.
- You can also do experiments to test the effects of salt concentrations, temperature, and nutrient concentrations.
- After all the plates solidify, incubate them at around 25-30°C. Ideally the temperature remains constant. Check the plates after 24 hours for growth.
- For liquid broths you can inoculate test tubes with a sample from the environment. Incubate and check like agar plates. If there is growth the liquid will be turbid instead of clear like a control tube with only broth.
- You can use liquid cultures for wet mounts under microscopes as samples for agar plates or to allow students to see the difference between growth and no growth.

11.4 What to use if you do not have plates or test tubes

- Use old water bottles or old plastic packaging for plates
- Use anything rigid and heavy for covered, e.g. building tiles
- Sealed/closed plastic syringes for test tubes
- Try to keep materials as sterile as possible but do not worry if there is contamination. Use contamination as a learning experience. Penicillin was contamination and it became a wonder drug.

11.5 Things to do once you have cultures

- Take a sample from agar plate and drop hydrogen peroxide on it. Does it bubble? (Yes, it has catalase)
- Extract DNA from *E. coli.*
- Fermentation = use a liquid broth with peptone, acid-base indicator like phenol red, and inverted tube to trap gas and 0.5 1.0% of carbohydrate you want to test. If fermentation occurs (phenol red), the broth will turn yellow and gas should be collected in the tube. If the tube remains red, you can test for glucose production by adding a few drops of methyl orange. If the pH is below 4.4, it will remain red. If the pH is above 6.0, it will turn yellow.

11.6 Guide to Identifying Common Microorganisms

- *Pseudomonas aeroginosa*: is green and smells like grape jelly (can grow in disinfectant)
- *Serratia marcescens*: grows pink-red between 25-32C (will be white otherwise)
- *Escherichia coli*: pale white/yellow, smells like inole
- *Proteus spp*: swarm on plates and smell like urine and brownies
- *Bacillus subtillis*: pale beige, smells a bit sweet
- *Vibrio cholera*: smells like buttery popcorn
- Staph vs Strep: Staph is catalase (+), strep is (-)

Using a Microscope

12.1 Parts of a Microscope

- Eyepiece: or ocular lens is what you look through at the top of the microscope. Typically, the eyepiece has a magnification of 10x.
- Body Tube: tube that connects the eyepiece to the objectives
- Objective Lenses: primary lenses on the microscope (low, medium, high, oil immersion) which are used to greater magnify the object being observed. A low power lens for scanning the sample, a medium power lens for normal observation and a high power lens for detailed observation. Normal groups of lens magnifications may be [4, 10, 20] for low magnification work and [10, 40, 100] for high magnification work. Some microscopes also use oil immersion lenses and these must be used with immersion oil between the lens and the cover slip on the slide. Oil immersion allows for a much greater magnification than air and typically ranges from 40x-100x.
- Revolving Nosepiece: houses the objectives and can be rotated to select the desired magnification.
- Coarse Adjustment Knob: a large knob used for focusing the specimen
- Fine Adjustment Knob: small knob used to fine-tune the focus of the specimen after using the coarse adjustment knob.
- Stage: where the specimen to be viewed is placed
- Stage Clips: used hold the slide in place
- Aperture: hole in the stage that allows light through to reach the specimen
- Diaphragm: controls the amount of light reaching the specimen
- Light Source: is either a mirror used to reflect light onto the specimen or a controllable light source such as a halogen lamp

12.2 How to Use a Microscope

- Always carry a microscope with two hands! One on the arm and one on the base!
- Plug the microscope into an electrical source and turn on
- Make sure the stage is lowered and the lowest power objective lens is in place
- Place the slide under the stage clips with specimen above the aperture
- Look through the eyepiece and use the coarse adjustment knob to bring the specimen into focus
- If the microscope uses a mirror as the light source, adjust the mirror so enough light is reflected through the aperture onto the specimen
- You can adjust the amount of light reaching the specimen by opening and closing the diaphragm
- Once the object is visible, use the fine adjustment knob for a more precise focus
- At this point you can increase the magnification by switching to a higher power objective lens
- Once you switch from the low power objective lens, you should no longer be using the coarse adjustment knob for focusing because it is possible to break the slide and scratch the lenses

- If you switch objectives, use the fine adjustment to fine-tune the focus of the object If the high powered objective lenses on the microscope say oil then you can place a small drop of immersion oil on the cover slip then switch to the oil immersion lens. *Only use the oil immersion lens with immersion oil and dont use oil with any other objective that does not say oil.*
- Once you have finished observing the specimen, lower the stage, remove the slide, and return to the lowest objective
- Clean the lenses with lens cleaner and lens paper (only use lens paper as other tissues will scratch the lenses)
- Wrap the cord around the base and cover the microscope for storage

12.3 Making a Wet Mount

- Collect a thin slice (one cell layer thick is optimal) of specimen and place on the slide
- Place a drop of water directly over the specimen
- Place a cover slip at a 45 degree angle over the specimen with one edge touching the drop of water then drop the cover slip over the specimen. If done correctly, the cover slip will completely cover the specimen and there will be no air bubbles present.

12.4 Staining a Slide

- Once you have completed the above process place one small drop of stain (ex. Iodine, methylene blue) on the outside edge of the cover slip
- Place the flat edge of a paper towel on the other side of the cover slip. The paper towel will draw the water out from under the cover slip and pull in the stain

12.5 Magnification

The actual power of magnification is a product of the ocular lens (usually 10x) times the objective lens.

Ocular lens (eyepiece)	Objective Lens	Total magnification
10x	4x	40x
10x	40x	400x
10x	100x	1000X

12.6 Troubleshooting

1. The Image is too dark!
   Adjust the diaphragm and make sure your light is on.
2. There's a spot in my viewing field, even when I move the slide the spot stays in the same place!
   Your lens is dirty. Use lens paper, and only lens paper to carefully clean the objective and ocular lens. The ocular lens can be removed to clean the inside.
3. I can't see anything under high power!
   Remember the steps, if you can't focus under scanning and then low power, you won't be able to focus anything under high power.
4. Only half of my viewing field is lit, it looks like there's a half-moon in there!
   You probably don't have your objective fully clicked into place.

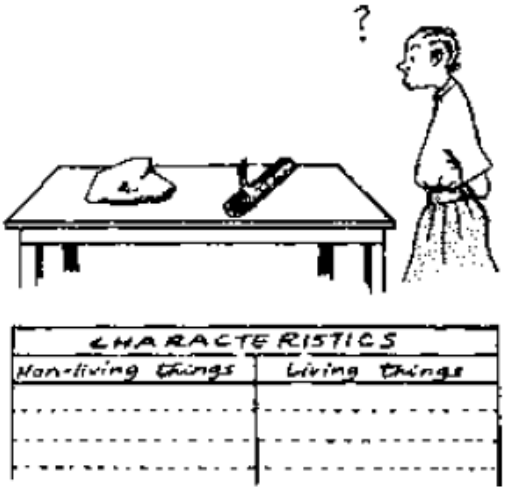
Hands-On Activities

Biology Activities for Form I

13.1 Introduction to Biology

Characteristics of Living Things

13.1.1 Obvious Characteristics of Living Things

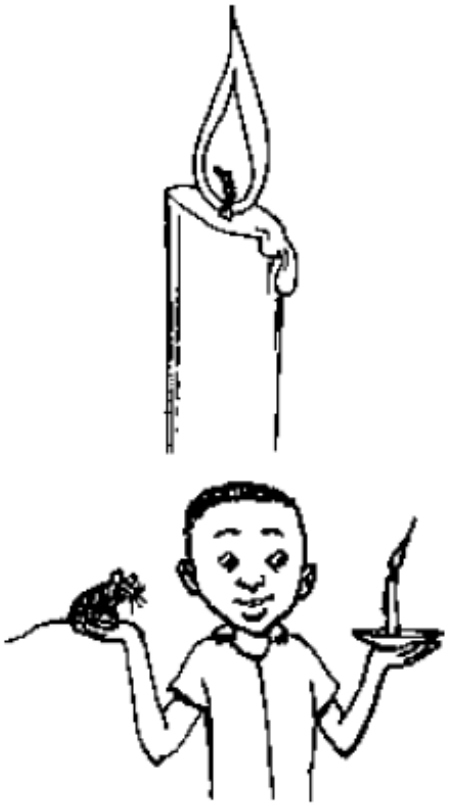


Procedure: Display some non-living things such as a stone, piece of wood, glass of water etc., and list any obvious differences between these things and a living organism (i.e. man). Produce a table from the whole class response.

13.1.2 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.

13.1.3 Is a Candle Living?



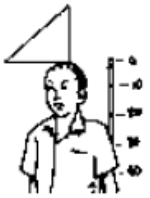
Procedure: Look at a burning candle. The candle flame can be considered as an example of a process in a state of dynamic equilibrium.

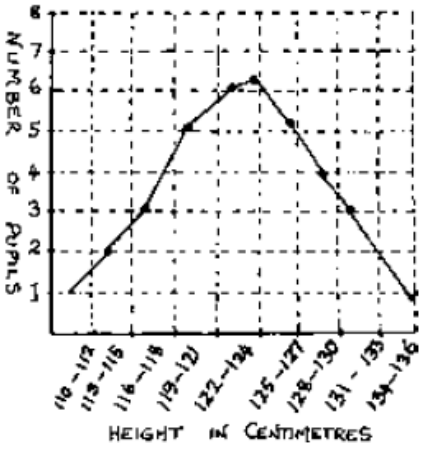
Questions: What are the similarities and differences between a candle flame and a living organism.?

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 selfsustained and cannot reproduce itself.

Measurement in Biology

13.1.4 Data on Height





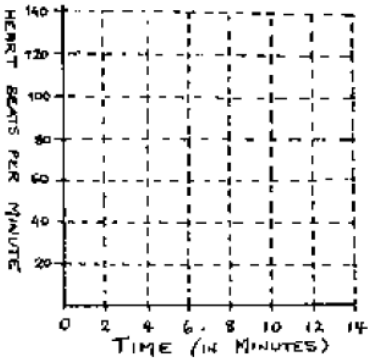
Procedure: Obtain the heights of all the student in the class (in centimetres). Use these heights to divide the students into groups (i.e. 110-112 cms, 113-115 cms etc). Count the number of pupils in each group. Plot a graph of height against numbers.

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.

13.1.5 Data on Pulse Rate



	← STRESS →					← REST →				
MINUTES	0	2	4	6	8	10	12	14	16	18	20
FIRST GIRL											
SECOND GIRL											

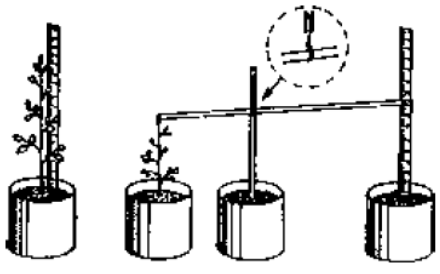
Procedure: Take the resting pulse rate of ten students, then ask them to run around the school compound for two minutes. Take the pulse of each student at two minute intervals until the pulse returns to normal. For each student plot a graph of pulse rate against time.

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.

13.1.6 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.

13.1.7 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.

13.1.8 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

13.1.9 Transport of Water

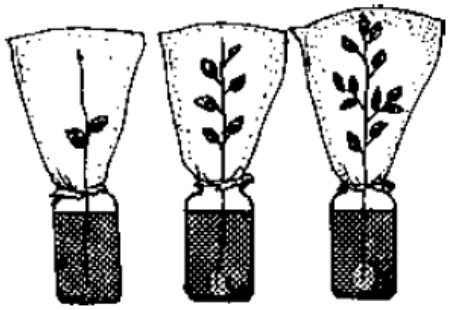
Hypothesis: Water is transported to the leaves where it is lost.

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.

13.1.10 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.

13.1.11 Hand Washing

Materials: Soap, water, bottle, basin/bucket, chalk, charcoal, food colour, stopwatch
Setup: Prepare a large amount of soapy water. Grind the chalk and charcoal into separate powders.

Problem: How long should we wash our hands?

Material	**Hypothesis (Seconds)**	**Experimental Result**
Chalk powder		
Charcoal powder		
Food colour		

Hypothesis: Predict how much time it will take to completely clean your hands and record in the table.
Procedure: Start a stopwatch and have a student or teacher slowly pour soapy water over a basin while the student washes his or her hands. Stop the clock when the student's hands are completely clean.
Observations: Record the time taken to completely wash your hands in the table.
Questions:

1. Why is it important to wash our hands?

2. When do we need to wash our hands?

Theory: Washing our hands with soap and water helps to kill harmful bacteria that can cause us to become sick if allowed into our bodies. It is very important to wash our hands before eating and after using the bathroom.

13.1.12 Lung Capacity

Materials: 1.5 L bottle, basin, water, plastic tubes/straws, soap, marker, ruler
Setup: Make a scale on the bottle using a marker and ruler (e.g. 100 mL increments). Prepare a soap solution for washing the tubes/straws

Problem: How much air can your lungs hold?

Breath	**Hypothesis (Volume of air in mL)**	**Experimental Result**
Normal breath		
Full breath		
After holding breath for 10 seconds		

Hypothesis: Record the volume of air that you think the lungs can hold for each case in the table.
Procedure: Fill a basin with water. Fill a 1.5 L bottle with water and invert it in the basin so that the mouth of the bottle is underneath the water. Place one end of the tube/straw inside the bottle under water. For each breath, blow into the tube to displace the water.
Observations: Note the reading on the scale before and after blowing into the tube and record the *difference* to give the amount of water displaced.
Questions:

1. Which breath produces the largest amount of air? Which give the smallest amount?

2. How long can you hold your breath?

   Hypothesis: I can hold my breath for _____ seconds.

   Experimental Result: I can hold my breath for _____ seconds.

Theory: When we breath in air, our bodies use the oxygen and produce carbon dioxide in a process called *respiration*. Oxygen is transported in our blood throughout our bodies. When we hold our breath, oxygen is not circulated throughout our bodies and we begin to feel lightheaded.

13.2 Safety in Our Environment

Waste Disposal

13.2.1 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!!

13.2.2 Planting Trees

Procedure: Planting trees and protecting newly planted trees from animals is one way for community members to look out for the well-being of their environment and maintain and beautify their homes and schools.

Theory: Trees consume excess carbon dioxide, which is a harmful greenhouse gas that eats away at our ozone layer. They produce the oxygen that we breath and help to maintain a balanced ecosystem for other organisms.

Applications: Many individuals cut down trees for firewood but fail to replace them with newly planted trees. Over time this can lead to erosion and degradation of the land.

13.2.3 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?

13.2.4 Water Purity Surveys

Procedure: Keeping a record of water purity and health in a local community is a great way to raise awareness about environmental protection. Students can test for hardness of water, pH, or other impurities and harmful bacteria present in water samples.

Questions: What are some other ways that you can get involved in protecting the environment?

13.3 Health and Immunity

13.3.1 Coughs and Sneezes Spread Diseases

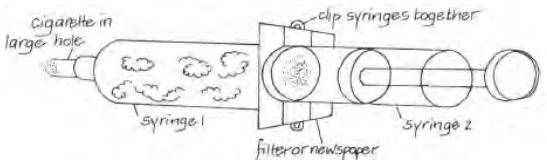
Procedure: Place the matches in the match box as shown and ignite one.

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.

13.3.2 Smoking and Health



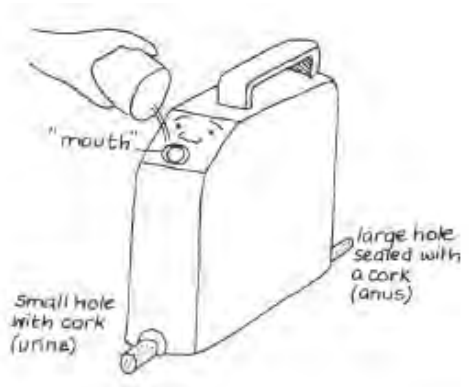
Materials: 2 syringes, filter paper, cigarette

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.

13.3.3 Water Baby



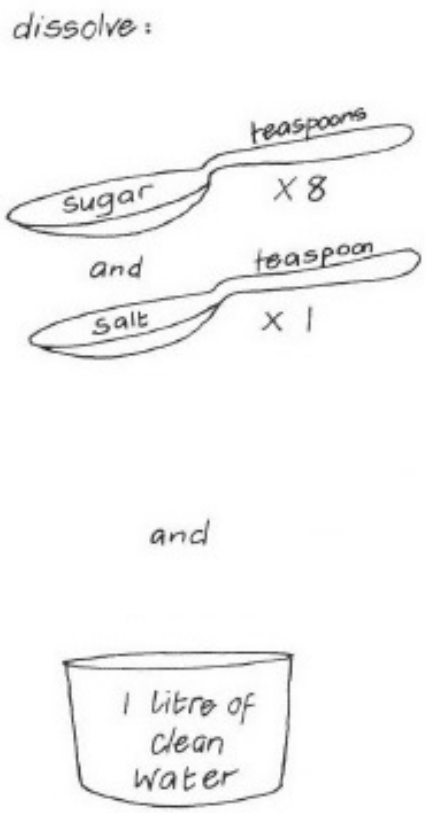
Materials: Plastic bottle, 2 corks, water

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.

13.3.4 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.

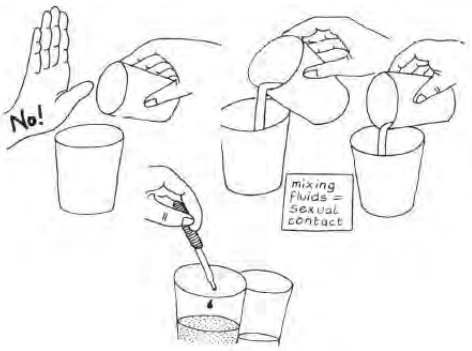
13.3.5 HIV Acting

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 HlV.

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.

13.3.6 Passing On HIV



Materials: Cards, starch solution, iodine solution

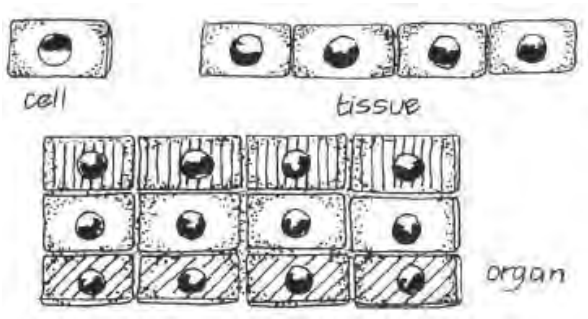
Setup: On the cards write down some sexual case histories. Give each student a card at random. The owner of the card is to follow the behaviour indicated on the card, e.g. faithful to one partner, many partners, no partners.

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 'HlV test' the contents of the cups using a few drops of iodine solution. lf 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.

13.4 Cell Structure and Organization

13.4.1 Cells, Tissues, Organs



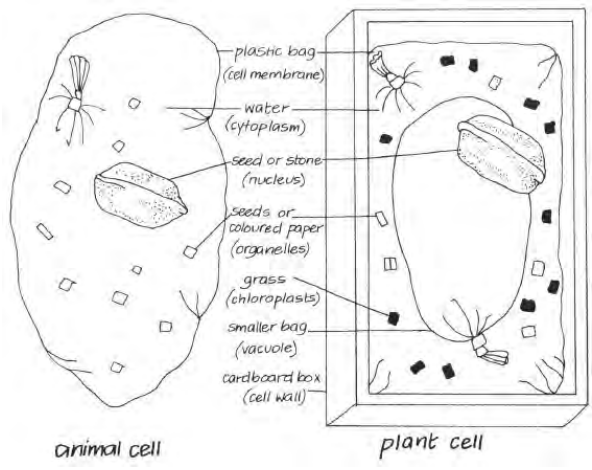
Materials: Matchboxes, peas/beans/stones, boxes of different colour or size

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.

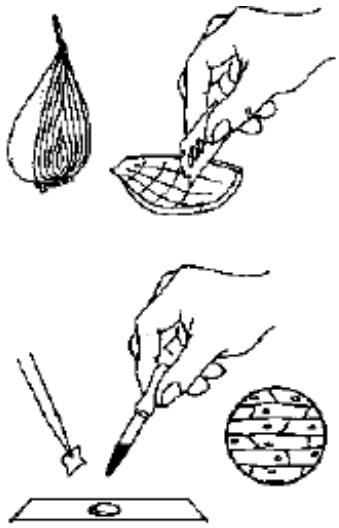
13.4.2 Cell Models



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.

13.4.3 Looking at Cells



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

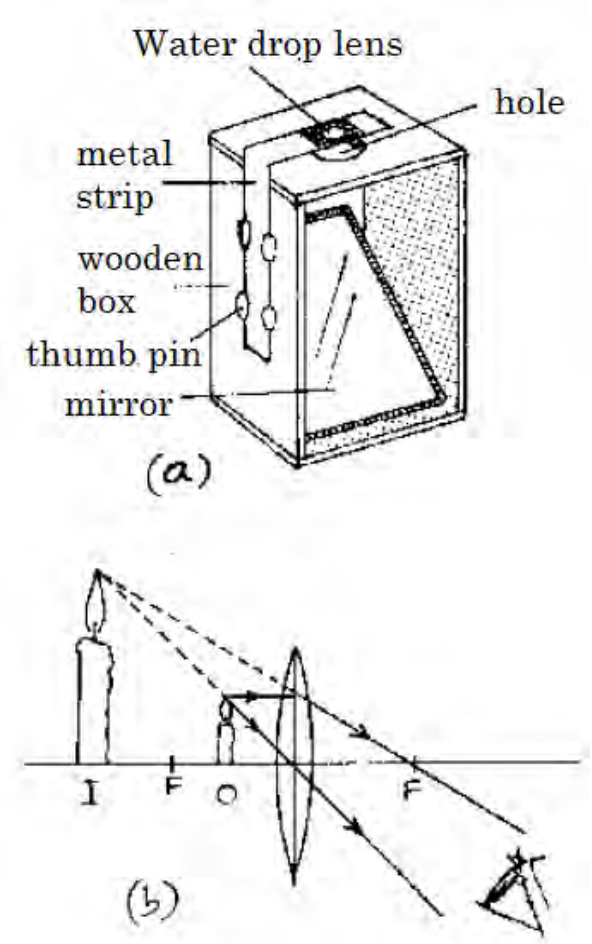
Procedure: Cut a slice of onion and gently peel off a piece of the thin inner surface skin layer. With a pin/needle place a piece of 'skin' in a water drop on a piece of glass. Stain the 'skin' with a drop of iodine solution. Lower a cover slip (plastic strip) onto the specimen taking care not to let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

13.4.4 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.

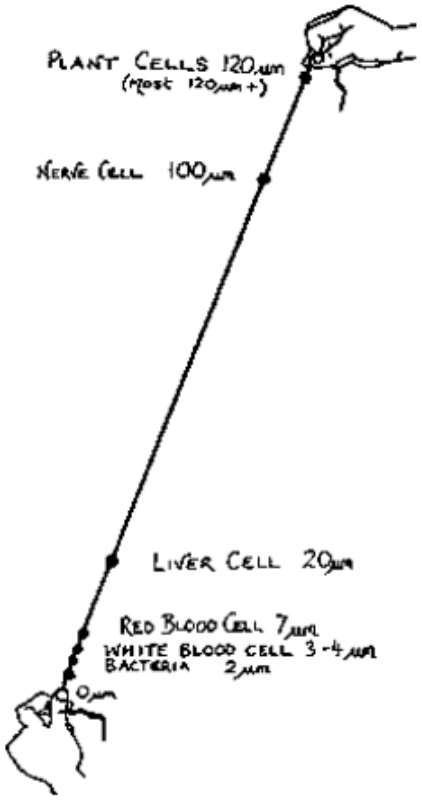
13.4.5 Simple Microscope



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.

13.4.6 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?

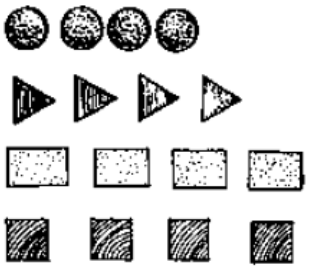
Observations: 50 times.

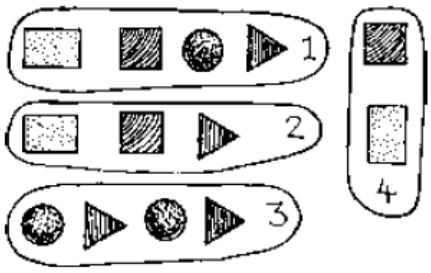
Theory: Although almost all cells are too small to be seen with the unaided eye, they show a wide range of sizes (about the same range as a mouse and an elephant).

13.5 Classification of Living Things

Concept of Classification

13.5.1 Arranging Shapes





Materials: Paper/card, coloured pens/pencils

Procedure: Make four of each of the following shapes: squares (3 cm × 3 cm) triangle (3 cm sides) rectangles (3 × 4 cm) circles (3 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).

13.5.2 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.

13.5.3 Find a Missing Person

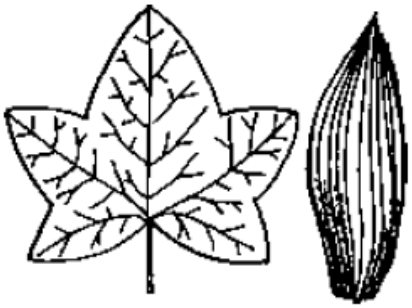
Procedure: Imagine that you have been asked to find one particular person on earth.

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).

13.5.4 Classifying Leaves



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

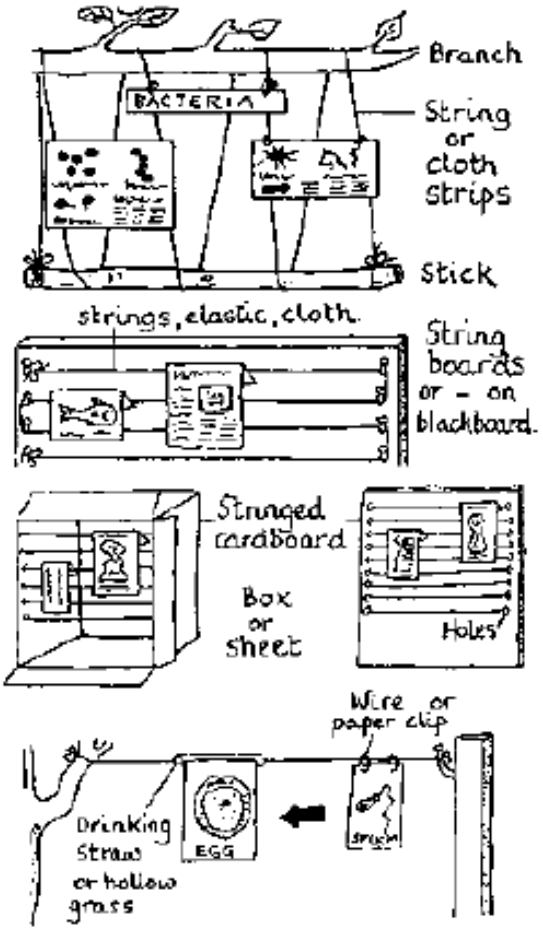
Questions: How many ways can you find to group the leaves?

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

13.5.5 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.

13.5.6 Display Boards



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

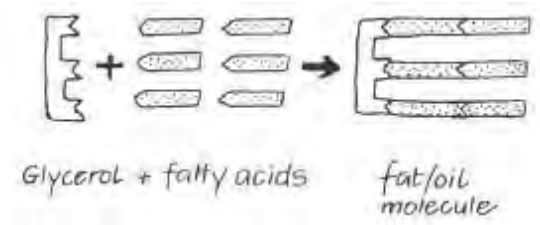
Procedure: Construct display boards as shown to present information about specimen collected. Students can present their displays to the class or as part of a science fair project.

Biology Activities for Form II

14.1 Nutrition

Properties of Food Substances

14.1.1 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.

14.1.2 Solubility of Fats and Oils

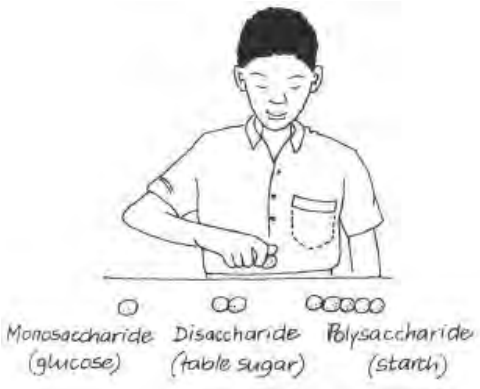
Materials: Oil, water, petrol, 2 containers

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.

14.1.3 Carbohydrates



Materials: Peas, beans or other small identical items

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

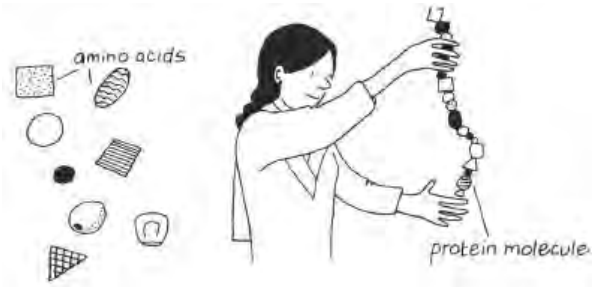
Theory: Each pea is a monosaccharide, e.g. glucose. Putting 2 together makes a disaccharide, e.g. table sugar, and a long chain of them a polysaccharide, e.g. starch.

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

14.1.4 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.

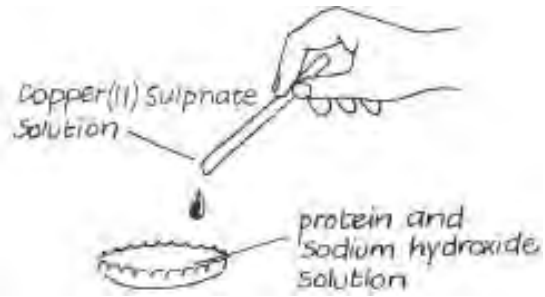
14.1.5 Protein Molecules



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.

14.1.7 Test for Protein



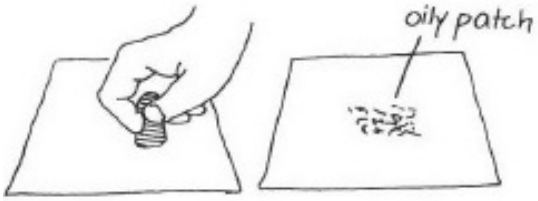
Materials: Copper (II) sulphate solution, sodium hydroxide solution, food sample (e.g. egg), bottle cap, straw

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

14.1.6 Test for Lipids



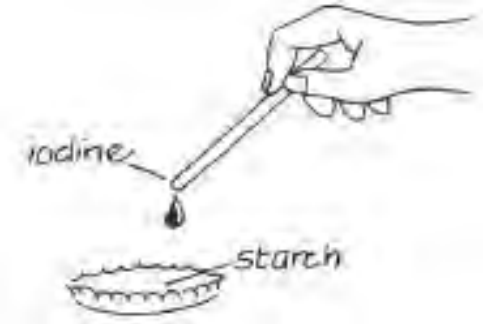
Materials: Cooking oil, water, plastic bottles, Test Tubes, iodine solution, straw

Procedure: Mix about 10 mL of cookingoil 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.

14.1.8 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.

14.1.9 Test for Reducing Sugars

Materials: Benedict's solution, Heat Source, 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.

14.1.10 Test for Non-Reducing Sugars

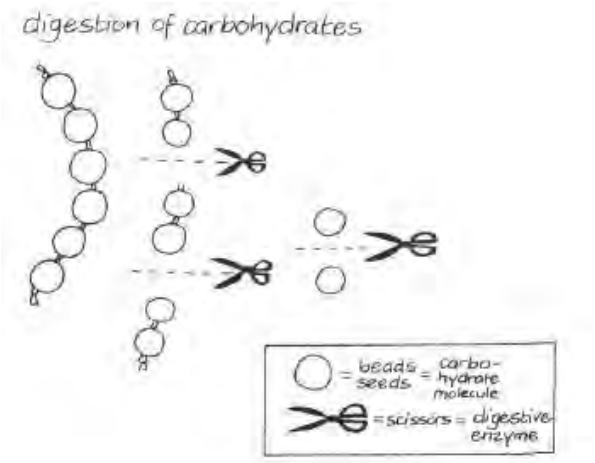
Materials: Benedict's solution, Heat Source, sodium hydroxide solution, citric acid, water, food sample (e.g. sugar/sugar cane),

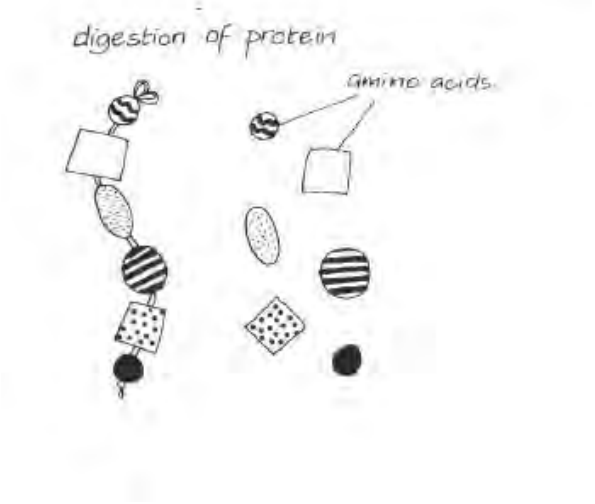
Procedure: Dissolve the food in water. Add a small amount of citric acid and bring to a boil. Allow it to cool and add a small amount of NaOH to the solution and shake. Add a small amount of Benedict's solution and boil again. Allow it to cool and observe changes in appearance.

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

Human Digestive System

14.1.11 Models for Digestion





Materials: Beads/seeds/cards, scissors, string

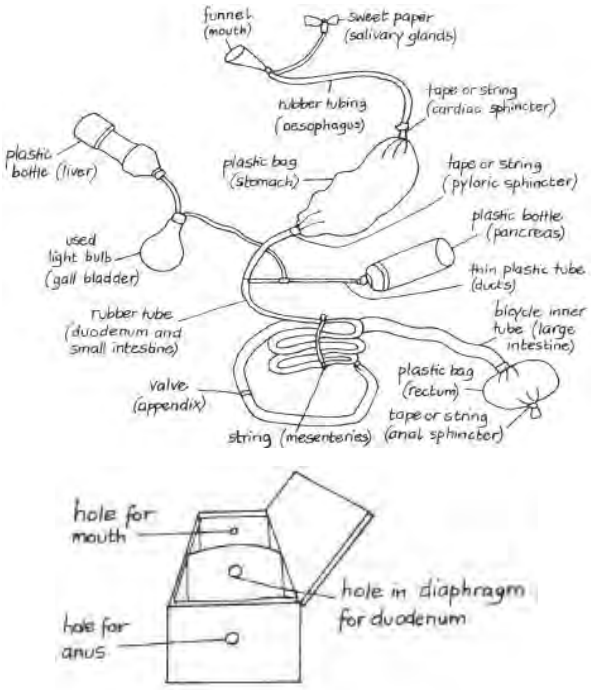
Procedure: String several beads or seeds together to make a chain. Or use toiler paper sheets or paper clips. Cut up or separate the models of food molecules to demonstrate digestion.

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. 27 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.

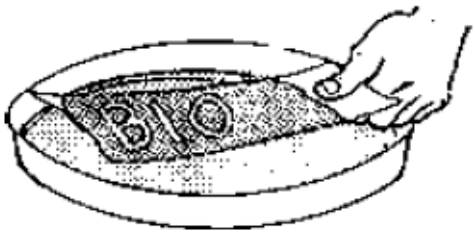
14.1.12 Digestive System Model



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.

14.1.13 Invisible Saliva Ink



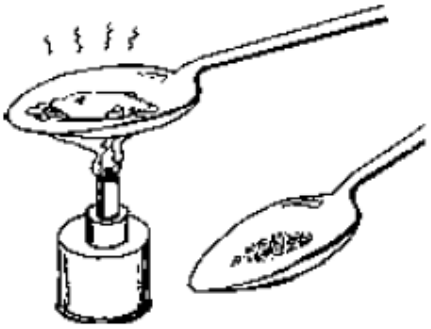
Materials: Filter paper/toilet paper, starch solution, iodine solution, matches/cotton swabs

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.

14.1.14 Salts in Saliva



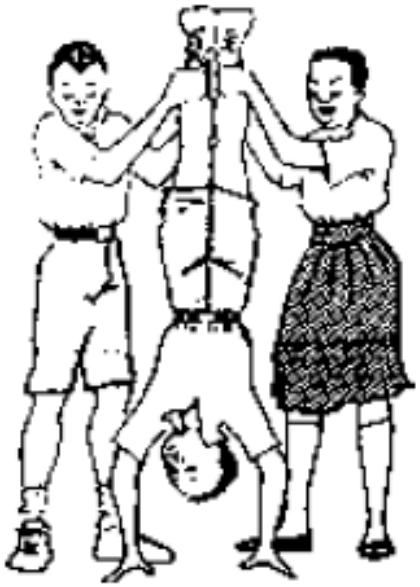
Materials: Spoon, candle, dilute HCl

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.

14.1.15 Swallowing Upside Down



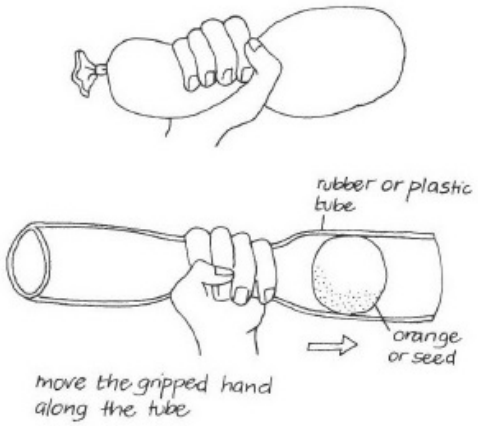
Materials: Drinking water/bread

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.

14.1.16 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.

14.1.17 Intestine Length

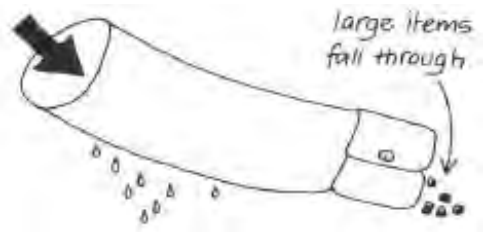
Materials: Long piece of rope

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 an 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.

14.1.18 Absorption Model



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

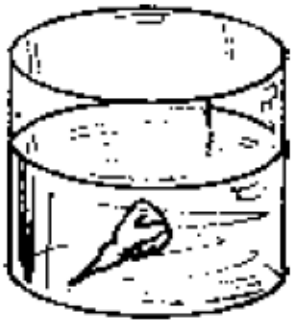
Procedure: Place the shirt sleeve over a container to catch the water as it drips through. Pour the mixture of water and peas down the tube.

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

14.1.19 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.

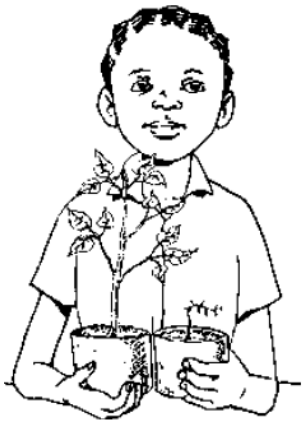
Observations: The soda has reacted with the egg shell or tooth enamel, digesting part of it.

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

14.1.20 Nutrients from Soil



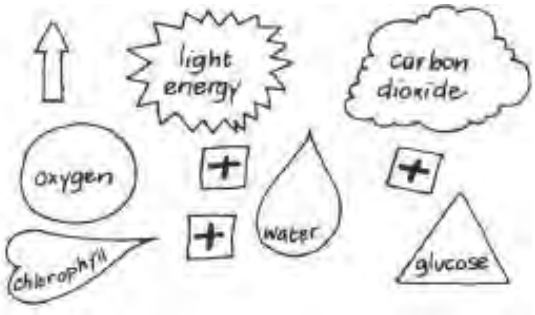
Materials: 2 containers, cardboard, soil, seeds

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 sunlight, 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.

14.1.21 Photosynthesis Model

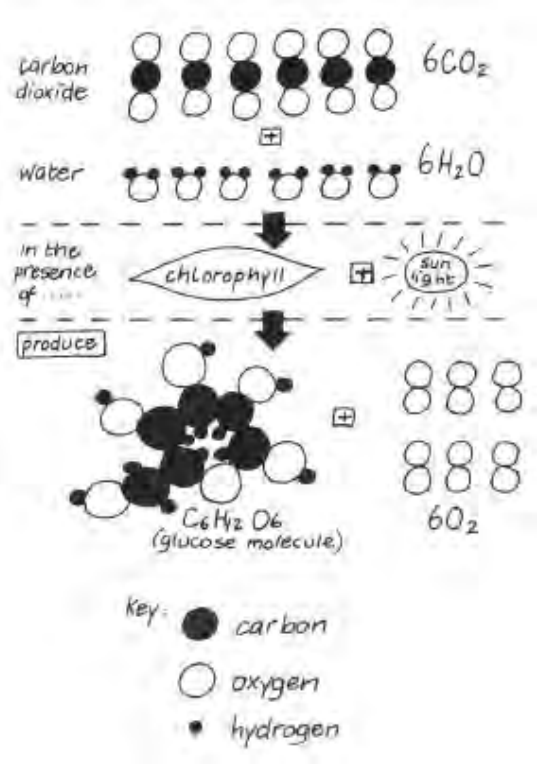


Materials: Card/paper, matches

Procedure: Draw and cut out the symbols shown above. Then arrange them in the correct order to show the chemical equation for photosynthesis. 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.

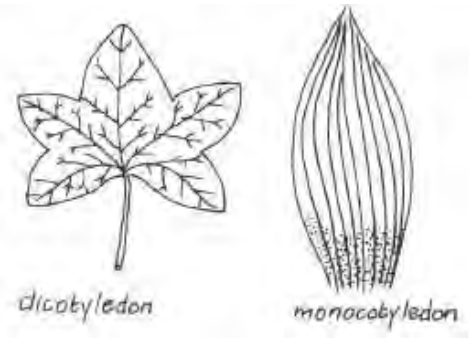
14.1.22 Photosynthesis Equation Game



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

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

14.1.23 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.

14.1.24 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.

14.1.25 Extracting Chlorophyll

Materials: Green leaves, 2 rocks

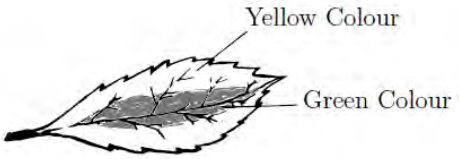
Procedure: Pick about 5, large soft green leaves. Cut these into small pieces and grind with a stone. Add a little water to the pulp and pour the mixture into a glass jar or test tune. Leave to settle.

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.

14.1.26 Chlorophyll and Photosynthesis

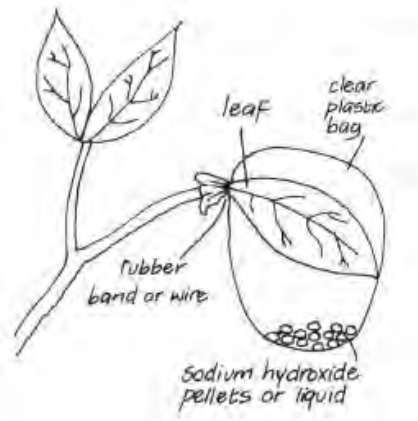


Materials: Variegated leaf, alcohol, water bath, Heat Source, iodine solution

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.

14.1.27 CO_2 and Photosynthesis



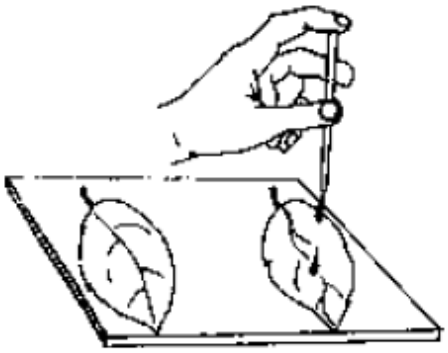
Materials: Plant, clear plastic bag, rubber band/wire, sodium hydroxide, alcohol, water bath, Heat Source, iodine solution

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.

14.1.28 Starch as a Product of Photosynthesis



Materials: 2 potted plants, alcohol, iodine solution, Heat Source, 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.

14.1.29 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

14.1.30 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.

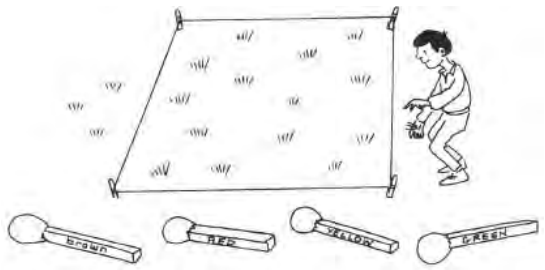
Applications: Canned foods, food processing

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

14.2 Balance of Nature

The Natural Environment

14.2.1 Camouflage and Protection



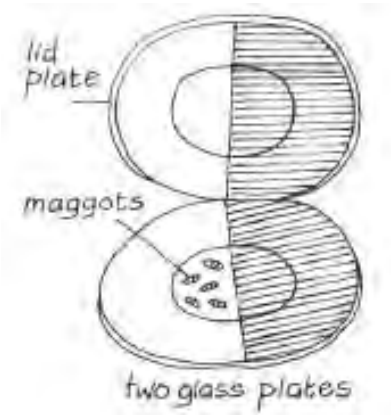
Materials: Long piece of string, 4 pegs, matches, marker pens

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?

14.2.2 Reactions to Light

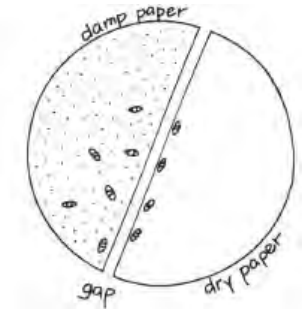


Materials: 2 plates, maggots

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.

14.2.3 Reactions to Humidity



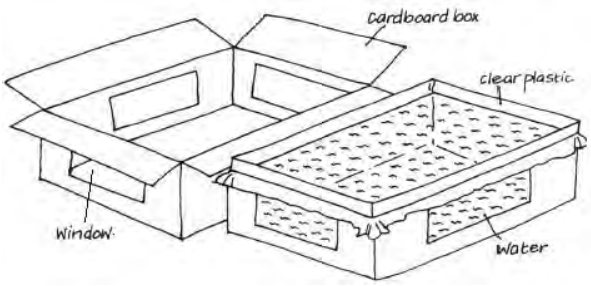
Materials: Plate, toilet paper, cloth

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?

14.2.4 Aquarium

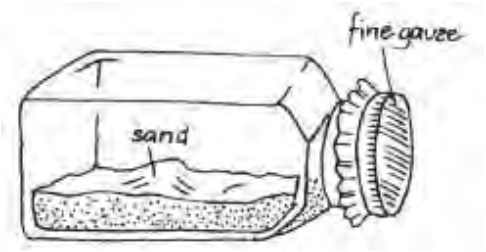


Materials: Cardboard box, clear plastic, tape, scissors, water

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.

14.2.5 Terrarium

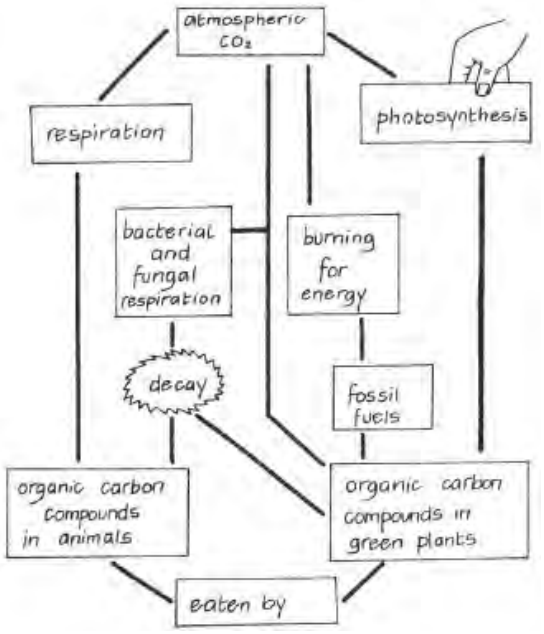


Materials: Square plastic bottle, sand, soil, rocks, plants, insects, fine gauze

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.

Interaction of Living and Non-Living Things

14.2.6 Carbon Cycle Cards

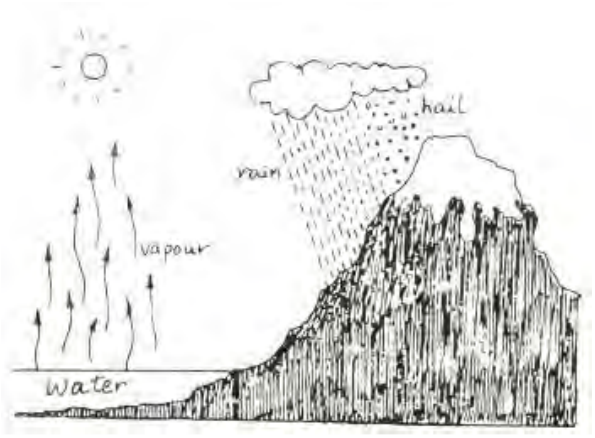


Materials: Cards, paper strips, string

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).

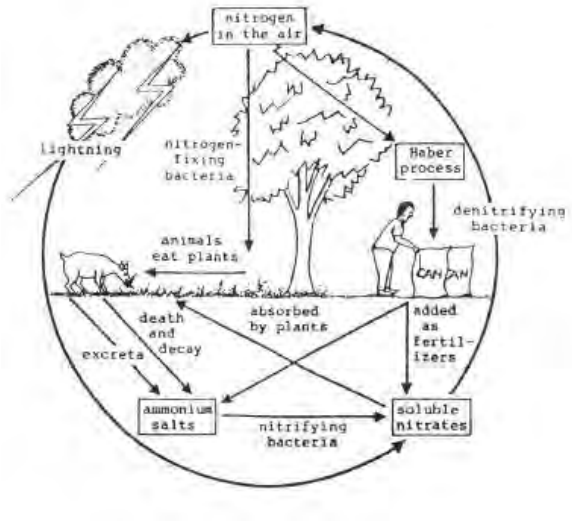
14.2.7 Water Cycle



Materials: Cards, paper strips, string

Procedure: Prepare activity cards as with the carbon cycle.

14.2.8 Nitrogen Cycle



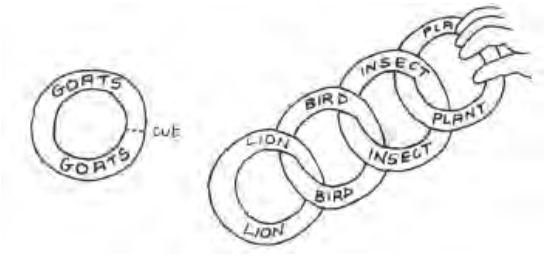
Materials: Cards/manila, flip chart

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 (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

14.2.9 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.

14.2.10 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.

14.2.11 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.

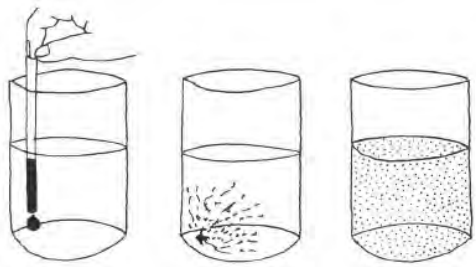
Theory: The food web represents the different interconnected species in an ecosystem - each student is a member of the food chain. If one species becomes extinct (i.e. one student drops the rope), then it impacts the entire food chain. Other species lose connections (i.e. food) and are in threat of extinction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

14.3 Transport of Materials in Living Things

Diffusion

14.3.1 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.

14.3.2 Smelling Particles

Materials: Orange or other citrus fruit, box

Procedure: Peel and 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.

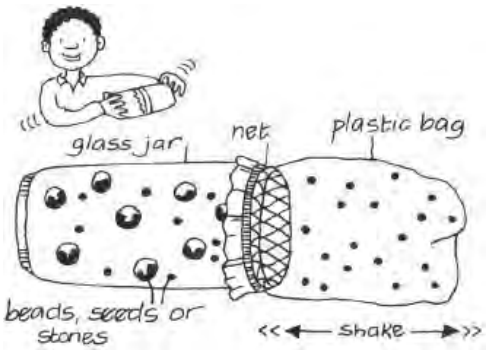
Observations: Students in the front center of the room should be the first to raise their hands, followed by those near the sides and in the back. When the orange is peeled behind the box it takes longer for the smell to reach the students.

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

14.3.3 Semi-Permeable Membranes



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

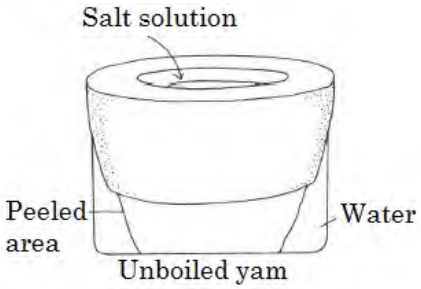
Setup: Place the mixture of beads and beans in the jar. Place the net and plastic bag over the top and tie them on securely.

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.

14.3.4 Osmosis in Dead and Living Tissues



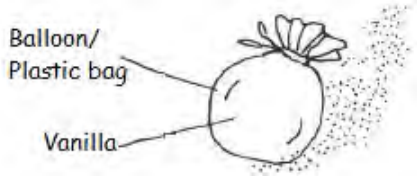
Materials: Potato, knife, 2 dishes of water

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.

14.3.5 Vanilla Balloon



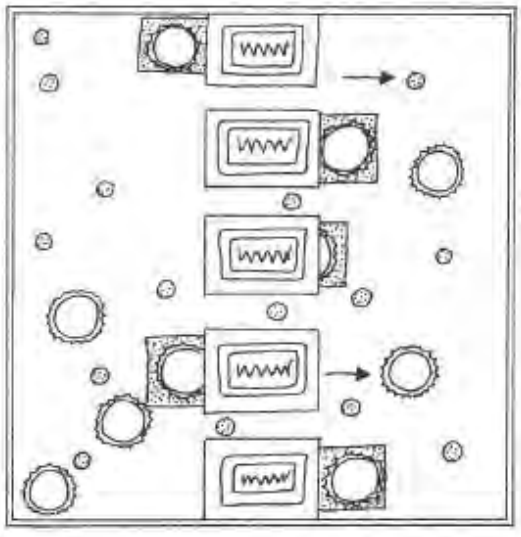
Materials: Balloon/plastic bag, vanilla, straw/syringe

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.

14.3.6 Osmosis/Active Transport Model



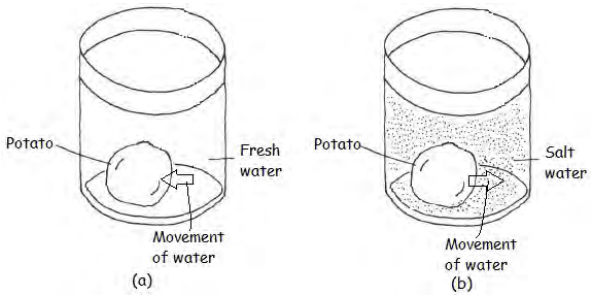
Materials: Cardboard tray, matchboxes, peas/beans, bottle caps, tape

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.

14.3.7 Potato Osmosis



Materials: Potato, 2 water bottles, salt, water

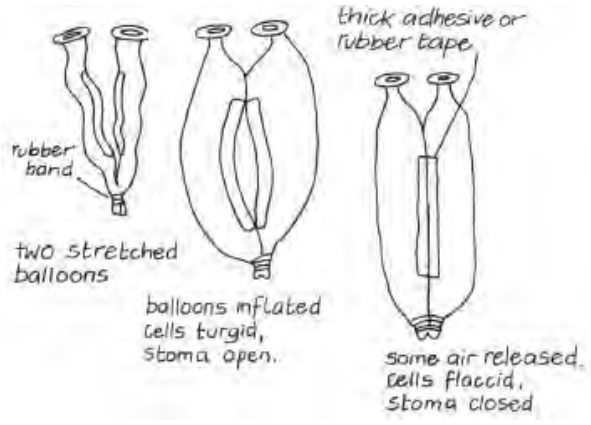
Setup: Cut two equal size pieces of potato. Fill one bottle with fresh water and the other with a salt water solution.

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.

14.3.8 Guard Cells in Osmosis



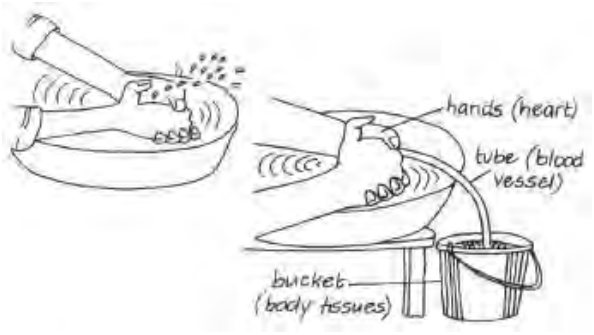
Materials: 2 long balloons, tape, rubber band

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

14.3.9 Heart Pump Action

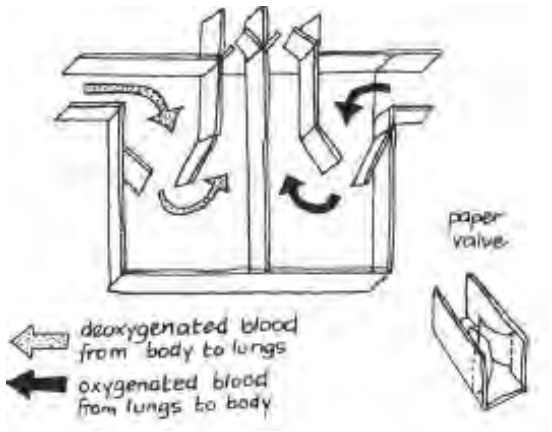


Materials: 2 bowls or buckets, rubber/plastic tubing

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.

14.3.10 Heart Model



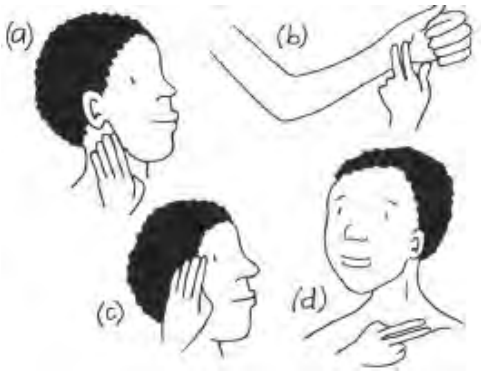
Materials: Cardboard box, paper

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

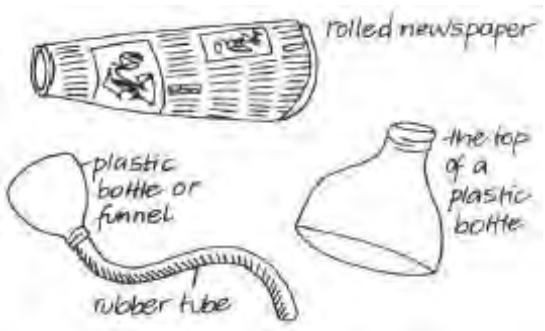
14.3.11 Measuring Pulse



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.

14.3.12 Simple Stethoscope



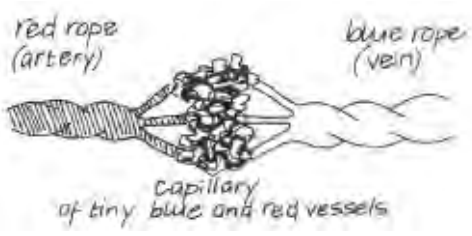
Materials: Newspaper, plastic bottle, rubber tube

Procedure: Roll a newspaper up into a hollow tube. Place one end of tube against another students 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.

14.3.13 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.

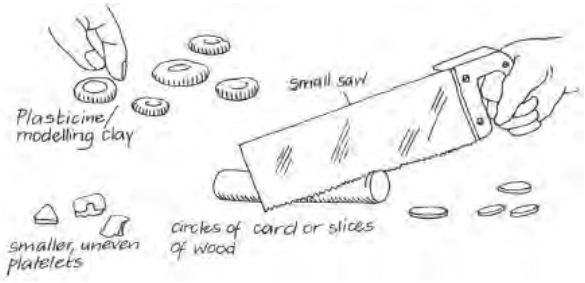
Blood

14.3.14 Blood as a Transporter

Applications: Blood brings substances to the cells, e.g. food and oxygen, and removes others (waste and CO_2). 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.

14.3.15 Red and White Blood Cell Models

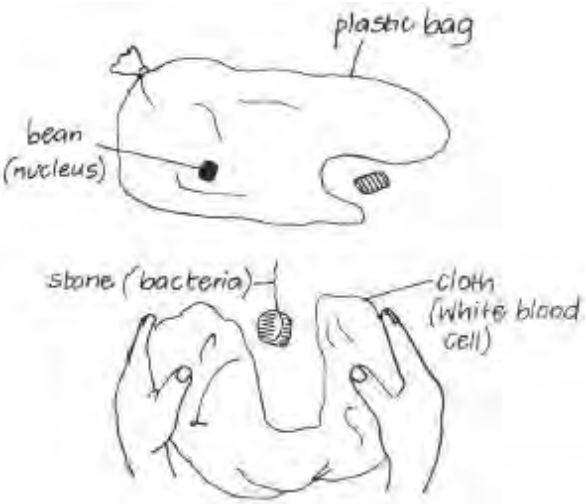


Materials: Plasticine, clay or wooden rod, card or sponge

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.

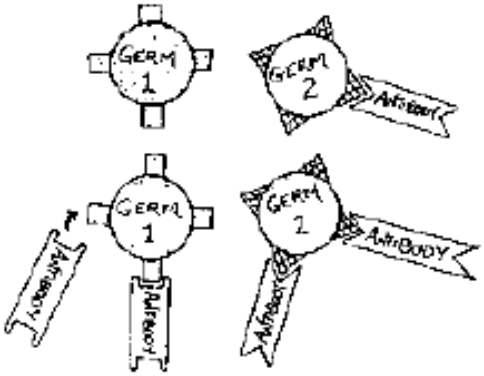
14.3.16 Engulfing Model



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.

14.3.17 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:

14.3.18 Blood Clotting

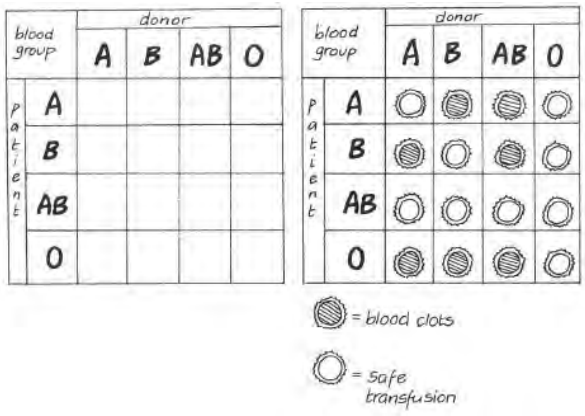
Materials: Red and white beans, container, grass or paper strips

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

14.3.19 Transfusion Checkers



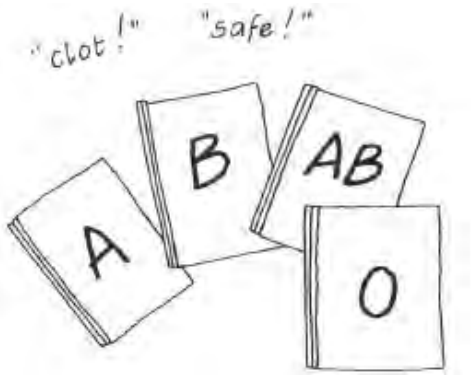
Materials: Bottle caps (2 types), card, coloured pens

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.

14.3.20 Transfusion Card Game



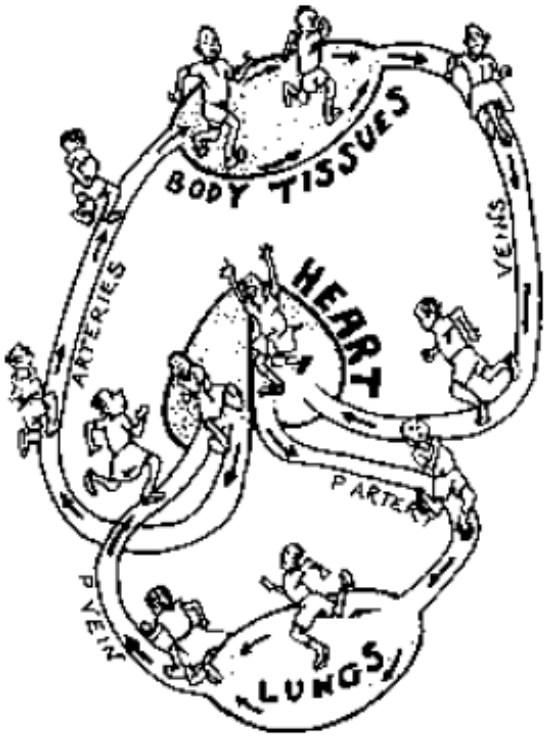
Materials: Cards, pen

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

14.3.21 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.

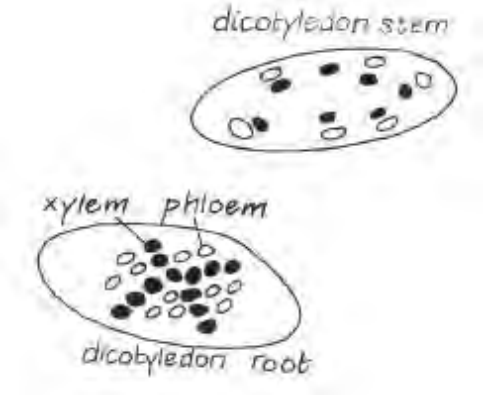
Procedure: To begin the game two or three pupils pick up blue petals at the body tissues and follow the arrows through to the heart and on to the lungs. At the lungs the pupils drop the blue flowers and pick up the red and return to the body tissues via the other side of the heart.

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

14.3.22 Xylem and Phloem Game



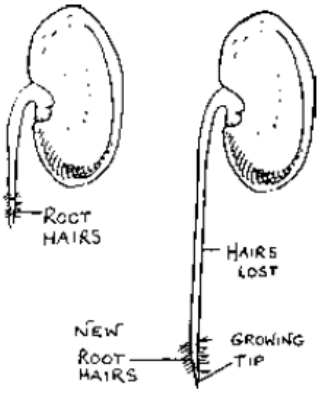
Materials: Chalk, card/paper, coloured markers

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.

14.3.23 Root Hairs



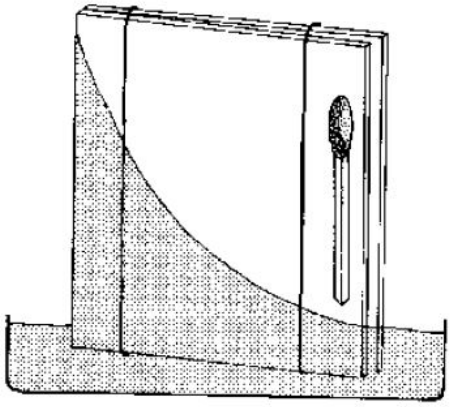
Materials: Pea/bean seeds, damp cloth

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.

14.3.24 Capillary Rise



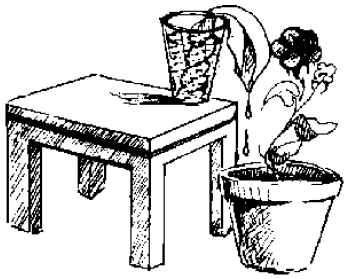
Materials: 2 glass sheets, match, rubber bands, water, food colour (optional)

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.

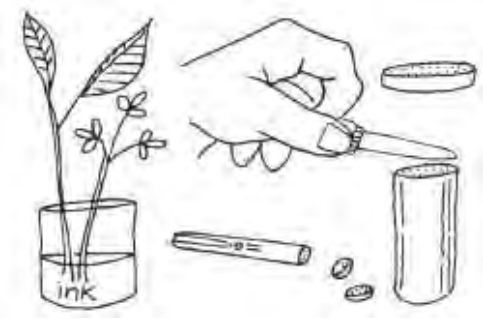
Theory: This is capillary action. Capillary rise results from adhesion, allowing the liquid to climb along the surface of the glass, as well as cohesion, which pulls the remainder of the liquid up. Water rises more where the glass sheets are closer together.

14.3.25 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.

14.3.26 Water Movement in Plants

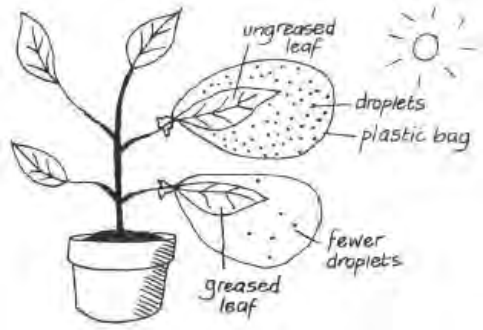


Materials: Various plant stems, food colour/ink (not black), water, knife

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.

14.3.27 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.

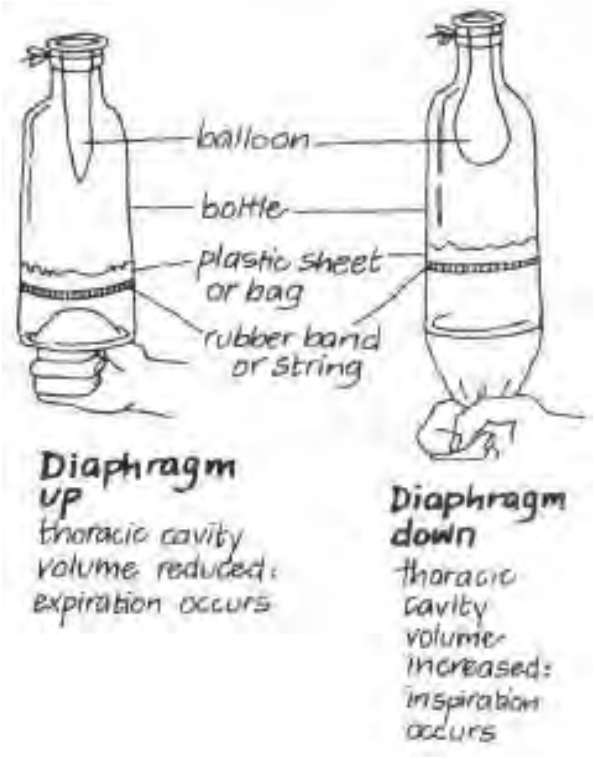
Observations: Water droplets appear on the inside of the bag placed over the ungreased leaf. Very little or no water collects in the other bag.

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.

14.4 Gaseous Exchange and Respiration

Gas Exchange in Mammals

14.4.1 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 the 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.

14.4.2 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.

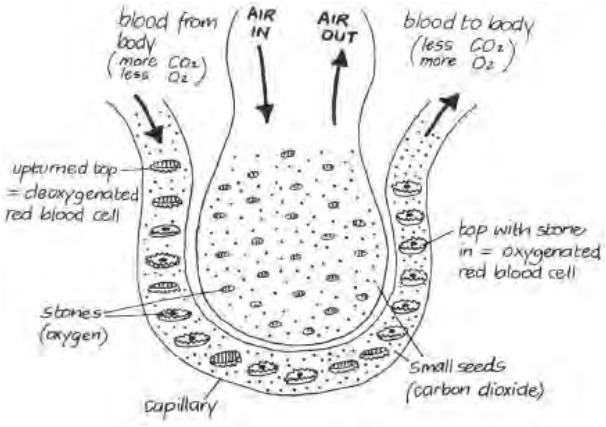
14.4.3 Gas Exchange Game

Materials: Cards, table

Procedure: The table represents the alveolus. Students wear either an 'R' or 'P' card and so 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_2' (carbon dioxide) cards.

Applications: Link this activity with Circulation Game (p. 58).

14.4.4 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

14.4.5 Germinating Seeds

Materials: Glass jar, limewater, plastic bag, peas

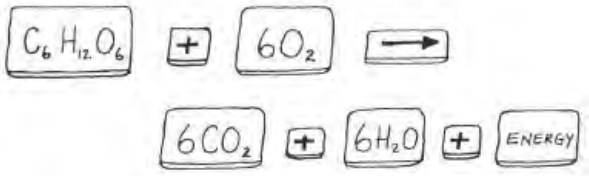
Procedure: Put some lime water into a wide-mouthed glass jar and hang a perforated plastic bag, containing soaked and germinating peas. Make sure that the peas are separated from the liquid. Seal the jar well and leave it to stand for a few hours.

Observations: The limewater becomes cloudy.

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

Respiration

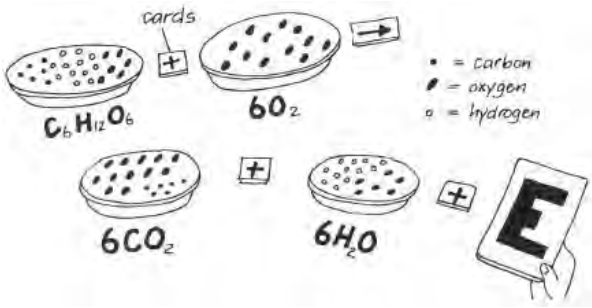
14.4.6 Respiration Cards



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.

14.4.7 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.

14.4.8 Exhaling CO_2

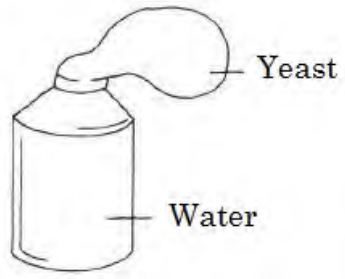
Materials: Straw or pen tube, limewater

Procedure: Breathe out through a straw or the barrel of a ball point pen into filtered limewater.

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.

14.4.9 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 a 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.

14.4.10 Fermenting Fruits

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

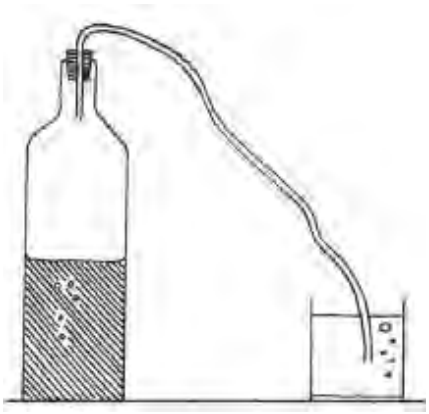
Procedure: Prepare a pulp of paw paw. Put the pulp into a glass. Let it stand for some time in a warm place.

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)

14.4.11 Fermenting Sugar



Materials: Yeast, sugar, bottle, tube, water, limewater (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.

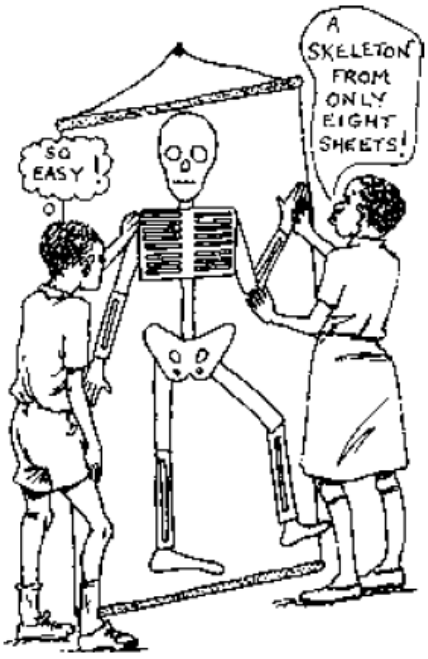
Theory: The yeast organisms break down the sugar and produce carbon dioxide gas through respiration.

Biology Activities for Form III

15.1 Movement

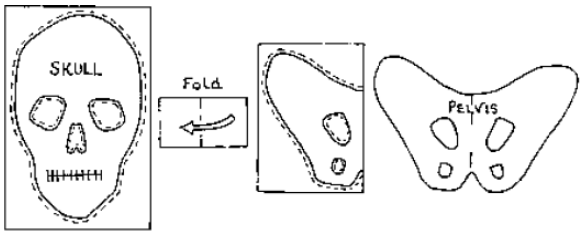
Human Skeleton

15.1.1 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.

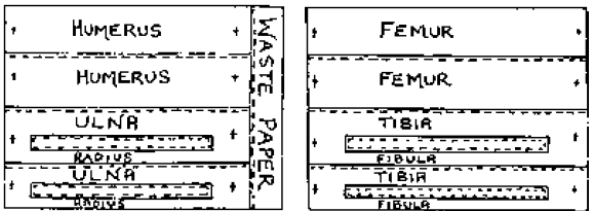
Skull and Pelvis



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

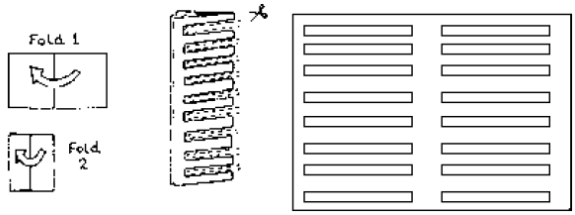
Pelvis: Draw half of the pelvis and cut out the basic shape when the paper is folded

Limbs



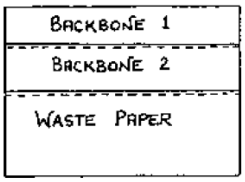
The lower limbs are cut out from one piece of paper. The upper limbs all fit onto another piece.

Rib Cage



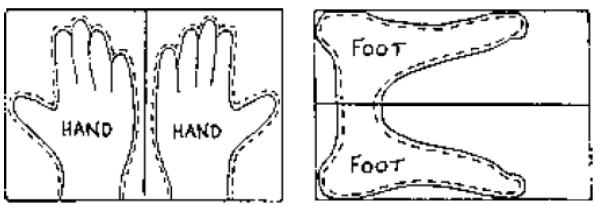
Fold the paper twice and then cut along alternate lines. Use a ruler to measure accurately if you want to have the exact number of ribs. You can cut the ribs out of the paper lengthwise instead.

Backbone



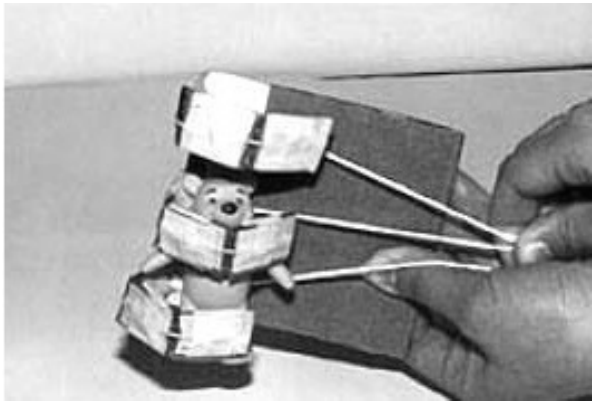
Cut out 2 strips for the backbone to give extra strength. piece to each side of the skeleton.

Hands and Feet



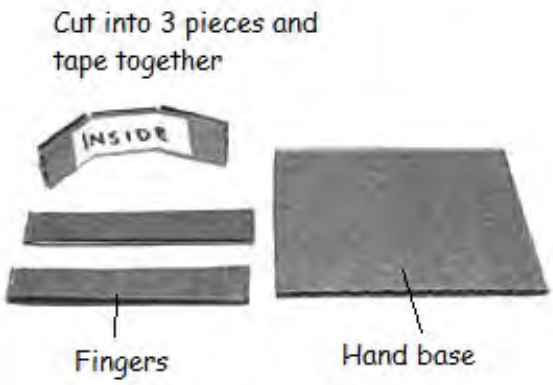
Fold the paper in half and draw around a hand. Use another piece of paper for the feet.

15.1.2 Robotic Hand



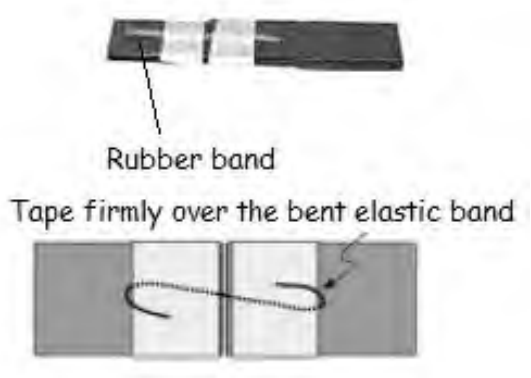
Materials: Rubber bands, straws, cardboard, string, masking tape, scissors

Hand Structure



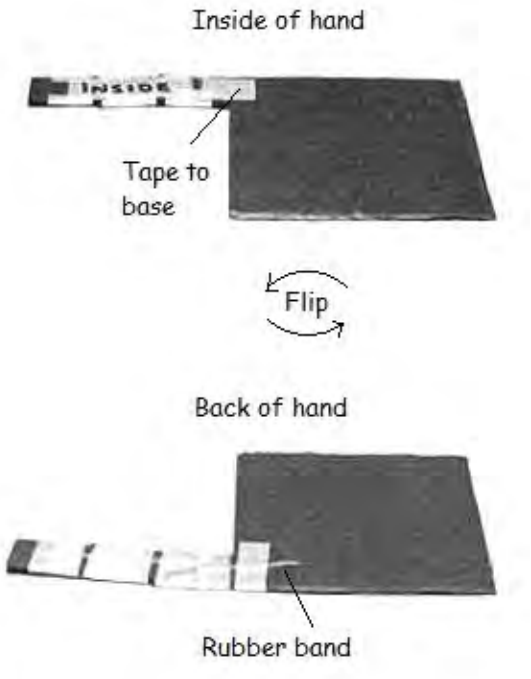
Procedure: Cut a piece of cardboard about 10 cm × 10 cm. This is the "palm" of the hand. Cut three pieces of cardboard about 2 cm × 9 cm. These are the "fingers". Cut one finger into three equal pieces. Place the three finger pieces back together and put a piece of tape over the two finger joints. Label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

Fingers



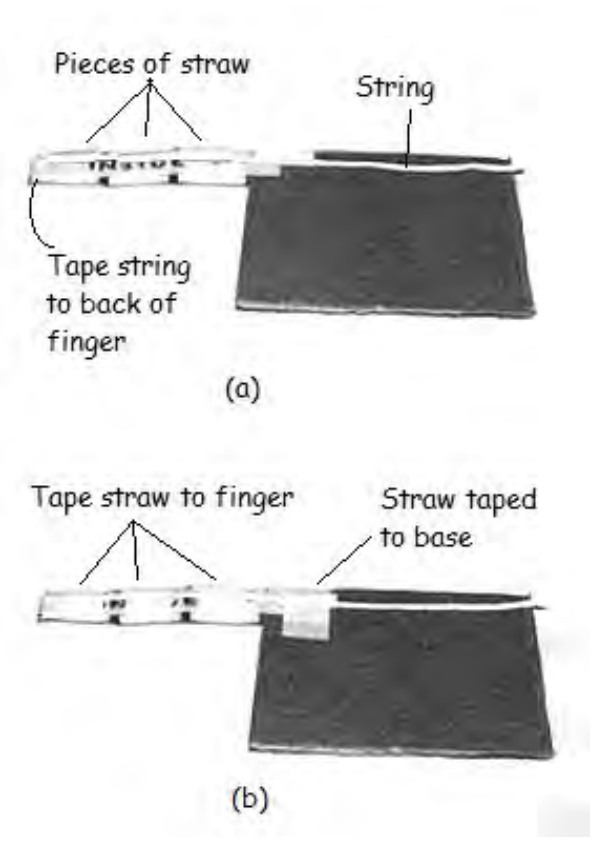
Procedure: Cut a piece of elastic about 5 cm long. Turn the finger over (inside facing down) and place the elastic across the middle of the first joint. Tape the elastic on either side of the joint, leaving the ends of the elastic untaped (rip tape to make it thin). Bend the ends of the elastic as shown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

Attach Fingers



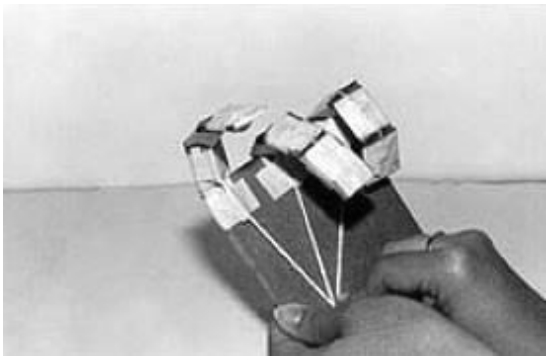
Procedure: Tape the finger (inside up) onto the palm. Turn the hand over and fasten the last finger joint to the palm using the same method as above.

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.

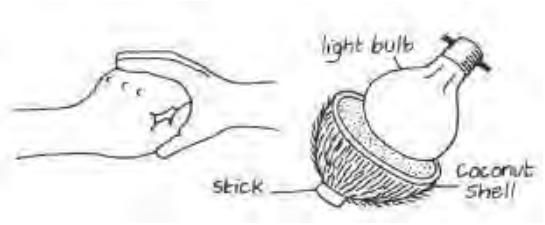
Completing the Hand



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

15.1.3 Ball and Socket



Materials: Light bulb, coconut shell, stick

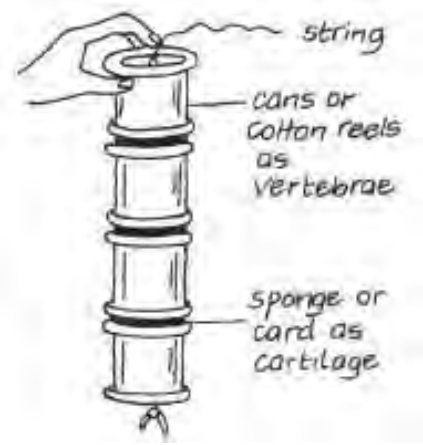
Procedure: The hip joint, which allows the thigh to move, is a ball and socket joint. You can demonstrate such a joint by cupping your hands or making one as shown.

15.1.4 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.

15.1.5 Sliding Joint

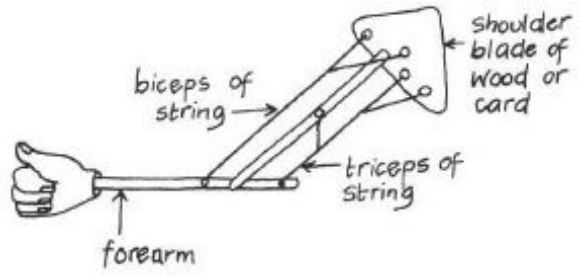


Materials: String, cans/cotton reels, sponge or card

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

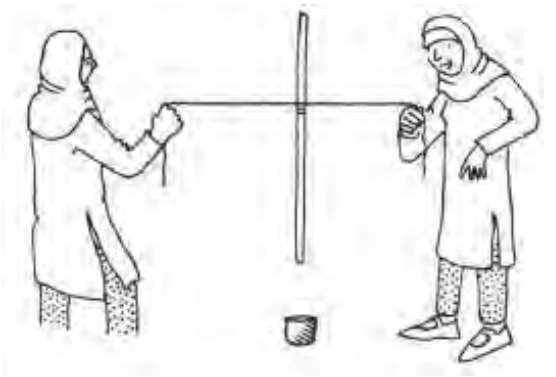
Muscles

15.1.6 Forearm Lever



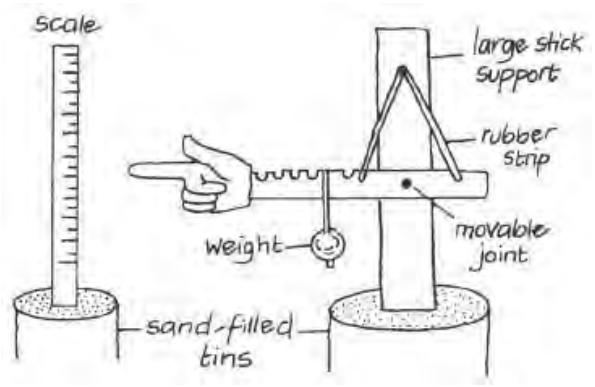
Materials: Card, string, 2 strong straight sticks
Procedure: Make a model of the forearm as shown.
Observations: Notice that the arm can only be bent by shortening one 'muscle' at a time.
Theory: Muscles can only pull, which in turn causes the motion of complementary muscle groups.
Notes: Try using rubber bands instead of string.

15.1.7 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.

15.1.8 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.

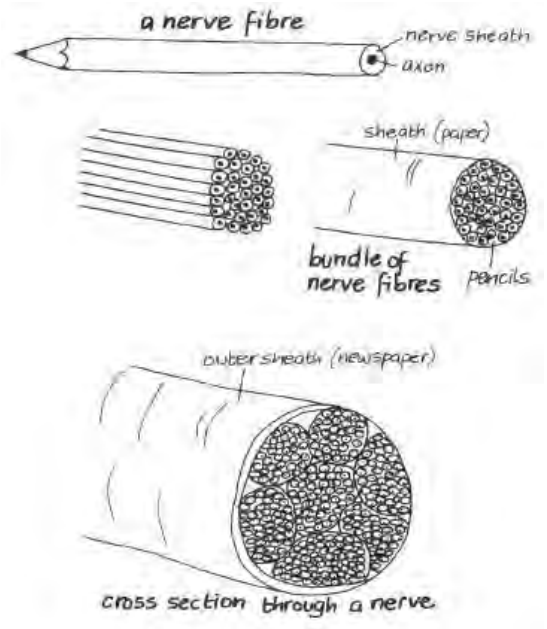
15.1.9 Support of the Spinal Column

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.

15.2 Coordination

The Nervous System

15.2.1 Nerve Model

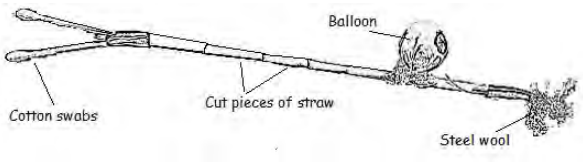


Materials: Pencils, paper, newspaper

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.

15.2.2 Neuron Models



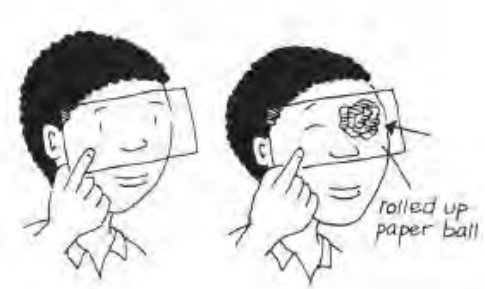
Materials: Straight stick/bamboo skewer, straws, tape, balloon, steel wool, cotton swabs, scissors

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

15.2.3 Blinking Reflex

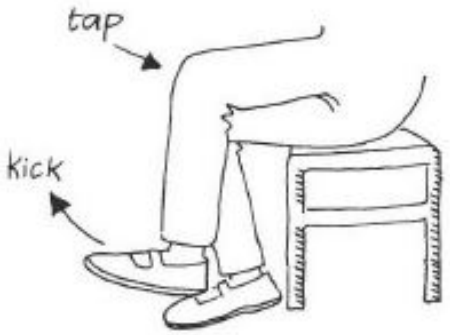


Materials: Plastic sheet, paper ball

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.

15.2.4 Knee Jerk

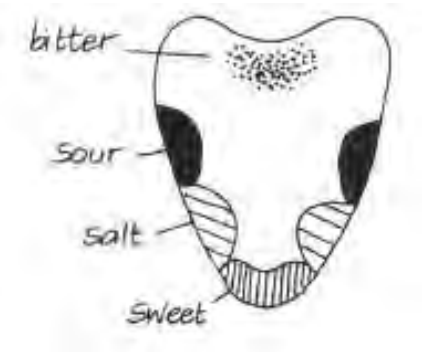


Procedure: Cross one leg over the other. Tap just below the knee cap as shown.

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

Sense Organs

15.2.5 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 in 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.

15.2.6 Coordination Fluid

Materials: Plastic bottle, water

Procedure: Have students bend over and spin in place, then try to walk in a straight line. Swirl a bottle of water around to represent the fluid in their ears being displaced by the spinning.

Observations: Students feel dizzy and disoriented after spinning in circles and are not able to walk in a straight line.

Theory: Coordination fluid is located in the ears and its displacement causes disorientation and decreased coordination. Just as the fluid in the bottle is displaced by swirling, the fluid in your ears is also displaced by the centrifugal force of spinning around in circles.

15.2.7 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).

15.2.8 Sight and Balance

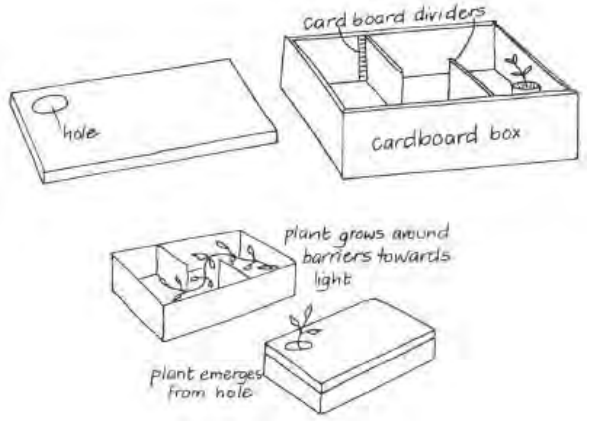
Procedure: Try balancing on one leg with both eyes closed. Now try with the eyes open.

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.

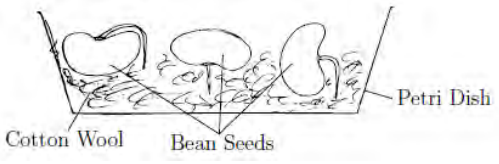
Coordination in Plants

15.2.9 Phototropism



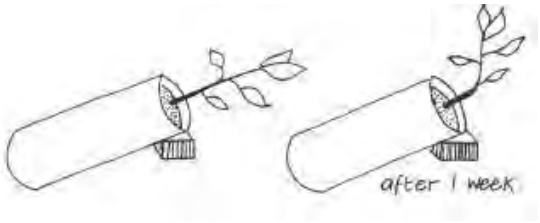
Materials: Cardboard box, seedlings in small pots
Procedure: Make a light maze box as shown. Lift the lid daily to watch progress.
Applications: Farmers and gardeners see leaves turning to the Sun after disturbance or transplanting. Place a house plant next to a window letting in sunlight. Leave it for 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.

15.2.10 Geotropism - Roots



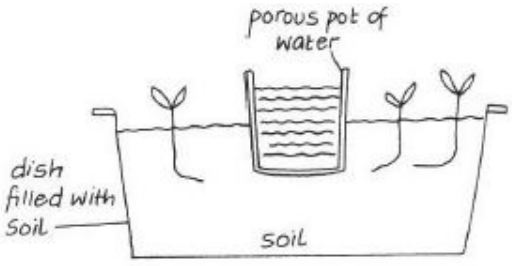
Materials: Cotton wool, bean seeds, plastic bottle
Procedure: Cut the bottom of a plastic bottle to act as a petri dish. Place damp cotton wool at the bottom and a few bean seeds on top.
Observations: Plant roots will grow towards gravity, showing positive geotropism. The stems will grow away from gravity, thus showing negative geotropism.

15.2.11 Geotropism - Shoots



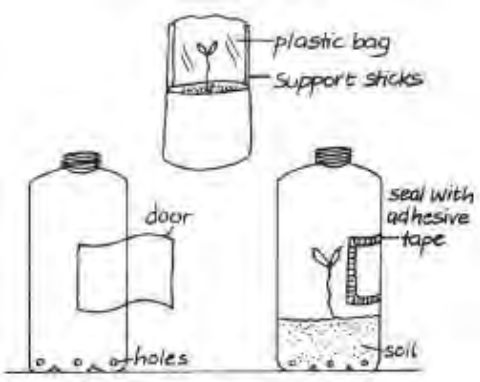
Procedure: Lean a pot plant at an angle. Leave it for a week. Notice that after this time the leaves turn upwards.

15.2.12 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).

15.2.13 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.

15.3 Regulation

Temperature Regulation

15.3.1 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.

15.3.2 Evaporation and Cooling

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

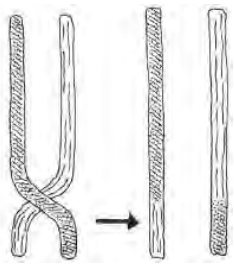
Procedure: Pour some petrol or spirit on the back of your hand.

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.

15.4 Reproduction

15.4.1 Meiosis Models



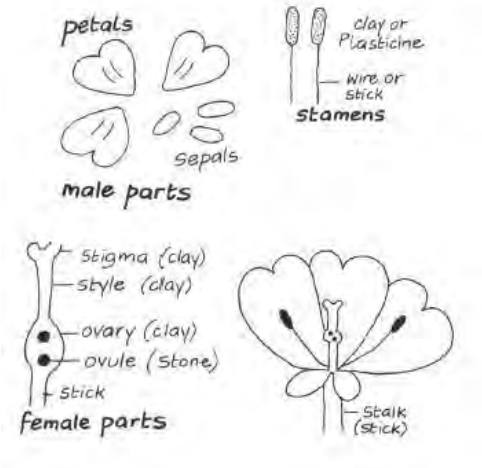
Materials: Manila paper, cotton swabs, tape, string, markers

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

15.4.2 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.

15.4.3 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.

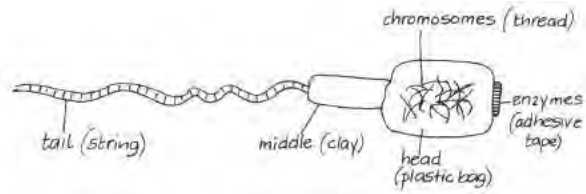
Reproduction in Mammals

15.4.4 Sperm and Egg

Materials: Football, bean

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

15.4.5 Sperm Model



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

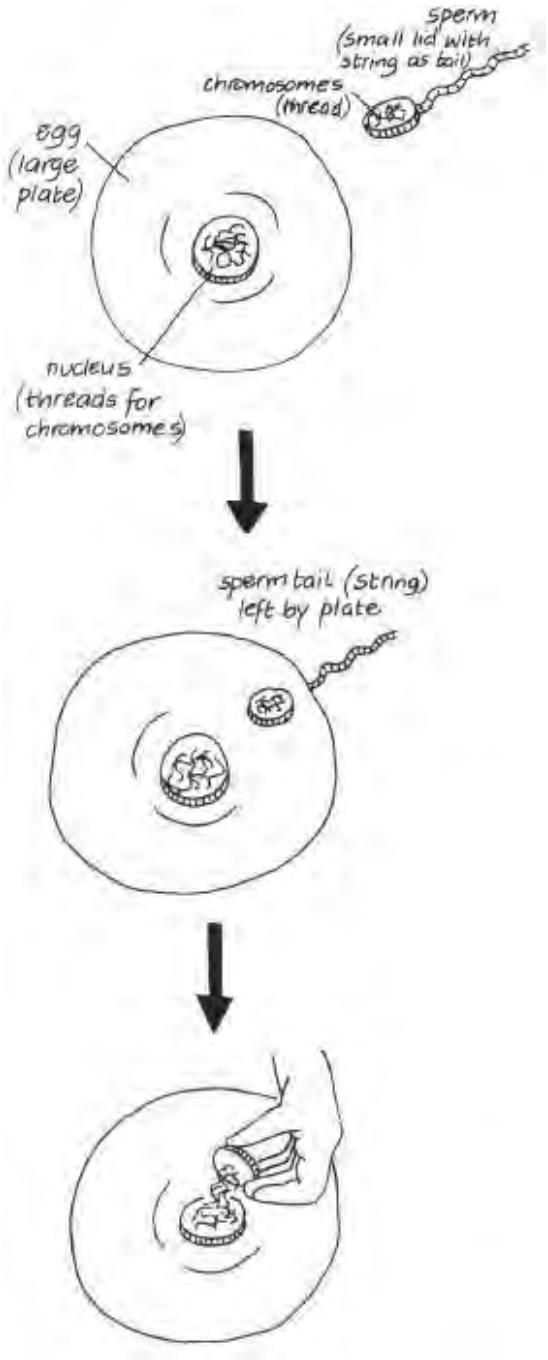
Procedure: Construct a simple sperm model as shown.

15.4.6 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.

15.4.7 Fertilisation



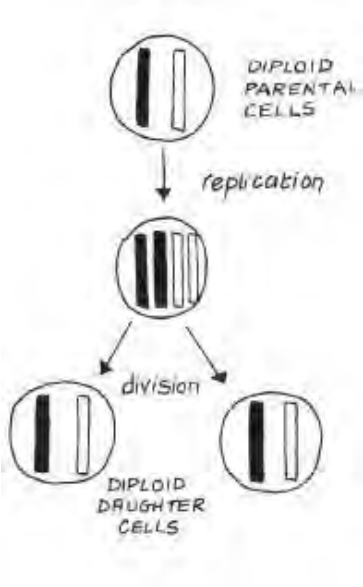
Materials: 2 bottle lids, thread, string, large plate

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

16.1 Growth

16.1.1 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

16.1.2 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.

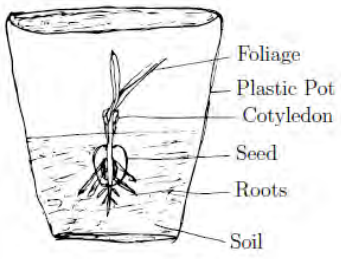
16.1.3 Conditions for Germination

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

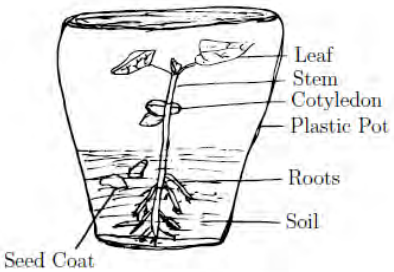
Procedure: Place cotton wool at the bottom of each container and add a few beans or seeds to each. In container 1, add enough water to soak the cotton wool. In 2, add cool boiled water to flood the seeds and a small amount of oil. In 3, add ice water. In 4, do not add any water. Record observations over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

16.1.4 Hypogeal and Epigeal Germination



Hypogeal germination



Epigeal germination

Materials: 2 pots or bottles, beans, maize seeds

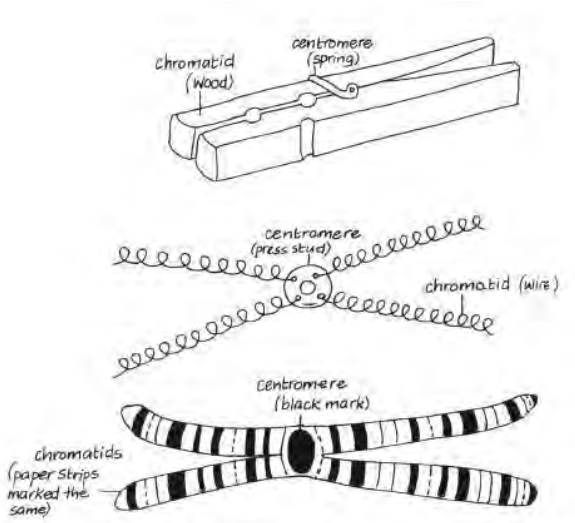
Procedure: Add soil to 2 pots or bottles. Place a few bean seeds in one and a few maize seeds in the other.

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

16.2 Genetics

Genetic Materials

16.2.1 Chromatid Models

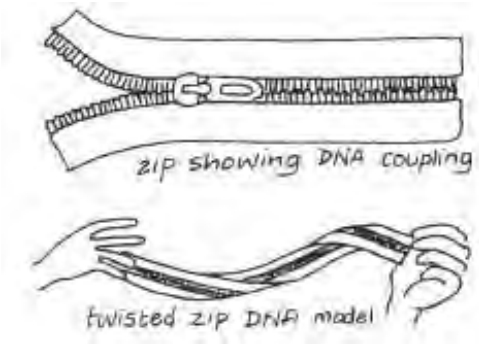


Materials: Clothespin, wire, washer/button, paper strips

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.

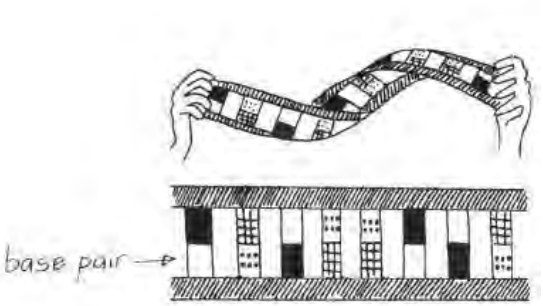
16.2.2 DNA Zipper



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.

16.2.3 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.

16.2.4 DNA Extraction

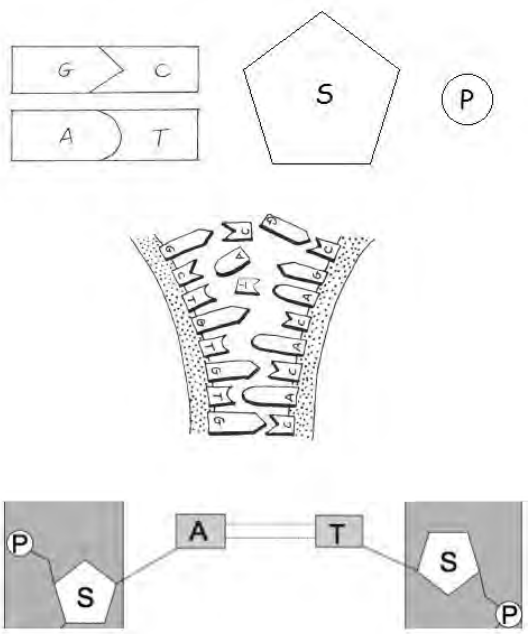
Materials: Salt, soap, water, methylated spirit, bottle

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.

16.2.5 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

16.2.6 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.

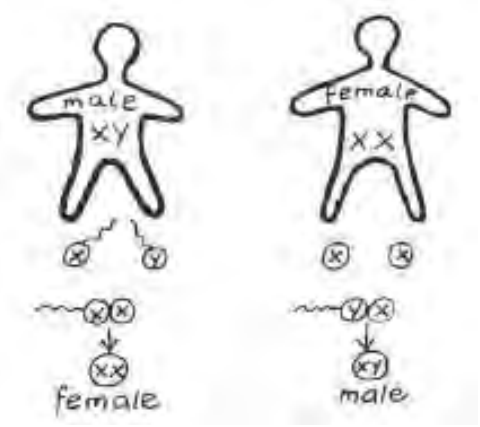
Observations: Several combinations are possible: ZZ, Zz, zZ and zz

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

16.2.7 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.

16.3 Evolution

16.3.1 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.

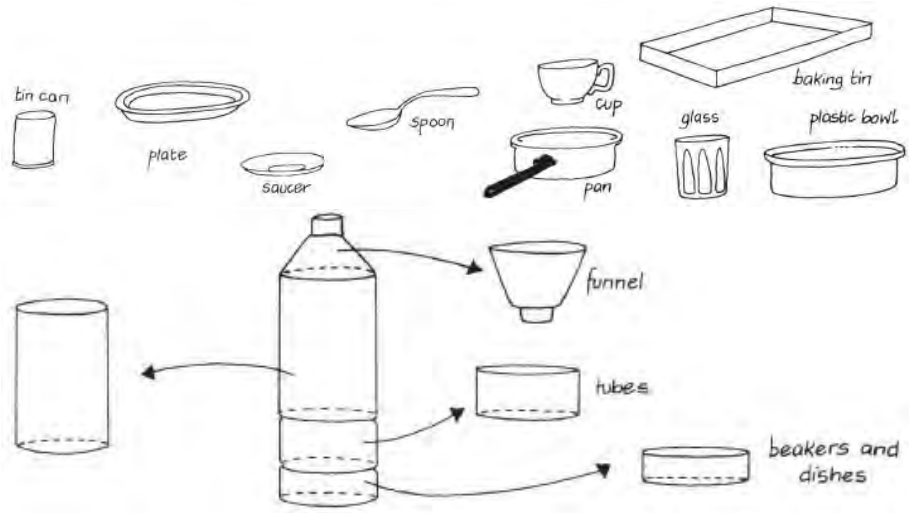
Imagination and innovativeness is encouraged on the part of the student and teacher to find other suitable local substitutions.

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:

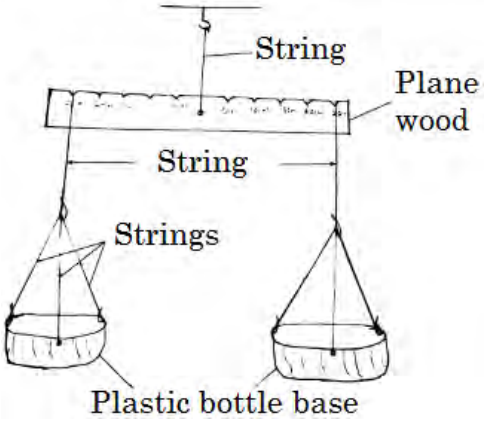
1. Balance
2. Beakers
3. Blowpipe
4. Bunsen Burner
5. Burettes
6. Crucible
7. Containers
8. Deflagrating Spoon
9. Delivery Tube
10. Drawing Board
11. Droppers
12. Electrodes
13. Filter Paper
14. Flasks
15. Funnel
16. Gloves
17. Goggles
18. Heat Source
19. Indicator
20. Iron Filings
21. Masses
22. Measuring Cylinder
23. Metre Rule
24. Microscope
25. Mortar and Pestle
26. Optical Pins
27. Pipettes
28. Retort Stand
29. Scale Pans
30. Scalpels
31. Slides and Cover Slips
32. Spatula
33. Stoppers
34. Stopwatches
35. Test Tubes
36. Test Tube Brush
37. Test Tube Holder / Tongs
38. Test Tube Racks
39. Tripod Stands
40. Volumetric "Glass"ware
41. Wash Bottle
42. Water Bath
43. Weights
44. White Tiles
45. Wire Gauze

How many experiments can be carried out with everyday items?



17.1 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.

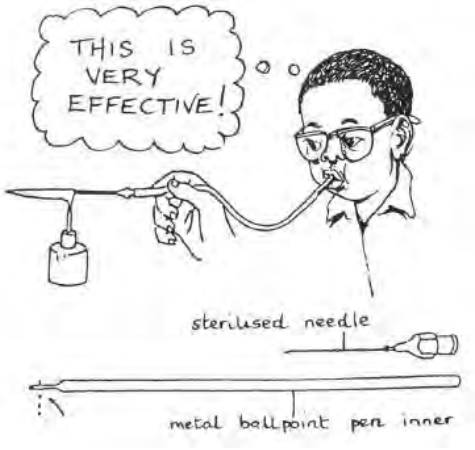


17.2 Beakers

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.

17.3 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.



17.4 Bunsen Burner

See Heat Source (p. 83).

17.5 Burettes

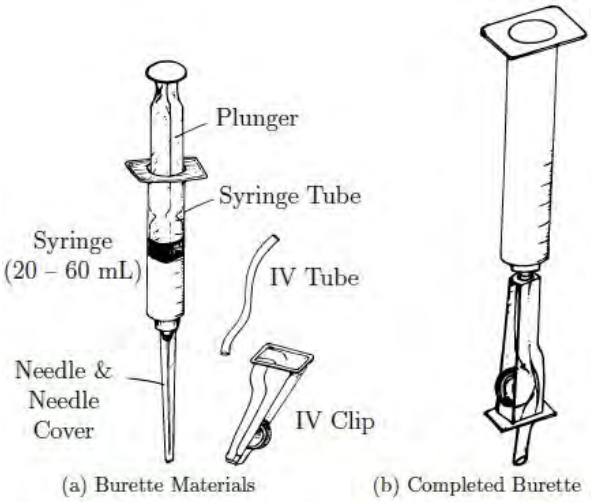
Use: Titration

17.5.1 Version 1

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.

17.5.2 Version 2

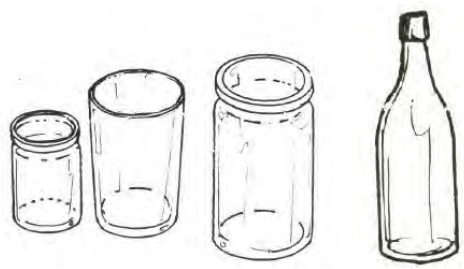
Materials: Syringe, IV giving set, super glue, knife
Procedure: Cut off the part of the IV tube with the flow control slider. Remove the plunger from the syringe and use superglue to attach the tube to the nozzle of the syringe.



(a) Burette Materials (b) Completed Burette

17.6 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.

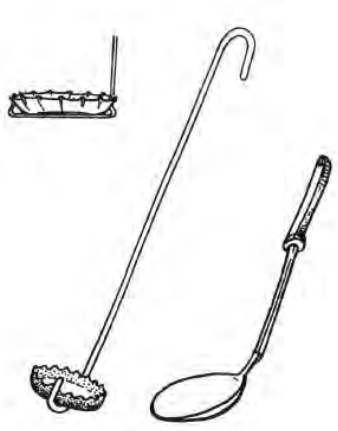


17.7 Crucible

Use: Heating substances at very high temperatures
Materials: 2 metal spoons, wire
Procedure: Place the material in one spoon and then wire 2 spoons together.

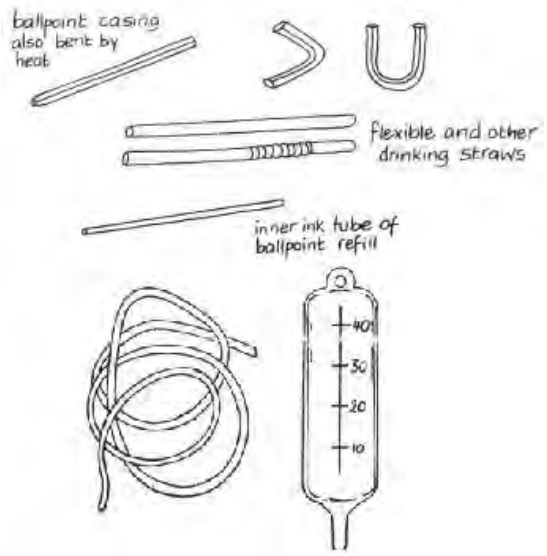
17.8 Deflagrating Spoon

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.



17.9 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



17.10 Drawing Board

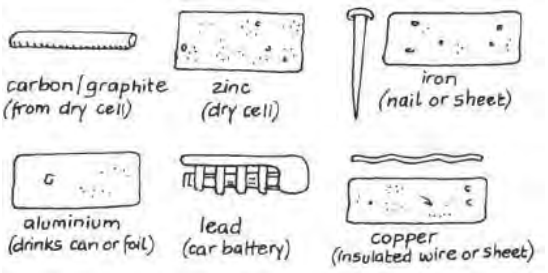
Use: Dissection, reflection, refraction of light
Materials: Thick cardboard

17.11 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.

17.12 Electrodes

Use: Electrolysis

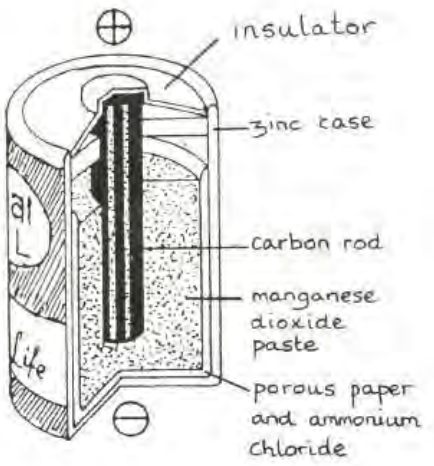


17.12.1 Graphite

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.

17.12.2 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.



17.12.3 Iron

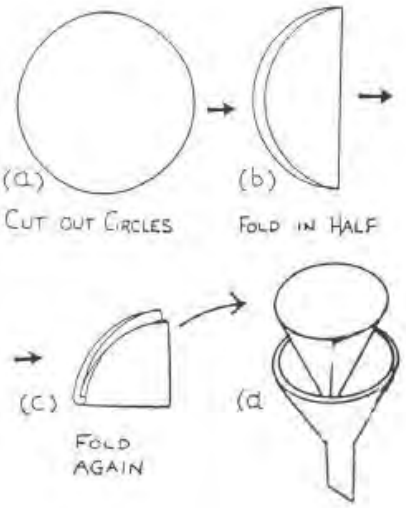
Materials: Ungalvanized nails from a hardware store

17.12.4 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.

17.13 Filter Paper

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

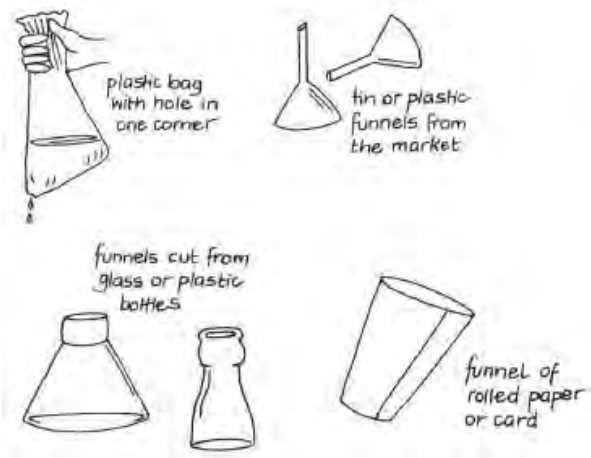


17.14 Flasks

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.

17.15 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.



17.16 Gloves

17.16.1 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.

17.16.2 Thick gloves

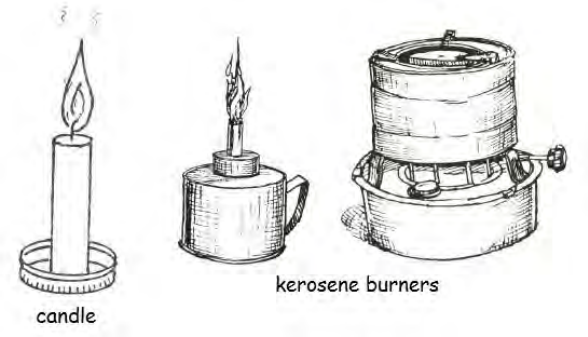
Use: For working with organic solvents. Remember that the most dangerous organic solvents (benzene, carbon tetrachloride) should never be used in a school, with or without gloves.
Materials: Thick rubber gloves from village industry supply companies and some hardware stores
Safety: In general, avoid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

17.17 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.

17.18 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.



17.18.1 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.

17.18.2 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.

17.18.3 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.

17.19 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 thing strips into the coloured solution. Rosella turns red for acids and greenish blue for bases.

17.20 Iron Filings

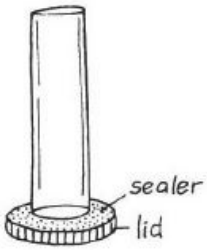
Use: To map magnetic fields
Materials: Steel wool / Iron wool used for cleaning pots
Procedure: Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

17.21 Masses

See Weights (p. 87).

17.22 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.



17.23 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.

17.24 Microscope

See Low Tech Microscopy (p. 88).

17.25 Mortar and Pestle

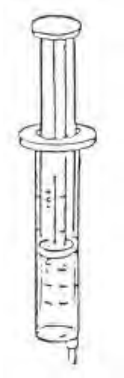
Use: To powder chemicals
Materials: 2 metal spoons, glass bottle
Procedure: Place chemicals between two nested metal spoons and grind down. Alternatively, crush chemicals on a sheet of paper by pressing on them with the bottom of a glass bottle.

17.26 Optical Pins

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

17.27 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.



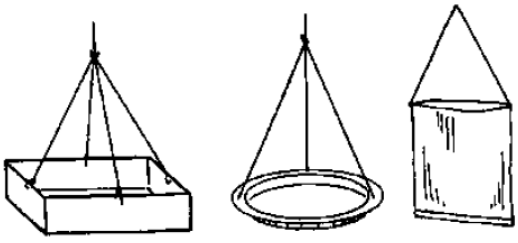
17.28 Retort Stand

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.

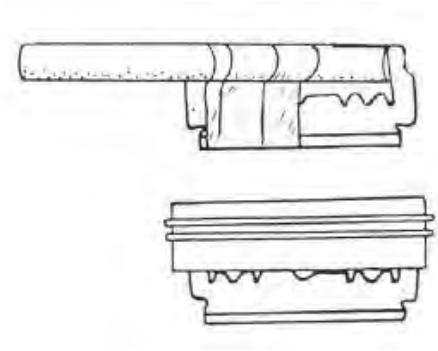
17.29 Scale Pans

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.



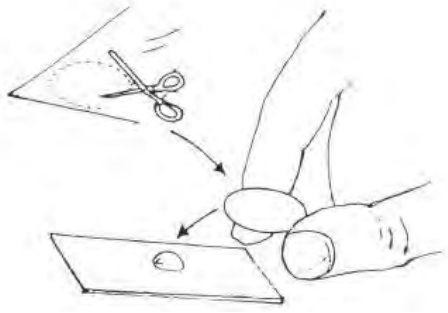
17.30 Scalpels

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.



17.31 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.



17.32 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.

17.33 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.

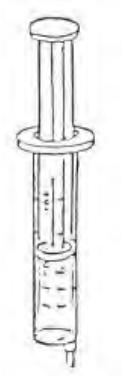
17.34 Stopwatches

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

17.35 Test Tubes

17.35.1 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.

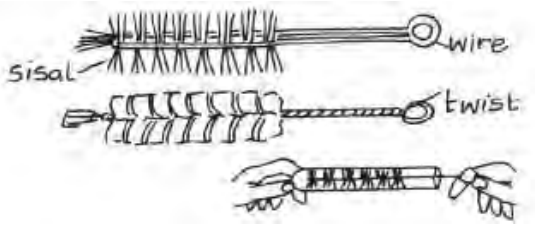


17.35.2 For Thermal Decomposition

See Deflagrating Spoon (p. 80).

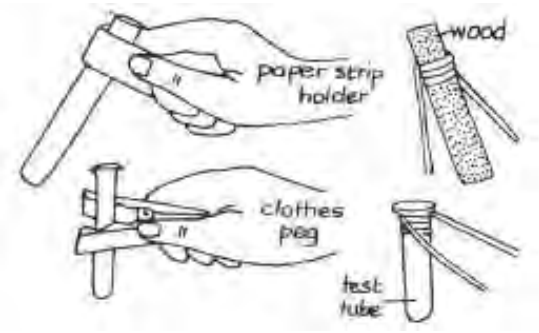
17.36 Test Tube Brush

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.



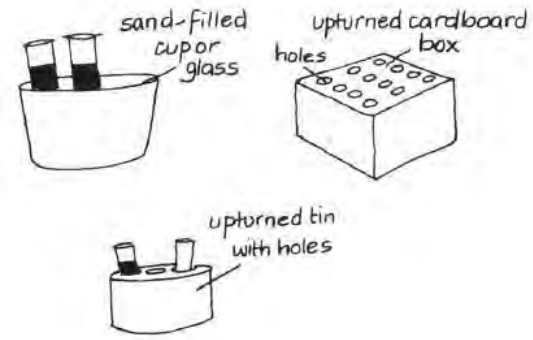
17.37 Test Tube Holder / Tongs

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.



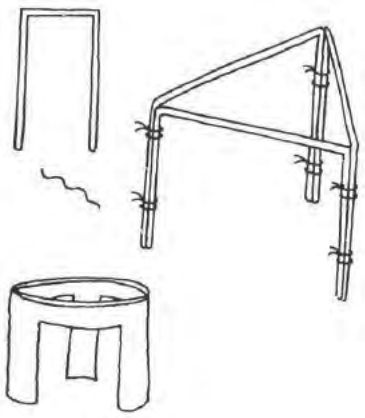
17.38 Test Tube Racks

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.



17.39 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.



17.40 Volumetric "Glass"ware

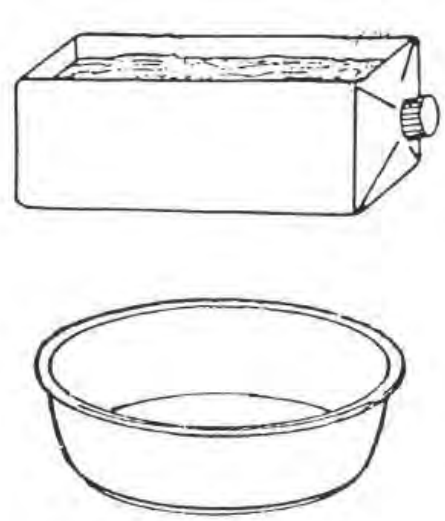
See Containers (p. 80).

17.41 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.

17.42 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.



17.43 Weights

17.43.1 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.

17.43.2 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).

17.43.3 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.

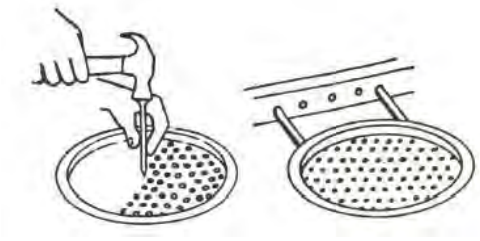
If using water, use a beam balance from a nearby school to measure the exact mass of an empty water bottle. Add a volume of water in mL equal to the mass in g needed to reach a desired total mass. (The density of water is 1.0 g/mL.) This can be done precisely by using a plastic syringe. Label the bottle with tape and a pen.

17.44 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.

17.45 Wire Gauze

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



Low Tech Microscopy

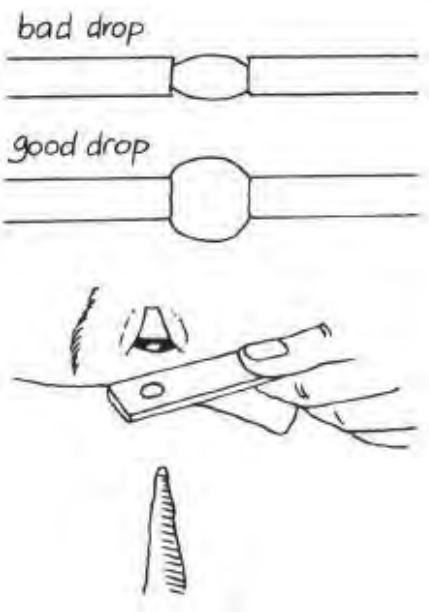
Microscopes are powerful tools for teaching biology, and many of their benefits are hard to replace with local fabrications. However, simple materials can be used to achieve sufficient magnification to greatly expands students' understanding of the very small. They may view up close the anatomy of insects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

18.1 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.

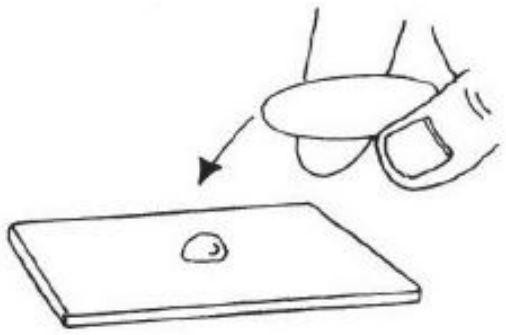
18.2 Perfect circles

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.



18.3 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.



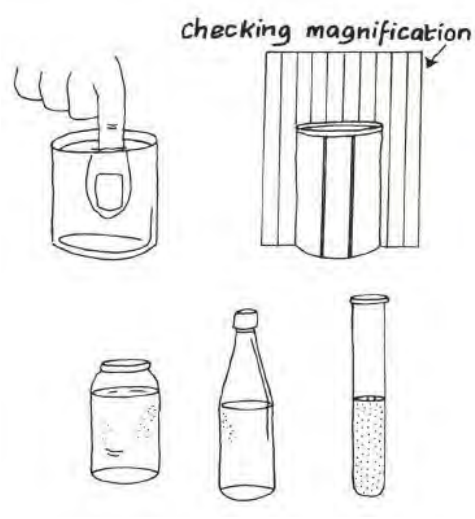
18.4 Backlighting

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.

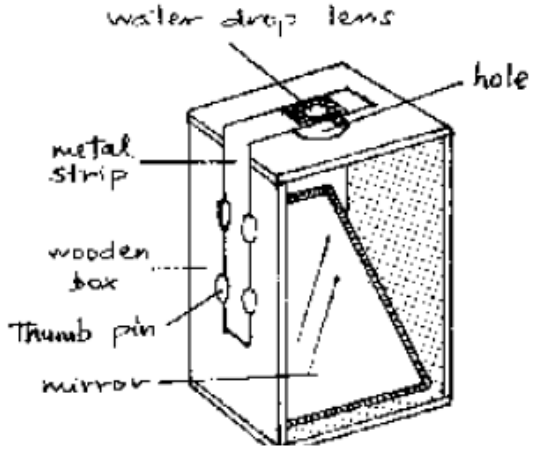
18.5 Simple Microscopes and Magnifiers

18.5.1 Clear-Container Magnifiers



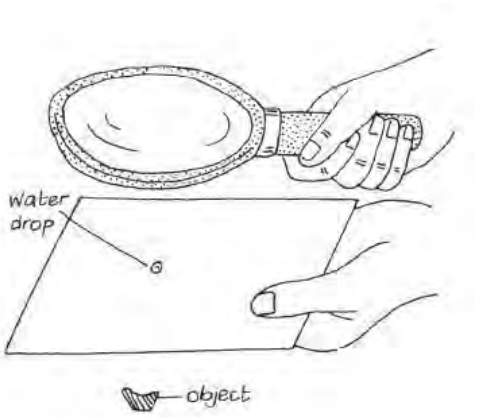
Any of these containers filled with water will make good magnifiers.

18.5.2 Simple Microscope



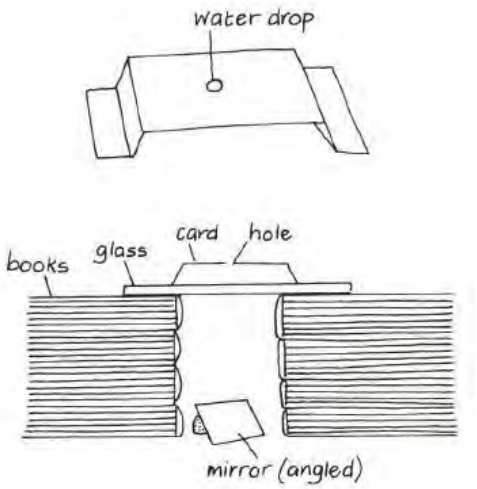
Construct a small wooden box from plywood as shown (or use a small cardboard carton such as a light bulb box). Make a round hole of 2 cm diameter, at the top. Fit a small mirror (glass or polished metal) in the box, angled to reflect light up through the hole. Make a small hole (about 6 mm) in a strip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

18.5.3 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.

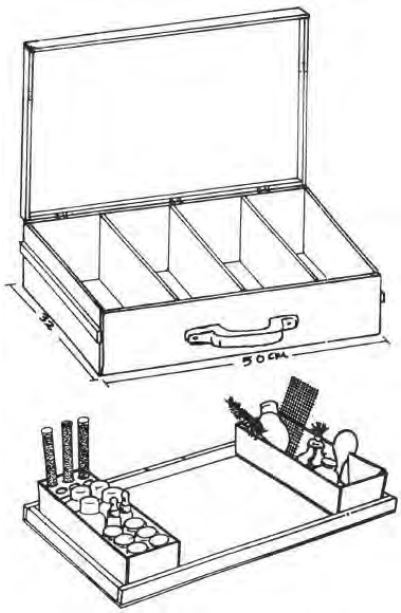
18.5.4 Card Bridge Microscope



- 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.

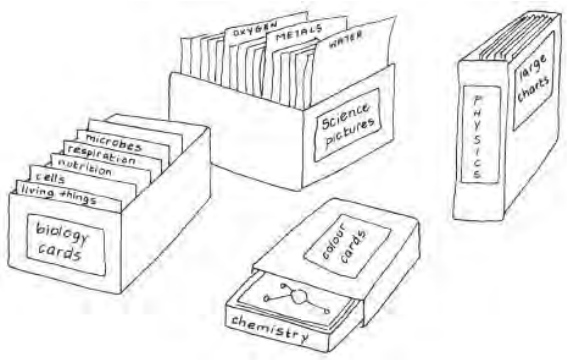
Storage of Materials

19.1 The Science Box



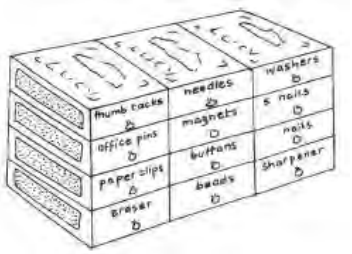
- Use a metal storage trunk to organize all of your new, locally-made science equipment.
- Metal or cardboard sheets can be used as dividers. Tape firmly in place.
- Use the lid as a science tray for safely and easily moving liquids and chemicals.

19.2 Card and Picture Boxes



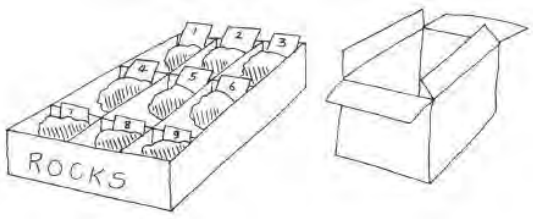
- Cards and pictures can be stored in all sorts of boxes. Store according to syllabus topic or alphabetically.
- Dividers and compartments can be made from cardboard.

19.3 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.

19.4 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.

19.5 Envelopes and Bags

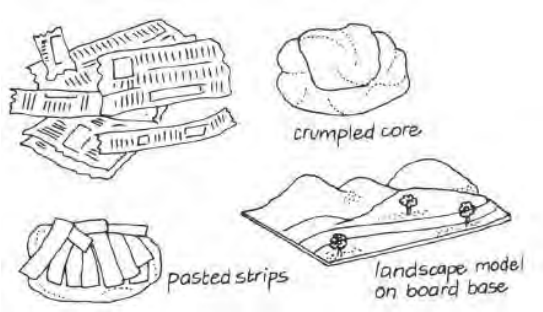
- Envelopes and bags of different sizes can be used for storage. Clearly label all containers.

Pastes and Modeling Materials

20.1 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.

20.2 Papier Mâché Layering

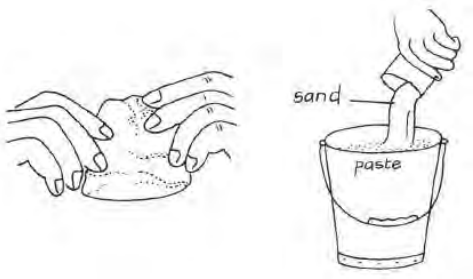


- Soak small pieces, or narrow strips, of newspaper in paste.
- Use crumpled newspaper as a core or skeleton for the model.
- Build up the model in layers of strips and pieces.
- After drying, sandpaper smooth and paint or varnish.

20.3 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.

20.4 Paste and Sand Cement

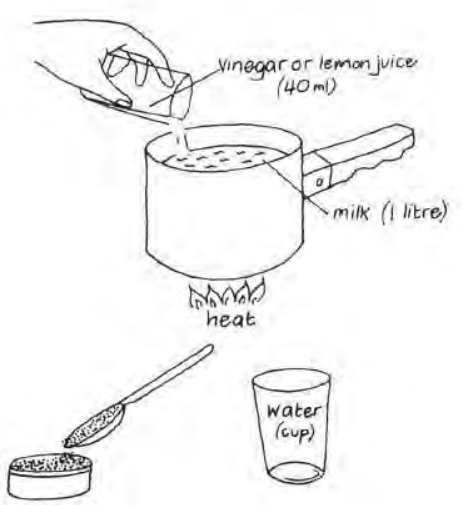


- Mix evenly together dry sand and flour paste or commercial glue.
- The wet cement moulds very easily and dries hard.

20.5 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.

20.6 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_2
Result: This liquid will change from clear to cloudy if CO_2 is present.
Procedure: Add 3 spoonfuls of white cement into about half a litre of water. Stir the solution and let it settle. Decant the clear solution and transfer it to a reagent bottle.

Citric Acid Solution
Description: Colourless solution
Use: To hydrolyse non-reducing sugars to reducing sugars
Procedure: Dissolve 2 1/2 spoonfuls of citric acid in half a litre of water.

Copper Sulphate Solution
Description: Light blue solution
Use: To test for proteins, to prepare Benedict's Solution
Result: Gives a purple colour when combined with NaOH in protein solution
Hazard: Copper ions are poisonous if they enter the body. Use tools to avoid contact between copper (II) sulphate and skin. Wash hands after using this chemical.
Procedure: Dissolve 1 spoonful of $CuSO_4$ crystals in 1/2 litre of water. Dissolve the $CuSO_4$ completely.

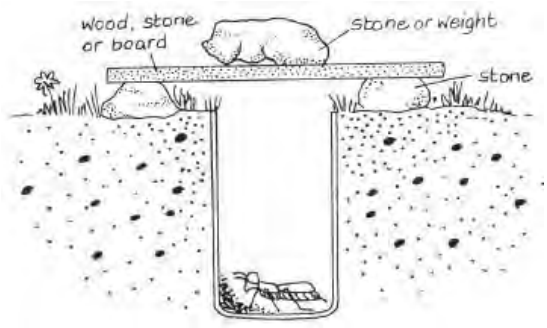
Iodine Solution
Description: Light brown solution
Use: To test for starch and lipids
Result: Gives a red ring with lipids and a black-blue with starch
Procedure: Dilute 1 part concentrated iodine tincture with 9 parts water. Keep the solution in a labelled reagent bottle.

Sodium Hydroxide Solution
Description: Slightly cloudy white solution
Use: To test for proteins
Result: Gives a purple colour when combined with $CuSO_4$ in protein solution
Hazard: Corrodes metal, burns skin, and can blind if it gets into the eyes
Procedure: Combine 1 spoon of NaOH with 1/2 litre of water.
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

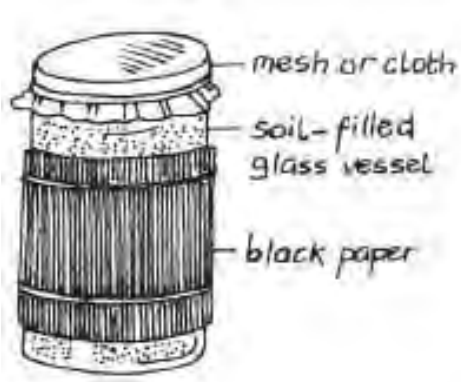
22.1 Methods of Collecting and Displaying

22.1.1 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!

22.1.2 Worm Jar

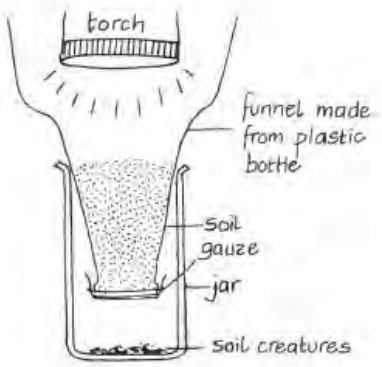


- Fill a plastic or glass vessel with soil and add the worms.
- Wrap black or dark paper around the jar to keep light away from the burrowing worms.
- Remove the paper to reveal the burrows.
- Make sure the soil is kept moist and never dries out.

22.1.3 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.

22.1.4 Soil Life

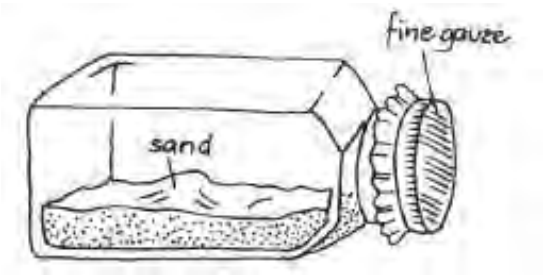


- Collect a sample of soil and place it in a funnel with a piece of gauze across its neck.
- Shine a bright light down onto the soil.
- Soil organisms usually prefer dark, damp and cool conditions so the heat and light drives them downwards until they drop into the collecting jar.
- Return organisms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

22.1.5 Flying Insect Cage

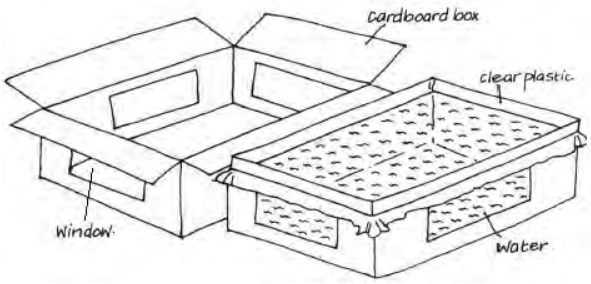
- Insects can be kept in many types of cage.
- Mosquitoes and other insects benefit from having water, vegetation and room to fly. The cage shown provides all these.

22.1.6 Reptile Cage



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

22.1.7 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.

22.1.8 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.

22.2 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.

22.2.1 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.

22.2.1.1 Phlyum 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.

22.2.1.2 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.

22.2.1.3 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.

22.2.2 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, Filiciniophyta, Coniferophyta, and Angiospermophyta.

22.2.2.1 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.

22.2.2.2 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.

22.2.2.3 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.

22.2.2.4 Division Angiospermophyta

Flowering Plants (mimea 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 Diocotyledons.

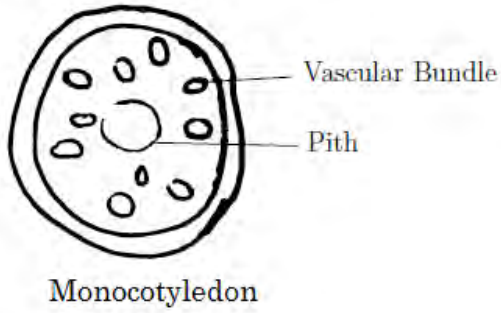
22.2.2.4.1 Monocotyledons Monocotyledon seeds have only one cotyledon. Monocots have a fibrous root system, leaves with parallel venation, three part floral systems, and vascular bundles which are scattered. Examples of monocotyledons are maize and grasses.

22.2.2.4.2 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.

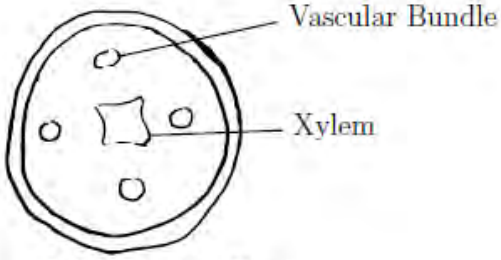
Collection Angiosperms are easily found in your surrounding environment. Monocotyledons are organisms like maize plants and grasses. Dicotyledons are organisms like mango trees, cashew nut trees, and okra.

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.

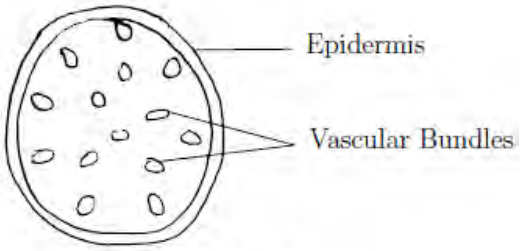
Dissection Hibiscus flowers can be easily dissected using a razor blade to identify the reproductive parts.



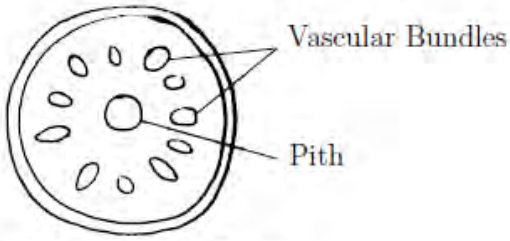
Monocotyledon



Dicotyledon Root



Monocotyledon Stem



Dicotyledon Stem

22.2.3 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, Arthropda, 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.)

22.2.3.1 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.

22.2.3.2 Phylum Nematoda or Ascehelminthyes

Roundworms
Phylum Nematoda, also known as Aschelminthyes, 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.

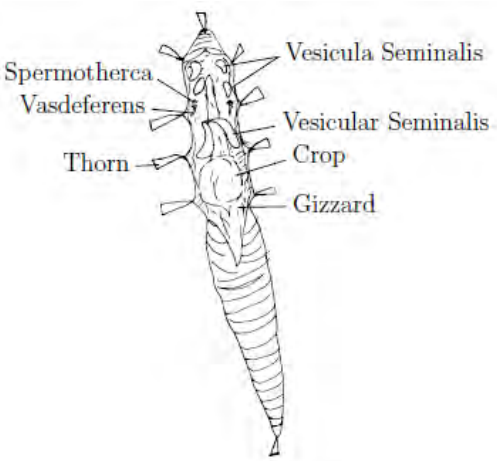
Preservation Organisms in Phylum Nematoda can be kept in labelled air-tight containers with formaldehyde solution.

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.

22.2.3.3 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.

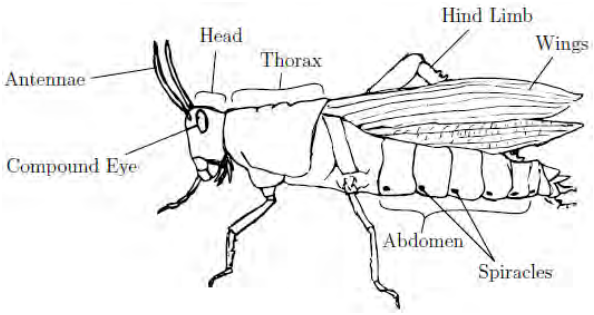
Killing Place the Annelida into a closed bottle in which is suspended a ball of cloth or mosquito net soaked in methylated spirits. Avoid direct contact with the spirit

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

22.2.3.4 Phylum Arthropoda

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

22.2.3.4.1 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.

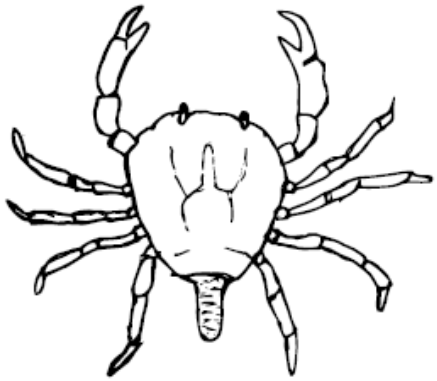
Collection Many insects can be caught in a field using a sweep net.

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, antenae, 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.

22.2.3.4.2 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.

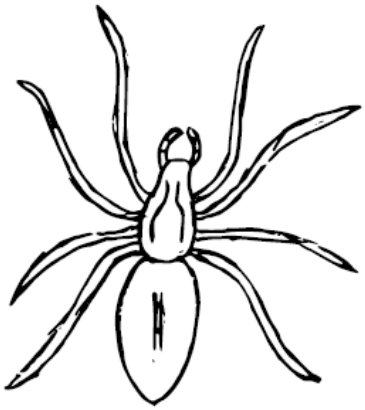
Collection Fresh water crabs, prawns, and shrimp can be found in most rivers, lakes, dams and swamps. Otherwise, they can be purchased in many markets.

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

Killing Crustesea 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.

22.2.3.4.3 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 Archnida, place them in an airtight container for a few days or use insecticide.

22.2.3.4.4 Class Chilopoda Centipedes (Tandu)

The following are the features of Class Chilopoda:

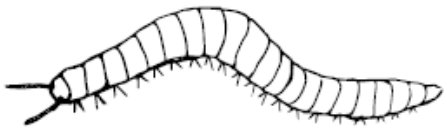
1. Chilopoda have long bodies consisting of many segments.
2. Each segment contains a pair of legs.

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.

22.2.3.4.5 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 Milipedes 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.

22.2.3.5 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.

22.2.3.5.1 Class Chondrichthyes
Sharks (Papa), Skates (Taa), and Rays

Chondrichthyes are also known as cartilagous 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.

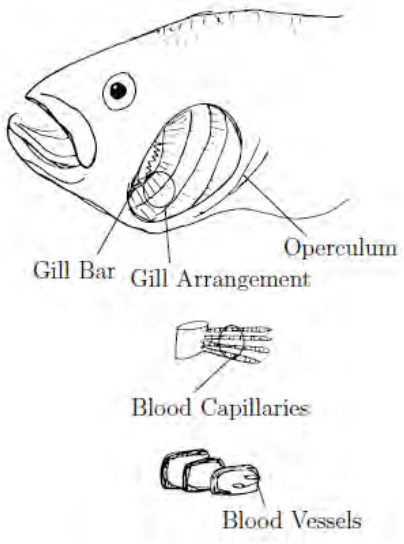
Collection Chondrichthyes can be found in most fish markets by the ocean.

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.

22.2.3.5.2 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.

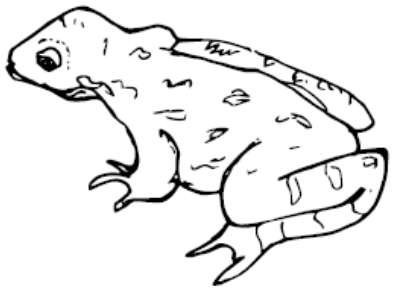
Preservation Osteichthyes can be preserved in a formaldhyde solution. Ostechithyes can also be dried and smoked. To smoke a fish, make a fire and put fish on a rack over the fire. Smoke the fish until it is dry. This takes from hours to days depending on the size of the fish.

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.

22.2.3.5.3 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.

22.2.3.5.4 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.

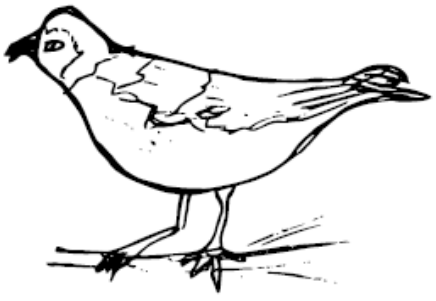
Preservation Live specimens can be held inside a cage or aquarium. Snakes should be fed small rodents and turtles can be given grass or leaves. For dead specimens, preserve them by placing them in an airtight container with formaldhyde solution.

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.

22.2.3.5.5 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.

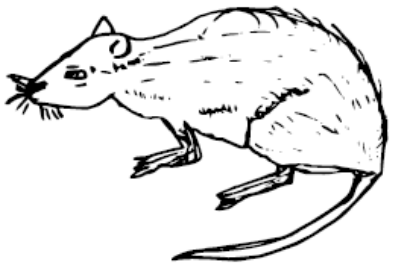
Dissection Make a lateral cut starting at the lower abdomen up to the sternum. Cut through the rib cage and pin it back to the dissection tray to examine the heart, respriatory system, and digestive system.

22.2.3.5.6 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.

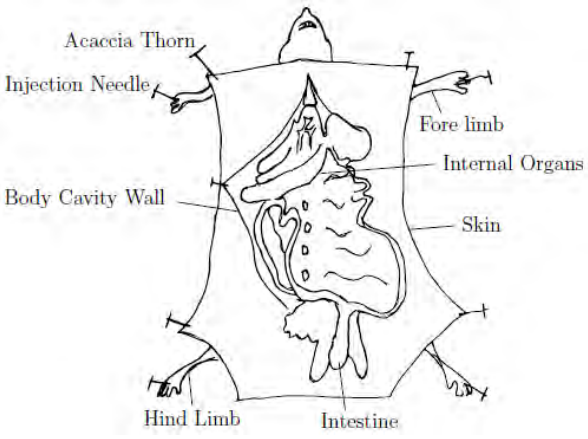


Collection Rats can be captured overnight using a trap. Bats can be collected during the day, when they are sleeping, by using a sweep net.

Preservation Mammals can be preserved in a formaldhyde 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.



Activity Template

The Shika members know that there is always room for new and improved activities, and it is much appreciated, so below is a template for contributing activities to the current manuals.

Please fill out the table below and send it to **shika.mikono.tz@gmail.com**. Not every cell has to be filled in - some cells may not be applicable to each activity. Examples of how the activities should look can be found throughout this manual. Corresponding pictures can also be sent to the above email address.

Section	Fill this in...	Comments
Title		The title of your activity
Form, Topic, and Subtopic		The form, topic, and subtopic that this activity applies to in the syllabus
Materials		List all the materials needed to complete the activity
Setup		What to do to prepare the activity
Procedure		How to carry out the actual activity
Hazards		If there is any danger involved with the activity, state it here and what to do if it happens
Questions		Possible follow-up or discussion questions
Observations		State what is observed as a result of the activity
Theory		Background information and theory behind the activity
Applications		Any real-life applications or uses of the activity
Notes		Any other information that should be stated about the activity