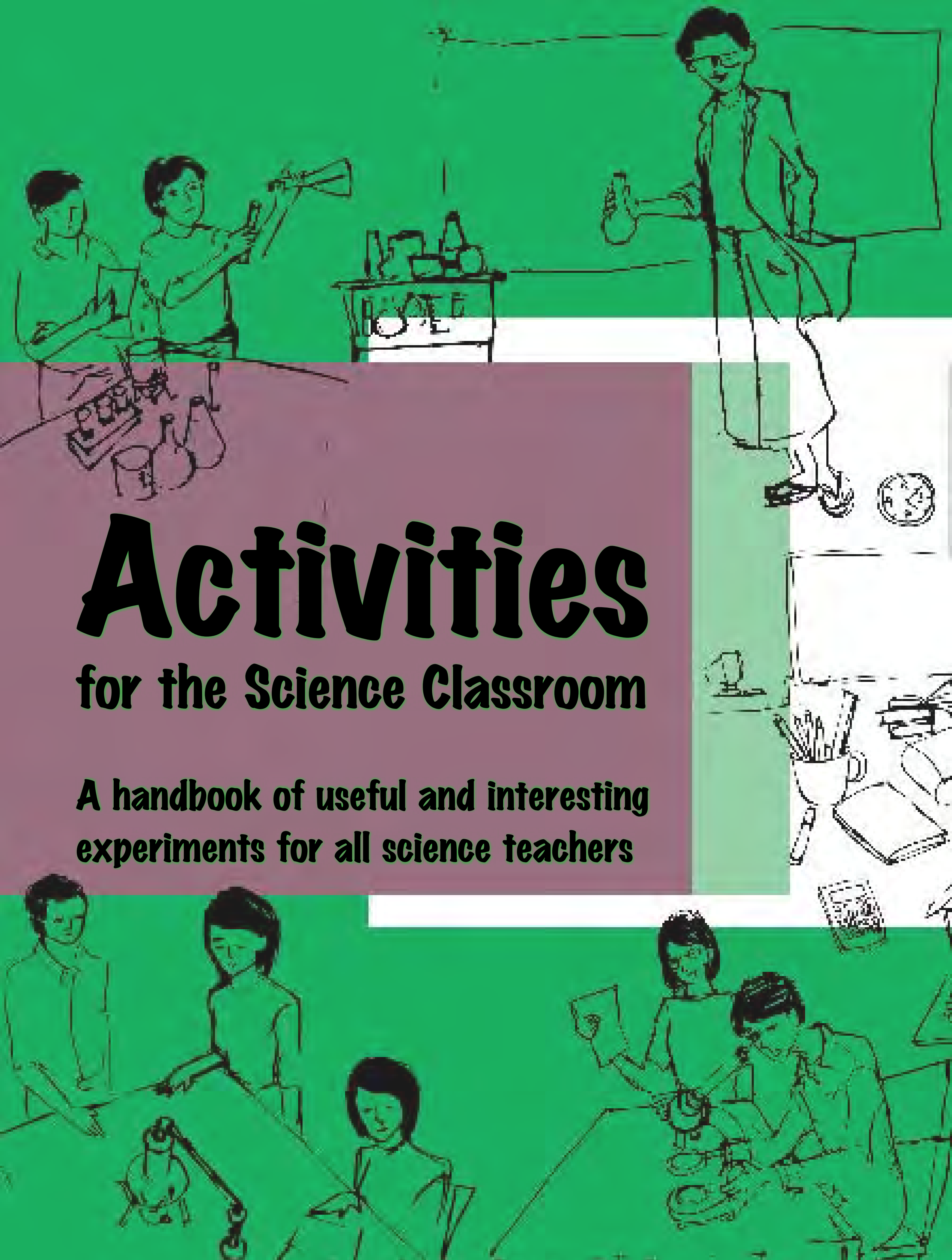

Activities

for the Science Classroom

A handbook of useful and interesting experiments for all science teachers

The Curriculum Project

educasia
Education in context

DRAFT
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About this book

Activities for the Science Classroom contains over 50 activities and experiments to help science teachers bring their classes to life, for themselves and for their students. We have organised the activities into four main sections:

> **General Science** looks at some of the most basic concepts we need to understand our world, gives ideas for making simple instuments, and suggests ways to measure, test and classify our observations.
>
> **Physics** looks at motion and Newton's laws, sound, electricity, pressure, light and heat.
>
> **Chemistry** examines chemical reactions, acids, chromatography and isotopes and radioactivity.
>
> **Biology** covers both human and animal bodies, plants, cells and basic ecology.

At the back of the book is a **Glossary** explaining all the terms in ***this style***, and a **Materials List** with all the items you need for each section of the book.

We selected the experiments and activities in this book because:

- ► they are easy to prepare, using (mostly) everyday objects, fluids and household equipment
- ► they have been used successfully by trainers who work with Myanmar science teachers
- ► they don't have complicated instructions
- ► they clearly illustrate important concepts

We hope you find this resource challenging, interesting and fun. Please send us your feedback so we can improve it for the next edition.

Thabyay Education Foundation
www.thabyay.org

This material is produced by Educasia and The Curriculum Project(CP), both programs of Thabyay Education Foundation. Educasia and CP produce context-appropriate learning materials, provide curriculum advice and deliver teacher training to a wide range of adult education programs in Thailand and Myanmar. For more information please visit our websites: www.curriculumproject.org; www.educasia.org

List of Activities

1. Introduction

Including practical activities in science classes has been shown to be an extremely effective way to teach scientific principles. Students learn faster when they ‘do’ – and they have fun learning that way too.

However, most science teachers in Myanmar face three problems in their classroom that prevent them from doing practical activities with their classes:

- Lack of equipment.
- Too many students to organise. Some teachers have classes of 60 or more.
- Lack of familiarity with the activities.

This book is designed to help teachers overcome these three problems, by explaining how to do some easy practical activities with their classes. The activities are designed for schools where there is little equipment available.

Most activities can be done by the whole class. Even if you only have enough equipment for half the class, you could start with half the class doing an activity while the other half does bookwork, and then switch.

When you carry out a demonstration, make sure the whole class can see it. Get everyone standing around the demonstration desk in a large semicircle. Do not let them crowd around the desk. If necessary, get students standing in two rows with the back ones standing on chairs so that they can see over the top of the front row.

Do not do the demonstration with the students remaining in their seats. The students at the back won’t be able to see what you are doing - unless, of course, it is you who is standing on the chair!

GENERAL SCIENCE

2. Equipment

Summary

World-famous Nobel Prize winner Ernest Rutherford (who developed the theory of the structure of the atom) once said *'All you need to do science is a room, a bench, and a sink. And if necessary, you don't need the sink*!'

There are lots of locally available resources that you and your students can use to make scientific equipment. There is a list at the back of this book of all the materials used to do these activities.

Start collecting used plastic bottles and empty drink cans now! Maybe you could do a fundraising activity at the start of the year so that you can purchase the materials you need for conducting science experiments.

2.1. Measuring Instruments

Length

The ***SI units*** of length ares *metres* (m), *centimetres* (cm) and *millimetres* (mm).

Materials

- 1 sheet of A4 paper for each student (A4 paper is the size of paper used in this book)
- 1 marker pen
- Tape or glue
- Scissors

Method

1. To make a ruler, take a sheet of A4 paper, fold it in half lengthwise, and in half again. Tear or cut along the folds to get 4 strips of paper, and either glue or tape the ends together so you have a strip that will be about a metre long.
2. Mark off 3-finger widths - they will be about 5 cm each. Divide each 5 cm gap into 1 cm spaces.

Students now have a ruler. They can keep it all year for science activities.

Volume

The SI units for volume are *litres* (shortened to L or l) and *millilitres* (mL or ml).

Materials

- Empty plastic bottles with the volume marked on them
- Plastic cups
- Marker pen
- Scissors

Method

1. Collect some empty plastic bottles with the volume marked on them. Remove the labels and wash them. Collect or buy plastic cups.
2. Use a pen to mark volumes. For a 1.5 L bottle, mark it off into thirds (0.5 L) and then into fifths (100 mL). To make measuring cylinders, cut the tops off some of the bottles.
3. Find a cup that holds about 200 mL. Five cups should fill a 1 L bottle. Try it to see.

The students can use their measuring bottles for other science activities, and you can use the same bottles for comparing mass (see below).

Mass

Materials

- Empty plastic bottles, as above
- Thin piece of bamboo about 20 cm long
- String
- 2 plastic cups

Method

The SI units for mass are the *kilogram* (kg) and *gram* (g).

- A litre of water has a mass of 1 kg and a 200 mL cup of water has a mass of 200 g.

Once you have the plastic bottles for measuring volume, you can use the same bottles for mass. For approximate measurement, compare a known mass with an unknown mass in each hand. For example, ‘This object is heavier than (or not as heavy as) this 1 kg bottle.”

For more ***accurate*** measurement, you can construct your own ***mass balance***:

1. Make two holes in the tops of two plastic cups.
2. Tie a piece of string around each end of the bamboo stick and attach the cups as shown in the diagram. The cups must hang at exactly the same level.
3. In the exact middle of the stick, tie on another piece of string so that you can hang the whole balance from a nail or hook. The bamboo stick should be able to rock like a see saw depending on which cup is heavier.
4. Mark off ~10 mL marks on the cups and use water to balance one side (10 mL = 10 g).
5. This balance can be used to measure out amounts of substances in later activities.

Temperature

The SI unit for temperature is the Kelvin, but the more common unit of measurement is *degrees Celsius* (°C). *Degrees Farenheit* (°F) is another unit for temperature, but it is not normally used in science.

If you do not have a ***thermometer***, your students can ***estimate*** the temperature of liquids with their skin. They can use the following scale:

Have you noticed these words in **bold**? They are words that have definitions in the glossary at the back of this book.

Temperature in °C	
Icy Cold	0 – 5
Cold	5 – 15
Tepid	15 – 30
Body Temp	37
Warm	30 – 40
*Hot**	40 – 50
*Very hot**	50 – 100
*Boiling**	100

*Water above 42 °C feels hot to human skin. Water above 48 °C can burn you. Do not touch very hot or boiling water!

The inside of your wrist is a good place to measure temperature.

Time

The SI unit for time is *seconds* (s) and *milliseconds* (ms).

- For activities you need a timer for, ask your students to bring a watch (preferably a digital one with a stopwatch), clock or mobile phone.
- Otherwise have them practise counting steadily: *"One banana, two banana, three banana"* etc.
- Or – students can use the pulse on their wrist to measure time: With the two forefingers of the right hand, feel for a pulse on the left wrist. Locate the two tendons in the middle of the inside of your wrist. To the thumb side of the left tendon, there is a soft hollow. Press your two fingers firmly in to this spot and feel for the pulse. Count the beats per minute to work out your heart rate, or use the beats as an approximate timer.

2.2. Heating – Making a 'Coke Can Burner'

Materials

- Aluminium cans (1 for each student or as many as possible)
- Candles (1 for each burner)
- Lighter
- Strong scissors

Preparation and Safety

When using metal can ***tripods***, remind students that *the metal gets extremely hot*. They should not touch any part of the tripod for 5 minutes after the experiment. They should also be very careful when cutting the aluminium, because the cut corners are sharp.

Method

1. Cut the top off the can using the scissors.
2. Cut three triangles out of the sides of the can to make a tripod.
3. The base of the can is now the 'hot-plate' of the burner.
4. Arrange the tripod over a small candle (if the candle is too tall it will not stay lit).

Explanation

A candle supplies a surprising amount of heat, so this clever burner is suitable for lots of simple experiments. The heat is ***conducted*** in the aluminium very efficiently, so the can gets very hot, very fast.

If you can get some ice cubes you can use this burner to demonstrate changes of state – from solid to liquid to gas. It only takes a couple of minutes to turn a small piece of ice into steam.

Alternatively, melt some candle wax in the top of the burner to compare melting and boiling points of candle wax and water.

Another idea is to compare the amount of time it takes to boil plain water and water ***saturated*** with salt.

3. The Scientific Method

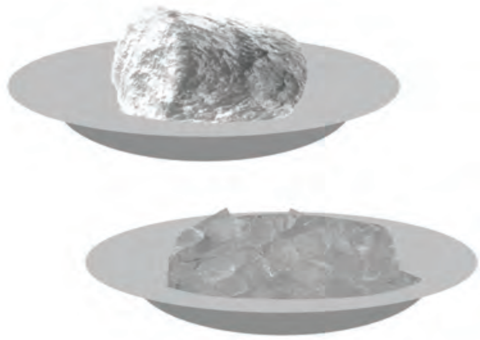
Fair Testing

A lot of science activities involve what is called *fair testing*. This means controlling all the variables except two – the INDEPENDENT VARIABLE and the DEPENDENT VARIABLE – and seeing how these two relate to each other. The three experiments below are designed to help students learn about variables, and learn how to draw graphs to compare the dependent with the independent variable.

3.1. Ice Melting and Variables

Timing

40 minutes, including the time to melt the ice and discuss the results.



Materials

- Ice blocks (or the largest ice cubes you can buy)
- Cooking plates/dishes
- Plastic bags for breaking up the ice
- Stopwatches or students willing to count out loud to time the melting rates (see section 2.1)

Preparation and Safety

Make the ice blocks before the lesson by freezing 2 plastic cups of water for each group of students who will be doing the experiment. Both cups should contain the same amount of water.

Method

1. Explain the aim. Which melts faster: A block of ice or ice that has been broken into pieces?
2. Get students to list all the variables that must be CONTROLLED (kept the same). It should include:
    - Volume of ice - you would not compare a small ice block with a large one that had been broken up. You need two blocks of ice with the same volume - one is left as a block, and the other block is broken up by putting it in a plastic bag and smashing it gently.
    - Put the ice in similar dishes - they should be made of the same thing, same shape and same size. If you used a metal bowl and a plastic cup, would you expect different results?
    - Dishes should be placed in the same position. What would happen if one dish was inside and the other was out in the Sun?
    - Make the observations on the same day and the same time. What would happen if you melted one ice block in the morning and the other in the afternoon?
3. Tell the students to conduct the experiment themselves and make observations.
4. You can use this experiment as practice for writing up reports with the format: Aim, Hypothesis, Materials, Method, Results, Discussion, and Conclusion.
5. In the Results section, get the students to draw a bar graph of the results. (See Activity 3.3 for advice about graphing.)

Explanation and Extension

An example graph for this experiment is in Activity 3.3.

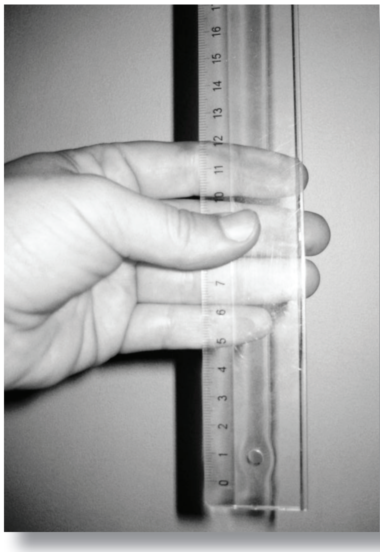
Explain that only the independent and dependent variables should change in a good experiment. If the controlled variables change, then you can't be sure what is responsible for the differences you see in the dependent variable. For example, if you use different dishes for melting, then you won't know whether it is the state of the ice or the type of dish that is responsible for the different melting times.

If you can't get ice, or want to do another demonstration of variables, get your students to find out which evaporates more quickly: pure water, water with salt dissolved in it, or water with sugar dissolved in it?

What are the CONTROLLED VARIABLES? Same amount of water, same amount of salt and sugar dissolved, same types of dishes and same placement of dishes. INDEPENDENT VARIABLES – water, water with sugar, water with salt. DEPENDENT VARIABLE – time to evaporate.

3.2. Reaction Time

Use this fair testing activity to work out who has the faster reaction time – boys or girls?



Timing

15 minutes, plus 15 minutes to work on the graph.

Materials

- Rulers

Method

1. Work in pairs. Student A holds a ruler vertically so that the '0 cm' mark is just level with the outspread thumb and fingers of Student B. Student A releases the ruler.
2. Student B must catch it by closing their fingers and thumb together as quickly as possible, while keeping their hand level and the same height.
3. Take at least five measurements of how far the ruler falls before being caught. Discard any that are significantly different. For example, if my readings are 9.5, 10.2, 8.9, 5.6 and 9.8, then the 5.6 is significantly lower and probably the result of luck. Discard it. Then take the average of the rest. *(9.5 + 10.2 + 8.9 + 9.8)/4 = 9.6*
4. Swap roles and record both students' reaction distances. The shorter the reaction distance, the better the reaction time.
5. ***Collate*** the results for the class in a table on the board and calculate the class average of boys' and girls' reaction distances.
6. Have the students draw a scatter graph of the results (see Activity 3.3).

Explanation

Ask the class how ***valid*** the results are. Can we really work out whether boys or girls have a faster reaction time using this experiment?

- Have they controlled for the variable of age? Are younger people faster than older people?
- Have they controlled for the variable of size? In smaller people, the neural pathways from the brain to the hand are shorter. Will they have a faster reaction time?
- Would they get the same result if they repeated the exercise at a different time of the day?
- What about how wide the finger and thumb are spread?

Your class will probably decide that none of these variables have been controlled properly so they will not be able to draw any strong conclusions from the results.

3.3. Graphing

You can add a lesson on graphing to many of the activities in this book. The four experiments from 3.1, 3.2, 5.1 and 16.2 are used below as examples of simple graphs.

Timing

Depends on the class. You could spend an extra 15 minutes after every activity working on graphs and the students will get faster and more confident over time.

Materials

- Coloured pencils and graph paper will make graphing easier but these are not essential

Method

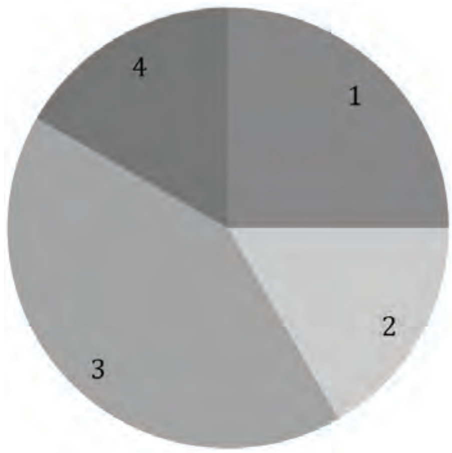
There are various ways to express data.

Pie chart

- These are usually used to display fractions of a whole. For example, you could make a pie chart for Activity 16.2 by classifying the invertebrates that your students bring in. Make a chart to show the percentages that are insects, arachnids, worms, crustaceans, etc. Within the 'Insect' group, they can make further classifications, e.g. 'with one pair of wings', 'with two pairs of wings', etc.

Activity 16.2, Pie chart for Invertebrate Classification

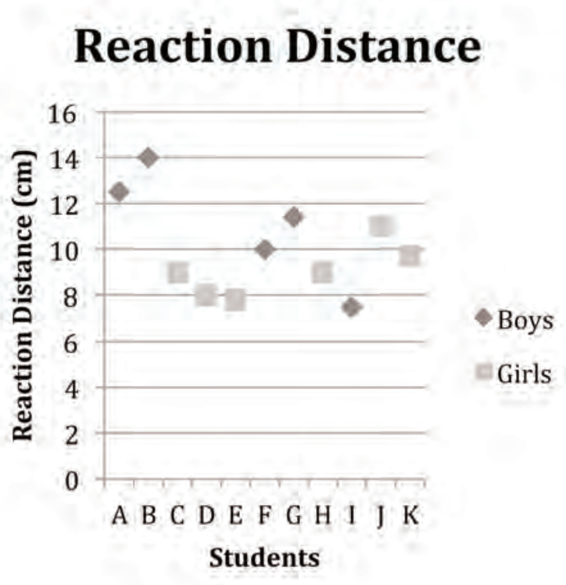
1. Have the students classify the invertebrates any way they like.
   - One option might be by 'phylum' – there might be representatives from three phyla – Annelida (which includes earthworms and leeches), Arthropoda – which includes insects, crustaceans (crabs, etc), centipedes, millipedes and arachnids (spiders, ticks and scorpions) – and Mollusca (which includes snails and slugs).
   - A further break down might be by 'class' – e.g., insects, arachnids and crustaceans are different classes of arthropods. Within the 'insecta' class, the students might be able to distinguish different orders, like moths, butterflies, flies, cockroaches, bees/wasps/ants, beetles, bugs, etc.
   - Or, they could classify by appearance: colour, number of legs, with or without wings, etc.



2. Work out the percentage of the total invertebrates that have been put into each group, and split up the 360° of the circle into these percentages. For example, if group 1 in the above example has 6 crickets in it, and there are 24 invertebrates all together, the segment is 6 ÷ 24 x 100 = 25%. 25% of 360° = 90°
3. Label the segments correctly – instead of *1, 2, 3, 4* in the above example, the students would write the names of the classes you have chosen.

Scatter graph

- These are usually used to display data points that are independent from each other. For example, the individual students' reaction distances from Activity 3.2.

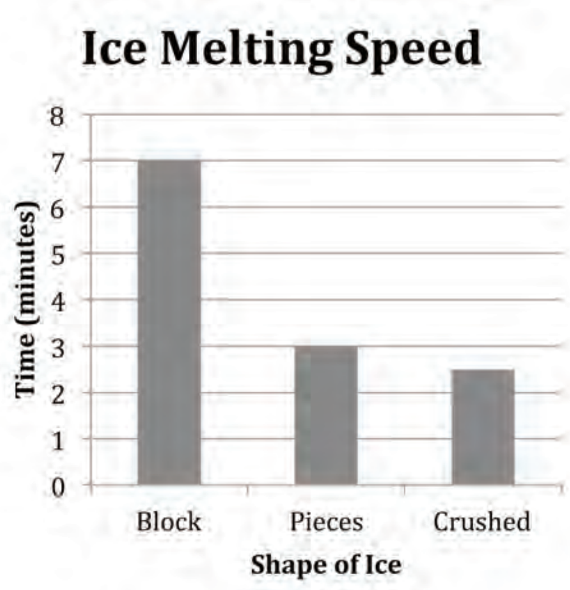


Activity 3.2, Scatter Plot for Reaction Time versus Gender

1. Always label the graph at the top.
2. Put the independent variable on the horizontal axis (the students, arranged in alphabetical or random order), and the dependent variable on the vertical axis (reaction distance).
3. Choose the scale of both axes so that they are approximately the same size (you don't want one that is long while the other is short).
4. Label the axes and the units in which they are measured.
5. Place a dot for each student's reaction distance – boys and girls in different colours. Do not join the dots because there is nothing to link the individual results.
6. Look for a trend – is one colour (gender) lower (faster) than the other?

Bar or column graph

- Bar or column graphs are used when the independent variable is a number of separate categories that you want to compare.



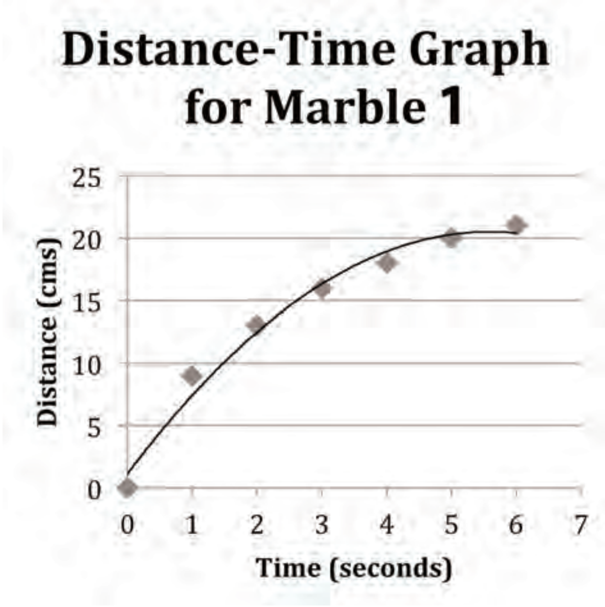
Activity 3.1, Column Graph for Ice Melting Speed

1. The independent variable will be the state of the ice – either in a block, or in pieces, or if your students want to try three states, crushed up. The dependent variable will be the time taken for the ice to melt.
2. The independent variable goes along the horizontal axis, and the dependent variable goes up the vertical axis.
3. You could add another variable by adding more columns in a different colour. For example, you could compare the melting rates in the sun and shade for the three shapes by adding a red column (sun) beside the blue columns (shade) for each shape.

Line graph

- A line graph usually compares a measurement over a period of time or measurements of a variable that are connected to each other somehow.

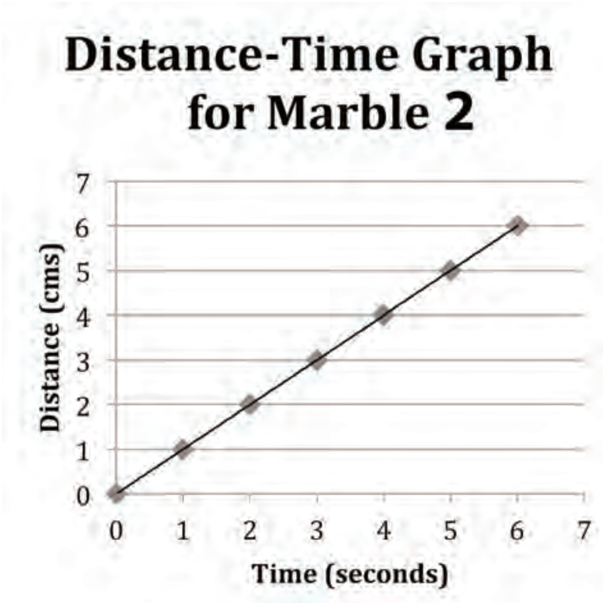
Activity 5.1, Line Graph for Distance–Time Measurement of a Marble



1. Decide whether the graph is going to pass through the origin. For example, if you are measuring the distance a marble rolls versus time, can it have travelled any distance at zero time?
2. Plot the data points.
3. Plot the *line of best fit*. Will it be a straight line or a curve? It should pass as close to as many points as possible, but it doesn't have to go through any of the points, except if you decided that it should go through the origin.
4. If the line is a curve, turn the page around so that the curve can follow the natural sweep of your hand when sketching.

Extension

For all of the above graphing exercises, you can ask the students to answer questions about the graphs. For example:



- For the graph on the right, how far had the marble travelled after 2.5 seconds? *(2.5 cm)*
- If the marble continued at the same speed, how long would it take to travel 10 cm? *(10 s)*
- For the two graphs on distance–time, which shows a constant rate of acceleration or deceleration? *(Marble 1 graph shows deceleration)*. Which shows a constant speed but no acceleration or deceleration? *(Marble 2)*
- What would a graph of acceleration look like? *(Like the Marble 1 graph, but with the curve going up, not down)*
- For the reaction distance graph, what is the difference between the fastest and slowest reaction times in the class? *(Subtract the lowest number from the highest number)*
- For pie charts, make up questions about the amounts of the different categories. If you do the exercise about the invertebrates in class, ask: *What proportion of the invertebrates are insects? Which invertebrate makes up 25% of the samples collected?* etc.
- If you have more than one line on a line graph, you could ask questions comparing the relative increase or decrease of the dependent variable.

4. Classification

Classification is an important scientific concept. Classification is the process of grouping similar items together. All scientists classify things in some way. To do this properly, we must identify features that some of them have in common. This is called an ***attribute***.

4.1. Classifying Your Class's Shoes

This activity is described using shoes, but you could do a classification exercise with just about anything – flowers, food items, nails and screws, invertebrates, clothing, and so on. Ask all the students to bring in one of your chosen item (i.e. each student brings one item), and then adapt the instructions below.

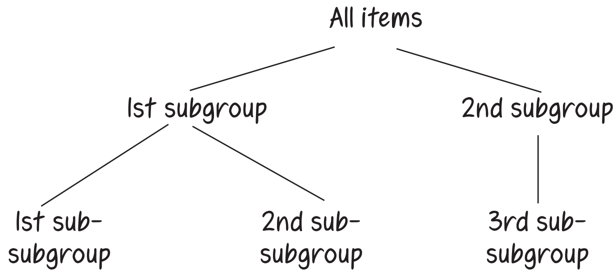
Timing

About 1 hour to explain about classification and have the students work out a suitable classification scheme themselves.

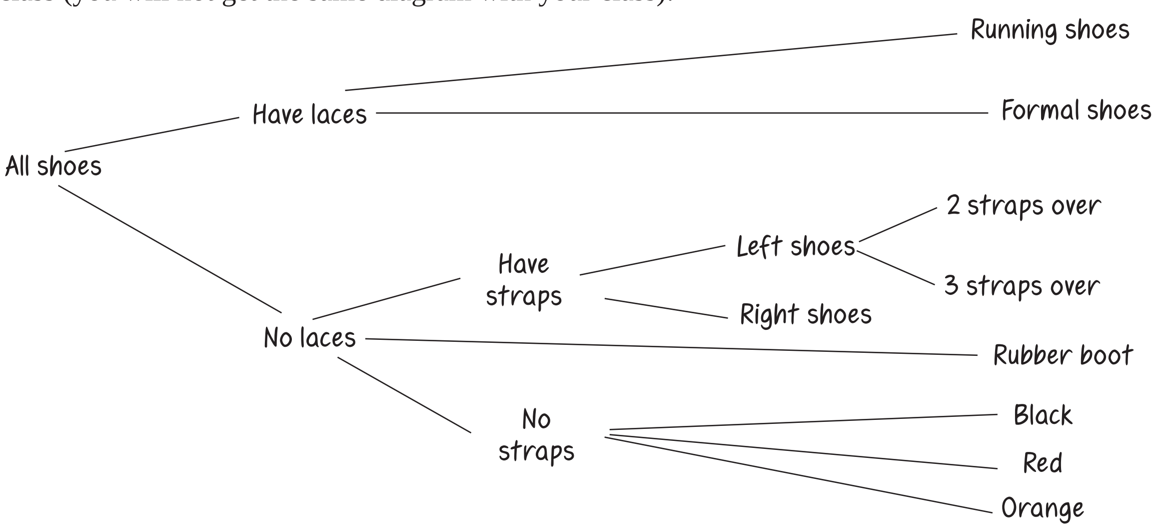
Materials

- All the shoes your class wore today

Method



1. Explain how to classify items into groups using a particular attribute at each grouping. Use the tree diagram on the right to explain how.
2. Go outside and have everyone take one of their shoes to add to the pile.
3. Have the students describe attributes of the shoes: left or right foot, colour, style, brand, size, etc.
4. Try to let the students run the classification themselves. You may need to choose a leader, or if there are too many students, split the class into smaller groups.
5. Help the students choose one attribute for the first split. For the first split, choose an attribute that divides the shoes into only two groups, e.g. all the shoes will be either right foot or left foot.
6. Keep dividing the shoes into smaller and smaller groups until there is only one shoe in each group. The students should discuss the best way to do this.
7. Have everybody draw a diagram of the classification they decided on. You could repeat the exercise a few times if there is a debate about the best way to do it. Here is an example of a diagram from one class (you will not get the same diagram with your class):



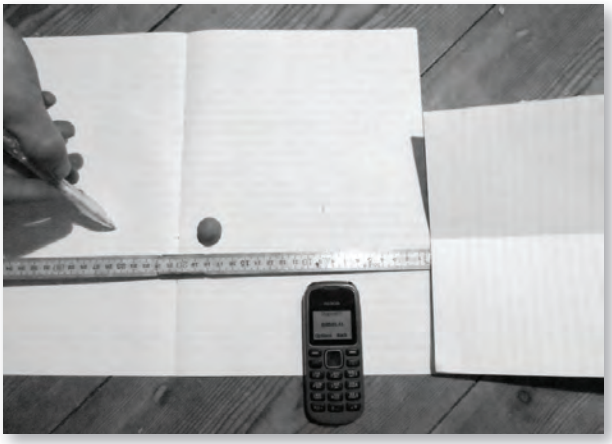
PHYSICS

5. Motion

5.1. Distance and Time

Timing

About 10 minutes plus about 15 minutes for the graphing exercise.



Materials

- Ruler (the students can use their paper ruler from Activity 2.1)
- A marble or ping pong ball
- Pen
- Stopwatch or students ready to count steadily
- A piece of paper or cardboard (one for each ball)

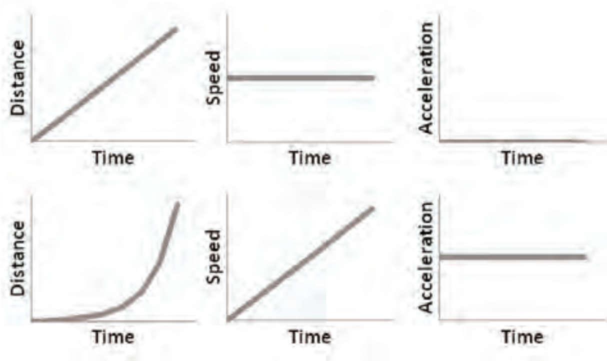
Method

1. Make a ramp out of the paper or cardboard, as shown on the right side of the picture.
2. Adjust the ramp so that the marble rolls down quite fast, and then keeps rolling along the floor. If the floor is very rough, put paper down to make a smoother surface.
3. As soon as the marble hits the floor, that is time zero and zero distance. Someone needs to count the seconds out loud. Have other students ready to mark with the pen on the paper the distance the marble has travelled each second.
4. Try a few times until you get consistent results.
5. Measure the distances marked for each second and fill in the table.
6. Teach students how to construct a line graph as per the instructions in Activity 3.3.

Time (s)	Distance (cm)
0	0
1	
2	
3	
4	
5	

Explanation

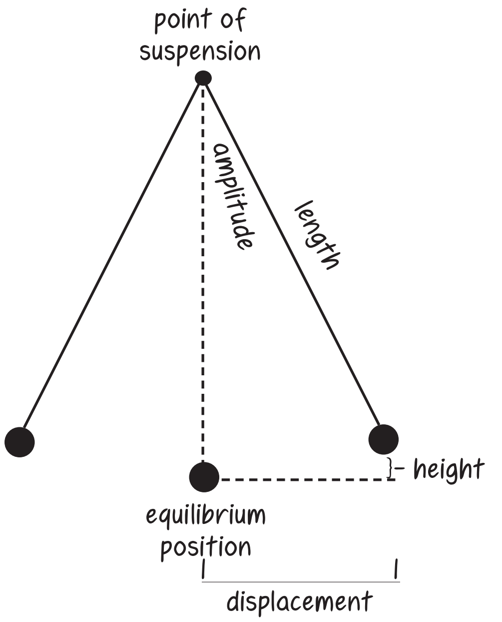
Discuss the properties of time (T or t), Speed (S), ***velocity*** (v), distance (D), acceleration (a) and deceleration (-a). If speed is constant, there is no acceleration. If speed is increasing, acceleration is constant. If speed is increasing exponentially, then acceleration is increasing. Draw simple diagrams to show these properties.



Introduce the formulas:

S ($m.s^{-1}$)	=	D (m)	/	t (s)
Speed		*Distance*		*Time*
a ($m.s^{-2}$)	=	Δ S ($m.s^{-1}$)	/	t (s)
Acceleration		*Change in speed*		*Time*

5.2. Motion of a Pendulum



Timing

45-60 minutes including explanations and graphing.

Materials

- A 1 L or 1.5 L plastic bottle filled with water
- String
- A beam in the ceiling or a hook on a door frame

Method

1. Tie the string to the bottle. Try to attach the string to the centre of the top of the bottle so the weight is centred. To do this, you could make a hole in the centre of the lid and tie a knot in the string inside, or you could make a loop at each side of the neck.
2. Attach it to a beam or a hook so that it can swing freely, and set it swinging back and forth in a straight line.
3. The time taken in seconds for one complete swing back and forth is the *period*, T.
4. The *displacement* is how far away from the centre you pull the pendulum before letting it go.
5. Have the students think about the following:
    - What is the period of your pendulum?
    - Does the period depend on the displacement? Try pulling it back to different displacements and see if the period varies.
    - Does the period depend upon the mass of the pendulum? Tip half of the water out and see if the period is any longer or shorter.

6. Explain about potential and kinetic energy (see the Explanation on the next page), then tell the students to go back to the pendulum to find out the following:
    - At which point in the swing of the pendulum is potential energy at a maximum?
    - At which point in the swing is the kinetic energy at a maximum?
    - Is all of the potential energy converted into kinetic energy?
    - Is all of the kinetic energy converted back into potential energy?
    - If not, where has the energy gone?
7. Measure the length of the pendulum, including the size of the bottle to the centre of its mass (about the middle of the bottle). Now reduce the length of string so that the pendulum is ¾ of the length and measure the period.
8. Now reduce it to half the length and measure the period. Then to ¼ of the length. For short periods, you might have to measure it 5 times, and divide the total by 5. Fill in a table like the one on the right.
9. Plot a graph showing length of string versus period. Does the graph pass through the origin? If the length of the pendulum is zero, can there be any period?

Length of Pendulum (cm)	Period T (s)
Full	
3/4	
1/2	
1/4	
0	

Explanation

The students should find that the mass of the pendulum *does not* affect the period, but the length of the string *does*.

Potential Energy is energy stored when a mass is about to move. It is calculated with the formula:

PE (Joules)	=	m (kg)	x	g ($m.s^{-2}$)	x	h (m)
Potential energy		*mass of pendulum*		*acceleration due to gravity*		*height from highest to lowest points of the swing*

Acceleration due to gravity is always 9.8 $m.s^{-2}$ on Earth, which many teachers round to 10 $m.s^{-2}$. Kinetic Energy is the energy of movement. When a mass is given potential energy by lifting it up against gravity, the mass will gain that same amount of kinetic energy when it starts to move.

KE (Joules)	=	½ m (kg)	x	v^2
Kinetic energy		*mass of pendulum*		*velocity of swing*

Remember that energy cannot be created or destroyed, only converted into different forms, so all of the potential energy becomes kinetic energy when it starts to move. At the bottom of the swing (the equilibrium position) the KE is at its maximum. Then it starts to become PE again as the pendulum swings up the other side. At the top of the swing on each side, in the moment before it starts to fall again, the PE is at its maximum.

The other factor affecting this pendulum is friction. If you were doing this experiment in space, the pendulum would never slow down, but because of the friction of air on the bottle, a little bit of the KE is converted into heat energy with each swing. We can ignore this effect of friction for our calculations because it is such a small amount, but friction is the reason the pendulum will eventually stop swinging.

5.3. Hooke's Law

Timing

15 minutes plus graphing time.

Materials

- Empty plastic bottles (1 L or larger)
- Rubber bands (or any other ***elastic*** material), 6 per bottle
- String
- Paper rulers (the ones you made in 2.1)
- 200 mL measuring cups or bottles
- Water
- Tape

Method

1. Join 5 or 6 rubber bands together and attach to a piece of string tied around the neck of the bottle. Attach the other end of the rubber bands to any hook or nail high on the wall.
2. Tape your paper ruler to the wall so that '0' is level with the bottom of the bottle as it hangs.
3. Add 1 cup of water to the bottle.
4. Mark the distance the lower end of the bottle comes to. This is the 'extension'.
5. Keep adding cups of water and measure the extension each time.
6. Add at least 5 cups and fill in a table like the one on the right.
7. Plot the results as a graph.

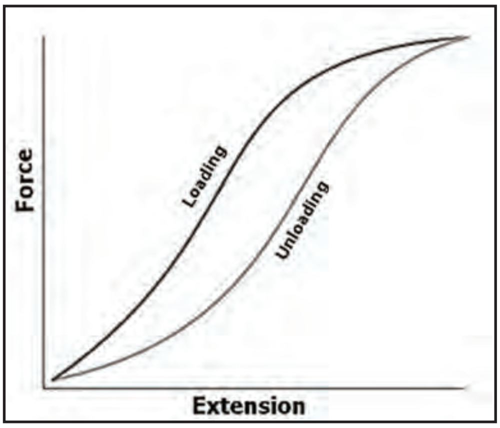
Force (cups of water)	Extension (cm)
0	0
1	
2	
3	
4	
5	

Explanation

Hooke's law relates force to extension by the formula:

F (N)	=	−k	x	χ (m)
Force in newtons		*constant*		*displacement*

This is a theoretical formula that means 'the extension of a material is directly proportional to the load applied to it'.



Because force is proportional to mass, and to the displacement (which is the extension in this experiment), we can plot cupfuls of water versus extension and see the relationship. For advanced students you could work out the actual force in newtons, from the formula:

$$F\ (N) = m\ (kg) \times a\ (m.s^{-2})$$

Acceleration due to gravity – 9.8 ms^{-2}

If you did this experiment for a steel spring, the result would be a straight line graph because steel obeys Hooke's Law. For rubber, however, the result is a curved graph. It is actually a special curve called a 'hysteresis' curve (the graph on the right shows an 'ideal' rubber band). This is because rubber bands do not stretch evenly. Some people say rubber is a 'non-Hookean' material!

6. Illustrating Newton's Laws

Summary

Newton's laws of motion:

1st Law – Law of Inertia: "*An object will continue in its state of rest or uniform motion unless acted on by an outside force*". The 'Egg Splash' (Activity 6.1), demonstrates inertia in a spectacular way. You can also point out the inertia that you have to overcome in Activity 6.2 'Marbles on the Move' when you first start blowing the marble.

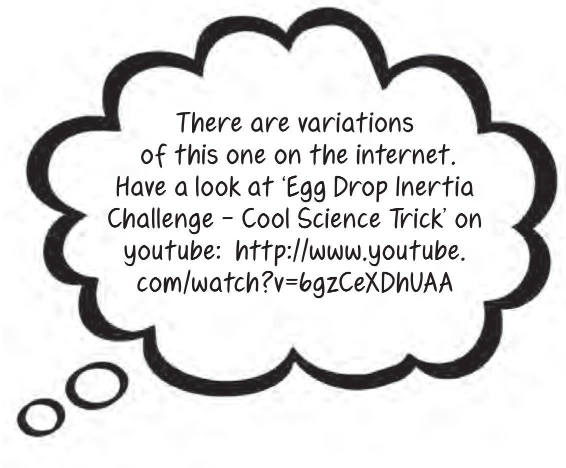
2nd Law – Force and Acceleration: "*If an unbalanced force is acting on a mass, it will cause it to accelerate, and the acceleration of an object is directly proportional to the force acting on it, and inversely proportional to the mass*". That is, $F = ma$. Use the marble activities suggested in Activities 6.2, 6.3 and any others you can think of, to demonstrate how changing the mass affects the force and acceleration. You can also introduce the concept of momentum, $p = mv$.

3rd Law – Action and Reaction: "*For every action, there is an equal and opposite reaction.*" There are many ways to demonstrate Newton's third law. The Newton's Cradle activity in Activity 6.4 is a simple demonstration that everyone can try.

6.1. Egg Splash

Timing

Around 20 minutes as a demonstration with an explanation, longer if the students are trying it for themselves.



Materials

- 3 heavy glasses or bowls, exactly the same size, two thirds full of water
- 1 piece of cardboard (stiff paper) or a plastic tray, with raised edges
- 3 cardboard inserts from toilet rolls
- 3 eggs (or objects with a similar size and mass, e.g. balls)

Method

1. Arrange the materials as shown in the picture. The toilet rolls and eggs must be directly above the glasses of water.
2. Prepare the class by asking them to predict what will happen when you hit the tray out of the way.
3. Hit the tray or cardboard firmly and the eggs will drop into their glasses.

Explanation

The eggs stay motionless because of inertia, even when you apply a force to the tray they are sitting on. Then gravity takes over and they drop straight down. You can modify this experiment so that each student tries it with one egg over one glass of water.

6.2. Marbles on the Move

Timing

About 30 minutes to play with the marbles and to explain Newton's second law.

Materials

- Marbles – small and large ones
- Ping pong balls
- Drinking straws

Method

1. Have the students blow through a straw pointed (almost) horizontally at a marble, moving so that they keep blowing on the marble from the same distance away. Notice that the marble keeps accelerating.
2. Now have them blow on a marble with a greater mass. The acceleration is a lot less.
3. Have the students blow on the ping pong ball. What is the acceleration like?
4. Roll a marble over the desk and while the marble is moving, blow from the side. What does the marble do?
5. Have a desktop marble contest. Place the marble in the centre of the desk and have two students facing each other. When you say 'go' they start blowing on the marble and try to get it to the other end of the desk.

Explanation

When you blow on the marble through the straw, you are applying a force. If the force increases, the acceleration will increase. If the mass is greater, the force will need to be greater to produce the same acceleration, because of the equation:

$$\underbrace{F\ (N)}_{\textit{force}} = \underbrace{m\ (kg)}_{\textit{mass}} \times \underbrace{a\ (m.s^{-2})}_{\textit{acceleration}}$$

You can give the students problems to solve using this equation.

When they start the marble rolling, and if they change the direction of a marble already moving in a straight line, they are overcoming the *inertia* of the object.

Have the students try blowing a flat object like an eraser. It doesn't work because the force of friction is opposing the force they are applying. Friction is the force between any two surfaces. As we saw in Activity 5.2, there is even friction between an object and the air around it, but this is a small force compared to the friction between two rough surfaces.

English Lesson!
Did you know that the word 'inertia' can also be used as a figure of speech? It can be used to describe someone who can't get started with what they ought to be doing, or won't change 'direction' in their life, even if they are 'forced' to do so!

6.3. Marbles with Momentum

Timing

15 minutes, plus 30-45 minutes if you have lots of marbles and the students want to play a game.

Materials

- 2 small marbles and 1 large marble
- A track made with two rulers or the space between two desks

Method

1. Place a marble in the middle of the track and roll another marble towards it. What happens?
2. Roll a large marble toward a small marble. What happens?
3. Roll a small marble toward a large marble. What happens?
4. If you have enough marbles, you could make a game of 'table billiards.'

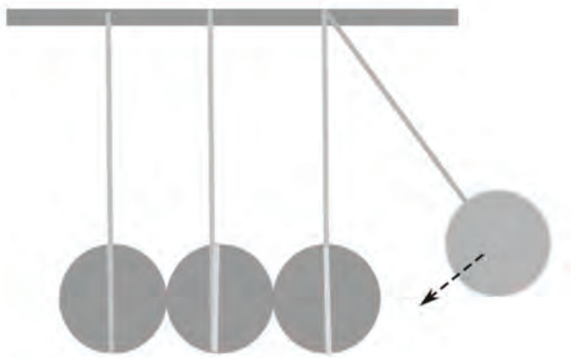
Explanation

Momentum is a measure of the mass and velocity, with the equation:

p	=	m (kg)	x	v (m.s^{-1})
momentum		*mass*		*velocity*

This means that the larger the mass, and/or the greater the velocity, the greater the momentum. The games of billiards, lawn bowls and ten pin bowling all rely on momentum.

6.4. Newton's Cradle



Timing

About 30 minutes.

Materials

- 3 to 5 ping pong balls
- A piece of bamboo or other stick
- String

Method

1. Tie a piece of string around the middle of each ping pong ball.
2. Hang the balls in a row so they are just touching each other and the string hangs straight.
3. Lift one ball away from the end and release it so it swings back and hits the next ball.
4. The ball at the opposite end should swing out and back with the same acceleration you applied to the first ball.
5. If you have 5 balls try swinging two balls out and see what happens.

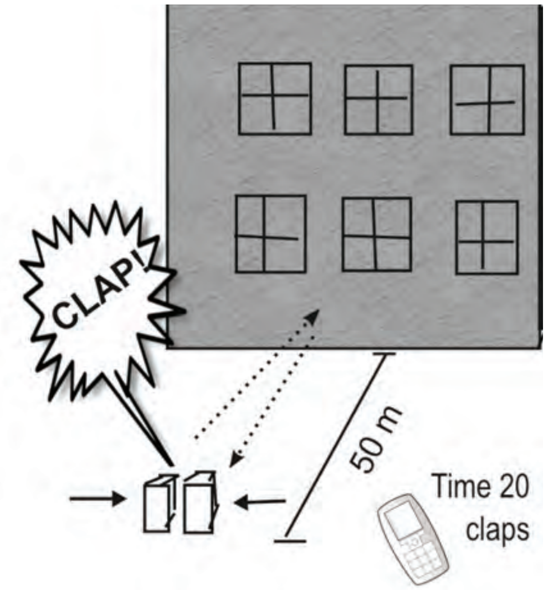
Explanation

The force that you applied to one end has applied an equal and opposite force to the ball at the other end.

This also demonstrates that momentum is transferred between the balls, as you discovered in Activity 6.3. Momentum and energy cannot be destroyed, so it is transferred from one ball to the next in the cradle.

7. Activities With Sound

7.1. Measuring the Velocity of Sound



Timing

About 20 minutes.

Materials

- A concrete or stone wall at least 2 metres high
- 2 blocks of wood or 2 flat stones
- Stopwatch

Method

1. Take 50 long steps away from the wall – each step should be about a metre long.
2. Have a student stand at the spot 50 m from the wall and clap (bang) the two pieces of wood or stones together to make a loud sound.
3. The sound will travel to the wall, bounce off it, and come back to you as an echo. This means that the sound has travelled a total of 100 metres to hit the wall and come back. (Make sure there are no other walls around to also make an echo and confuse you.)
4. The clapping student should set up a rhythm of clapping so that each clap is ***superimposed*** on the echo. This is not easy and will take some practice. Other students can help decide when they can only hear the clapping, not the clapping plus an echo.
5. Once they have the rhythm, the clapping student tells the person with the stopwatch when to start it and everybody counts 20 claps out loud.
6. Measure the time taken for 20 claps.

Explanation

Work this out on the board using the times your class has measured:

Time for 20 claps _______ = 't' seconds

Time for 1 clap ________________ = $t/20$ seconds

This is the time for sound to travel 100 metres

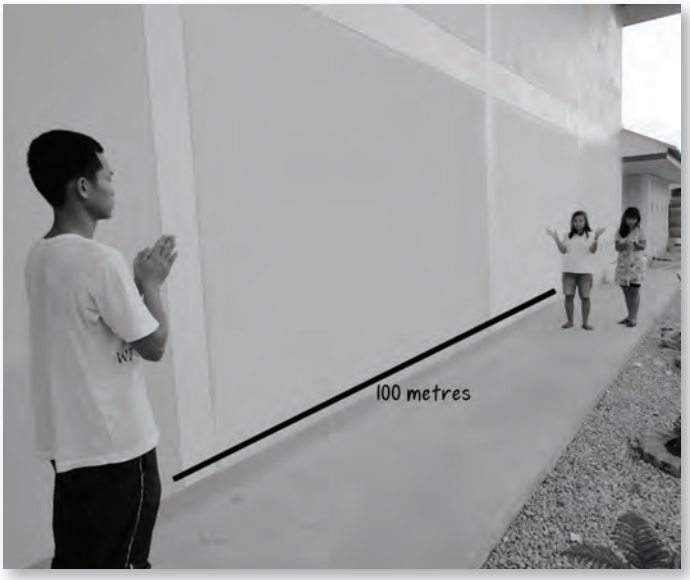
Velocity of sound = Distance/Time

Velocity of sound _______ = $100/(t/20)$ $m.s^{-1}$

*Is your answer about 300 metres per second? The real velocity of sound in dry air is 342 $m.s^{-1}$

Variation 1

If you cannot find a high concrete wall to give an echo you can try it with 2 people standing 100 metres apart, but this is much harder:



1. 2 students should stand 100 m apart, with an additional student holding a stopwatch at one end.
2. The first person claps. The sound travels to the person 100 metres away who claps at the exact time they hear it so that the two set up a rhythm of clapping and the timing person hears only one clap.
3. The timing person tells the other two to speed up or slow down.
4. Once the rhythm is achieved so that only one clap is heard, the timing person takes the time for 20 claps.
5. The calculation is the same as the above.

Variation 2

Here is another option if you have a big space and a few students with stopwatches:

1. One person stands a long distance away from the students with stopwatches. Try for about 400 m and measure the distance, in metres.
2. Then have the person a long distance away bang two rocks together. The students timing need to start the timer when they SEE the rocks touching and stop the timer when they HEAR the sound.
3. The difference in time is the amount of time it has taken the sound to travel the distance separating the students. To calculate, first take an average of all the students' times, in seconds.
4. Calculate d/t to get the speed of sound.

For this variation, we are assuming that the speed of light is '***infinite***'. That means there is no time taken between the movement the person makes and when the students see the movement.

Thunder and lightning are also separated by the speed of sound. When a lightning flash happens, you can start counting the seconds until the thunder is heard. Thunder is the sound of the rapid expansion of air that happens because of the extreme heat of the electrical discharge in lightning. For every 3 seconds that goes by, the lightning is 1 km away from you. For example, if you start counting when you see lightning and get to 6 seconds before you hear the thunder, then the lightning strike was approximately 2 km away. If you hear and see the lightning at the same time, watch out! The strike was very close!

7.2. Transmission of Sound

Timing

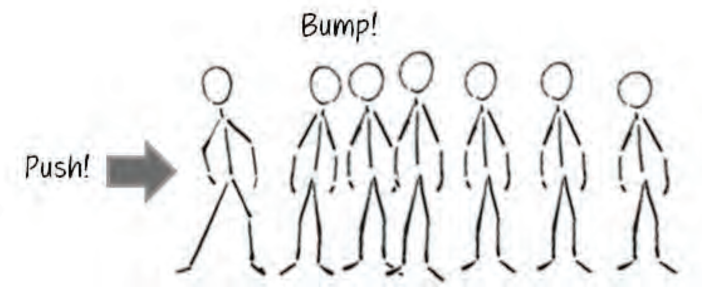
About 20 minutes to do both parts, with explanations, or 5 minutes each as short demonstrations in two lessons about sound.

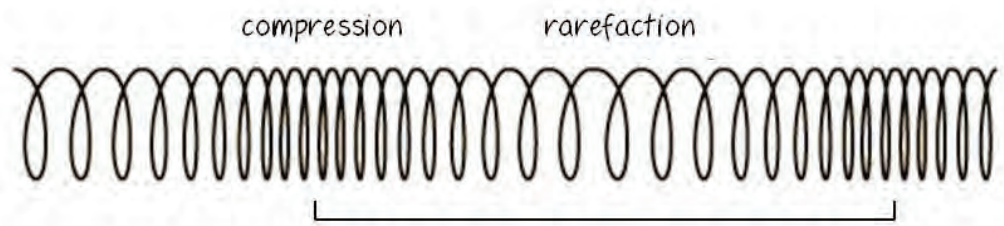
Materials

- Students
- Plastic bottles
- Desks
- Water

Method Part 1

1. 6 or more students stand in a line, shoulder to shoulder with the last student standing next to a wall.
2. Give the first student a push so that his or her shoulder pushes against the next student and so on. The push reaches the last student who rebounds off the wall and then the push travels back along the line.
3. This movement represents a sound wave which is a 'longitudinal' wave, travelling in ***compressions*** and ***rarefactions***.
4. Get the students to draw a diagram of the wave's movement.





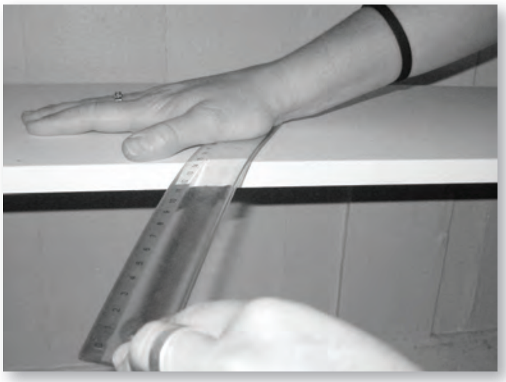
Method Part 2

1. Tap your finger on the top of a desk. How loud is it?
2. Now put your ear on the desk and tap it. Does sound travel better in solids or in air?
3. Hold an empty plastic bottle against your ear and tap one side of it with your finger.
4. Now repeat with a bottle full of water. Does sound travel better in air or in water?

Explanation

The students should discover that sound travels better in a solid, then next best in water, and then in air.
A longitudinal wave moves by moving each particle ***laterally*** so that it hits the particle next to it. As each wave travels along it displaces the particles the way the people are displaced in our demonstration. When the particles are close together, that is a compression, and when they are further apart, that is a rarefaction.

7.3. Qualities of Sound – Pitch and Loudness



Timing

5 minutes.

Materials

- Plastic rulers
- Desks or tables

Method

1. Take a ruler and hold it firmly down on a desk so that most of it is hanging over the edge of the desk. Give the end a flick with your other hand so that it starts vibrating (remember one hand is holding the ruler firmly down). Listen to the sound it makes.
2. Now decrease the length of ruler that is hanging over the end and set it vibrating again. What happens to the sound?
3. Keep shortening the length of the ruler and keep making it vibrate. Keep listening to the changes.

Explanation

Volume (or loudness) is a measure of the energy of the sound. Clap your hands and listen to the difference between clapping them together soft and hard.

Pitch is determined by the *frequency* (number of cycles per second) of the sound. Clap your hands slowly. Now clap them as fast as you can. Notice how the pitch goes up. When you change the length of the ruler, you change the pitch because you change the number of vibrations per second in the ruler.

If you like, discuss how musical instruments work and go on to try out the 'Straw Oboe' experiment below.

7.4. Straw Oboe

Timing

About 20 minutes.

Materials

- At least one plastic drinking straw per student
- A pair of scissors

Method

1. Flatten the end 2-3 cm of the straw, making sharp creases in the sides.
2. Cut the same end of the straw into a triangle shape about 1.5 cm long.
3. Put the triangle shape into your mouth and blow. To make a sound, put your lips just beyond the triangle, and squash the straw gently with your lips so that the plastic can buzz.
4. Tell the students to cut bits of straw off using the scissors while you are blowing. What effect does this have on the noise?

Explanation

The buzzing is caused by vibrations at the right frequency to make a sound. As you cut bits off the straw, the sound will get higher pitched. You may also notice that if you move your mouth along the straw a bit you can get different notes, and you could also try making some holes and covering them with your fingers, just like a real oboe. This experiment comes from: http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/straw-oboe/. Check it out!

8. Electricity

Summary

Electric current is the number of electrons passing a given point per second.

An *electric circuit* is a closed loop that electrons can flow along. A source of electrons, like a battery, needs to be included in the circuit.

A *coulomb* is 6.25 x 10^{18} electrons, and an *amp* is one coulomb per second. In other words, when one amp of electricity flows, there are 6,250,000,000,000,000,000 electrons passing that point every second.

A *joule* is the unit of measurement for work done or energy used when electricity is made to travel a distance or go through a resistor.

Volts are a measure of the energy supplied to the electrons by the battery, or the energy used up as the electrons flow through a resistor or light bulb. One *volt* is 1 joule per coulomb.

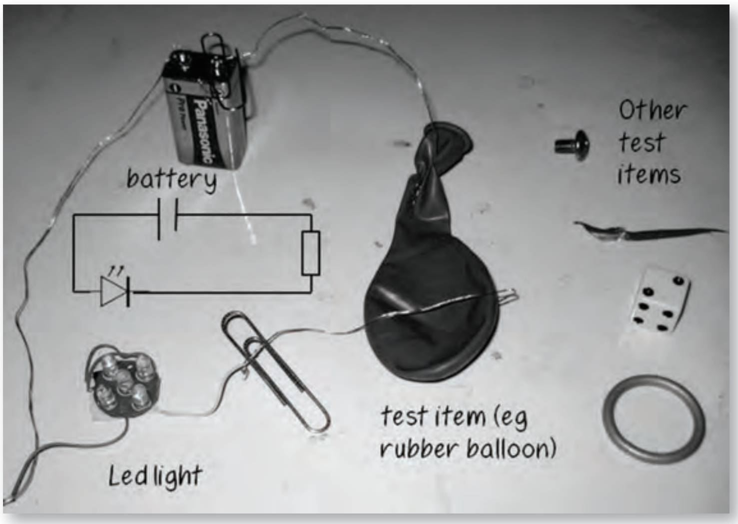
In other words, if 6.25 x 10^{18} electrons (one coulomb) flow through a light bulb and the voltage drop is 1 volt, then 1 joule of electrical energy will have been converted to light and heat.

Current, I, is measured on an ammeter connected in series in a circuit, and measured in amps, A.

Voltage (change in volts), V, is measured on a voltmeter connected in parallel in a circuit, and measured in volts.

There are only a limited number of practical activities you can use to demonstrate electricity if you don't have access to connecting wire, light bulbs, variable resistors, ammeters, voltmeters and batteries. If you can get a small battery-operated torch (flashlight), you can try Activity 8.1.

8.1. Conductivity



Timing

30 minutes.

Materials

- A torch with batteries
- Pieces of aluminium foil or a piece of a Coke can, pieces of plastic, paper, coins, a cup of water, a lime, a piece of glass and any other household items
- Paper clips
- Some copper fuse wire or any insulated electric wire

Method

1. Unscrew the parts of the flashlight and use the batteries and the bulb to create an electric circuit with the wire and paper clips.
2. Once you have the circuit working and the light bulb lighting up, experiment with placing samples of each of the other materials into the circuit.
3. If the bulb lights up, it shows that the sample conducts electricity. You may be able to see a difference in the strength of the light depending on whether the material is a good or bad conductor.
4. Have the students fill in a table of materials and say whether they conduct electricity.
5. Practise drawing circuit diagrams for the circuits that you make.

Sample	Conductor?
Aluminium	
Paper	
Plastic	
Metal Coin	
Water	
Glass	
Other	

8.2. Student Model of Electric Current

Timing

20 minutes.

Materials

- Students
- Chairs
- A bag of sweets, or a plate of cooked rice

Method

1. Clear the furniture from the edges of the classroom so that students can walk around 'in a circuit'. They will represent the electrons.
2. Choose a place in the circuit where there will be a 'resistor' and arrange chairs so that the students have to climb over them. They will have to use energy to climb over the resistor.
3. Have some students standing at the front handing out sweets (or grains of rice) as the electron students come past. They are the 'battery' and they supply 'energy' to the students who are exhausted after climbing over the chairs. The battery students must hand out the energy fast enough so that there is not a build up of electrons in the circuit. If they give more food, the electrons will have to move faster (representing a higher voltage).
4. Have one student count the number of 'electrons' going past before entering the resistor. Have another student who will count the number of 'electrons' leaving the resistor. They will be 'ammeters'.
5. Once everyone is in position, 'close the circuit' so that all the 'electrons' start moving. There should be a build-up of 'electrons' waiting to go into the 'resistor'. Once everything stabilises – perhaps after about 10 seconds – the 'ammeters' start counting.
6. After a minute, stop and compare the number of 'electrons' counted by each 'ammeter'. They should be the same.

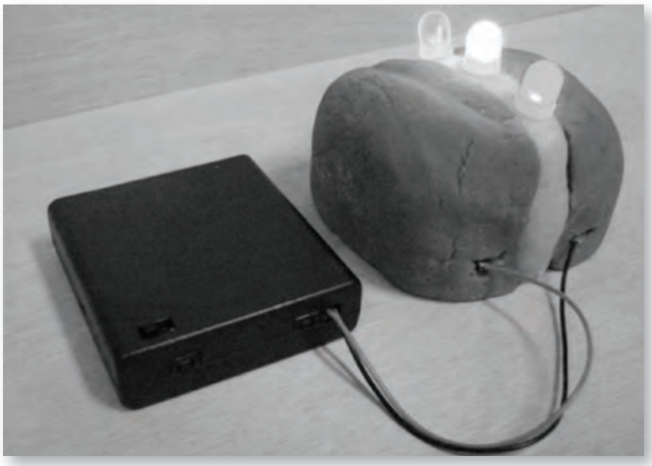
Explanation

It is impossible for more students to enter the 'resistor' than the number coming out of it. It would mean that students disappear. Similarly, it is impossible for more students to be coming out of the resistor than the number going into it. Where would they have come from?

This illustrates that:

- *A current is a flow of electrons that can be measured to determine the amperage.*
- *In a simple circuit, the current is the same in all parts of the circuit.*
- *Energy is used by a current (electrons) passing through a resistor. The energy in a current comes from the battery.*

8.3. Squishy Circuits



The idea and method for ‘squishy circuits’ comes from this website: http://courseweb.stthomas.edu/apthomas/SquishyCircuits/index.htm.

Note: 1 tablespoon (Tbsp.) is about 15 mL or about 3 teaspoons (tsp.).

Timing

Up to 1 hour, depending on the level of interest of the students.

Materials

For conducting dough:

- 1 cup tap water
- 2 cups flour
- ¼ cup salt
- 3 Tbsp. vinegar
- 1 Tbsp. vegetable oil
- Food colouring (optional)

For insulating dough:

- 1 ½ cup flour
- ½ cup sugar
- 3 Tbsp. vegetable oil
- ½ cup bottled water
- Food colouring (optional, and should be different from above)

For circuit building:

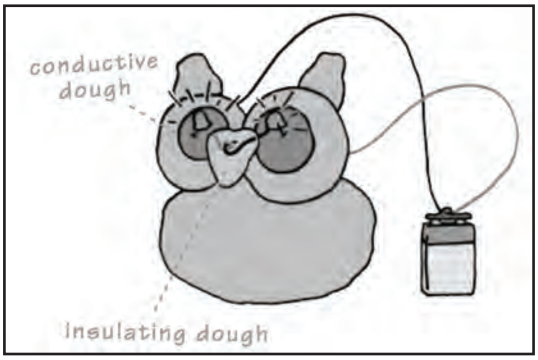
- Battery packs
- Connecting wires
- LED lights

Preparation

1. To make the conducting dough, mix water, 1 cup of flour, salt, vinegar, vegetable oil, and food colouring in a medium-sized pot.
2. Cook over medium heat and stir continuously until it begins to boil and starts to get chunky.
3. Keep stirring the mixture until it forms a ball in the centre of the pot.
4. Once a ball forms, place the ball on a lightly floured surface. WARNING: The ball will be very hot. Flatten it out and let it cool for a couple minutes before handling.
5. Slowly add the remaining flour a little at a time, and knead it into the ball until you have a rubbery dough ball that doesn’t stick to your hands.
6. For insulating dough: Mix solid ingredients and oil in a pot or large bowl, setting aside ½ cup flour to be used later.
7. Mix in a small amount of bottled water (about 1 Tbsp.) and stir. Keep adding the water slowly like this until most of it is absorbed by the mixture.
8. Start to knead the mixture, which will probably be very sticky. Add flour slowly until it is the same rubbery, mouldable consistency as the conducting dough.
9. Both doughs can be stored in airtight containers or plastic bags. While in the bag, condensation will form but this is normal. Just knead the dough after removing it from the bag, and it will be as good as new. The dough should keep for several weeks.

Method

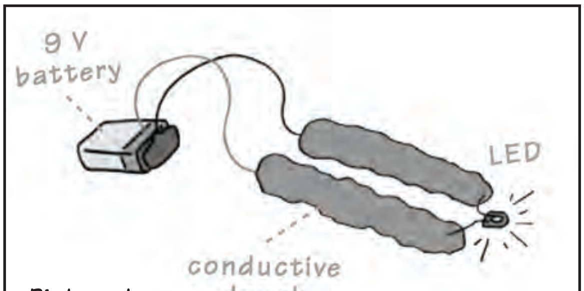
1. Now, build a circuit! The simplest circuit to build consists of an LED, battery pack, and three small "snakes" of dough (two conductive and one insulating). To build this circuit, separate the two pieces of conductive dough with a piece of insulating dough.
2. Now, insert each of the battery pack wires into the conductive dough, as shown in the picture .
3. Do the same with the wires from the LED but it will only work when the positive wire of the LED is inserted into the same piece of conductive dough that holds the black, or negative, battery pack wire.
4. Make up more complicated, creative circuits of your own, like this owl with LED eyes.



Explanation

The salt in the conductive dough allows it to conduct electricity. Electricity flows in a loop called a circuit. A circuit starts and stops at the electron source (in this case, the battery pack), and the electrons flow through metal wires, conductive dough, and electrical components such as LEDs (Picture 1).

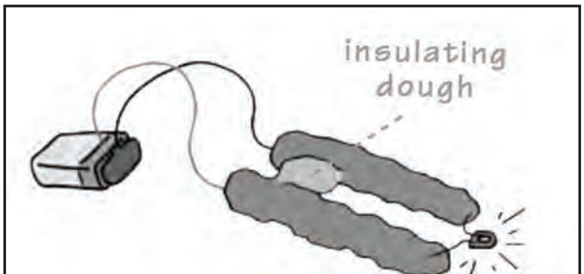
Electricity always takes the path of least resistance. It is easier for the electricity to flow through the dough than through the LED, so if the dough on each side is touching, electricity does not flow through the LED at all. Therefore, the light stays unlit. This is called a short circuit (Picture 2).



Picture 1

Picture 2

Instead of separating the pieces of dough, you can also use the insulating dough to separate the conductive dough (Picture 3).



Picture 3

Unlike conductors, insulators do not let electricity flow through them, so the electricity must go through the LED. If you have more LEDs, you can experiment with parallel and series circuits too.

9. Pressure

Pressure is an effect that occurs when a force is applied to a surface. Pressure is the amount of force acting per unit area, so we can use the formula P = F/A. The SI unit for pressure is the 'pascal' (Pa), equal to one newton per square meter (N/m^2 or $kg.m^{-1}.s^{-2}$).

A sharp knife is an example of how pressure works. If we try to cut a piece of fruit with the flat side, it won't cut, but if we take the sharp side, it will cut smoothly. The reason is that the flat side has a greater surface area (and so less pressure on each part that is touching the fruit) and so it does not cut. If you try the sharp side, the surface area is reduced and so the same amount of pressure cuts the fruit easily and quickly. This is one example of a practical application of pressure.

9.1. Balloon Balance

Timing

15 Minutes.

Materials

- 6 balloons
- A strong wooden desk
- Brave students

Safety

Make sure there is a clear space around the upside-down desk so that if anyone falls they are not injured. Have some students stand around the outside of the desk so they can help the balancing students to stay balanced.

Method

1. Blow up the 6 balloons half way.
2. Place them on the ground evenly around the shape of the desk, and turn the desk upside down so the flat side is resting on the balloons.
3. Have the students stand on the desk one at a time and see how many can balance on the desk before the balloons burst
4. If the desk is full but the balloons haven't burst, you will have to start removing balloons one at a time and replacing the students one at a time.

Explanation

This experiment demonstrates the amount of air pressure that the rubber of a balloon can handle. Eventually the pressure being applied by the mass of the students and the desk exceeds the capacity of the rubber in the balloons to stretch.

To demonstrate this more clearly, you could blow up the balloons to different sizes and have the students predict which one will burst first.

9.2. Spray Bottle

Timing

About 10 minutes.

Materials

- A 1 L water bottle with the top cut off
- Something to punch holes with like a knife or a skewer
- Water

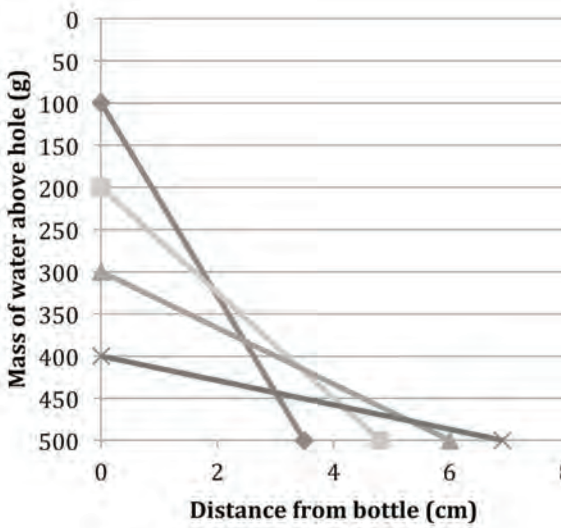
Method

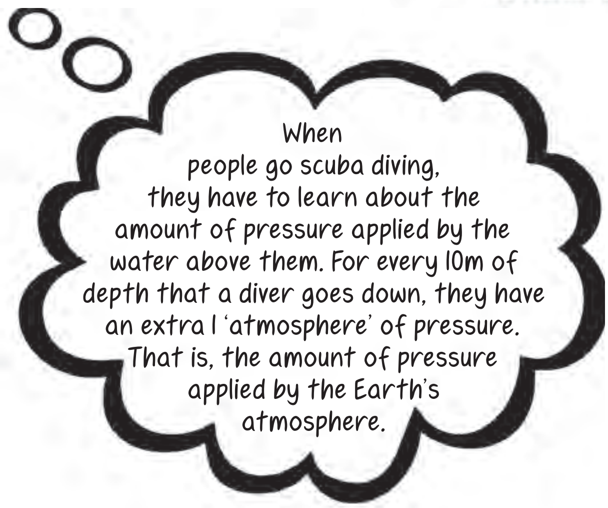
1. Make 4 small holes (the same size) evenly spaced down the side of the bottle, so the gaps between the holes are 1/5 of a bottle apart.
2. Have the students help plug the holes by pressing their fingers on the outside of the bottle.
3. Fill the bottle with water (outside or over a sink).
4. When everybody is ready, the students remove their fingers and everyone watches how far the water sprays.

Explanation

The bottom hole sprays much further than the top hole because of the greater mass of water applying pressure above the hole. 'The more depth, the more pressure,' is true in the ocean as well.

For the Spray Bottle experiment, you can have the students graph the results by measuring the furthest distance each hole sprays, and the depth that each hole is under water (from the top). With advanced students, you might want to have them calculate the mass of water above each hole, and plot mass of water versus distance. An example graph is provided:





The next experiment demonstrates more about the relationship between water pressure and air pressure.

9.3. Cartesian Diver

Timing

About 15 minutes to demonstrate and explain the principles if you have set up the diver beforehand. If the students are going to make their own divers, then this will take about 45-60 minutes.

Materials

- Plastic bottle full of water
- Pen cap
- Plasticine or ‘sticky tak’ (may also be called ‘blue tak’ or ‘white tak’ – like chewing gum for sticking posters up)

Method

1. Weight the end of the pen cap with plasticine/sticky tak until it *just floats* in a cup of water.
2. Draw on the pen lid so it looks like a diver or an animal.
3. Carefully put the diver in the plastic bottle and screw the top on.
4. Squeeze the side of the bottle and the diver will sink. Stop squeezing and the diver will rise. It may take a bit of experimenting until the diver goes up and down easily. Add or remove plasticine to change the weight.

Explanation

Archimedes Principle – “Any object, wholly or partially ***immersed*** in a fluid, is buoyed up by a force equal to the weight of the fluid ***displaced*** by the object.” This force is called *buoyancy*.

Squeezing the side of the bottle increases the pressure in the water in the bottle. This compresses the air inside the pen cap so that it no longer displaces the same amount of water, and it sinks. When the pressure is released the air inside the pen cap ***expands*** so that it displaces more water and it floats.

You can impress your class by telling them that you have trained the diver to go up and down. Then holding the bottle in the palm of your hand you say ‘Go down’ and gently squeeze with your fingers. When the cap is at the bottom you say ‘Come up’, and stop squeezing.

Extension

A man is in a small boat that is floating in a swimming pool. There is a large rock in the boat. The man lifts the rock and drops it into the pool. What happens to the level of water in the pool? Does it rise, stay the same, or drop?

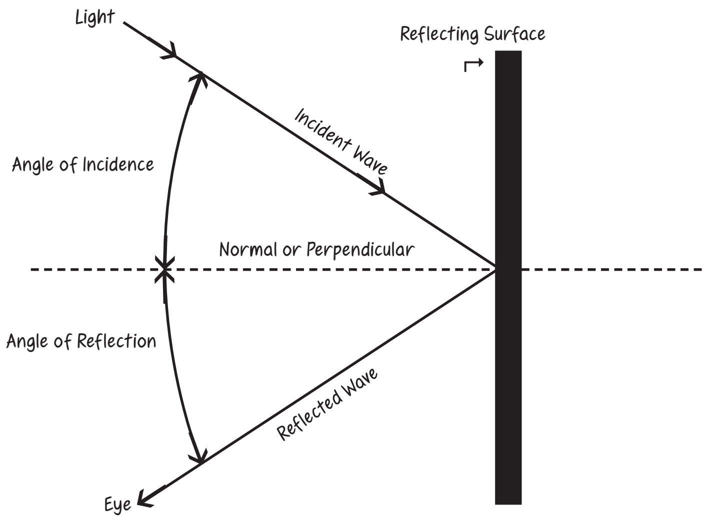
Fill a bucket with water and float a plastic bowl with a rock in it. Mark the level of the water in the bucket. Take the rock out of the bowl and put it in the bucket. What happens to the level of water in the bucket?

The water level goes down. The rock displaces its own weight of water when in the boat. When it is dropped into the water, it displaces its own volume. Since the density of the rock is greater than 1, the volume of water displaced by its weight is greater than the volume of the rock.

10. Light

Use these experiments to demonstrate the properties of light. Light travels in waves which can be reflected, refracted or diffracted. Define these terms with your class first:

- Reflection is the return of a wave that has hit a surface. It could be a light, heat or sound wave.
- Refraction is the bending of a wave direction due to a change in speed and wavelength as the wave passes from one medium to another.
- Diffraction is the bending of waves around obstacles and openings. The amount of diffraction increases with increasing wavelength.



To show which way the rays of light are going, scientists commonly draw 'ray diagrams' to represent the movement of light. You can use ray diagrams in the following experiments to explain how lenses and mirrors work.

10.1. Transmission of Light

Timing

15 minutes plus explanation time.

Materials

- A large basin half full of water
- Several stones

Method

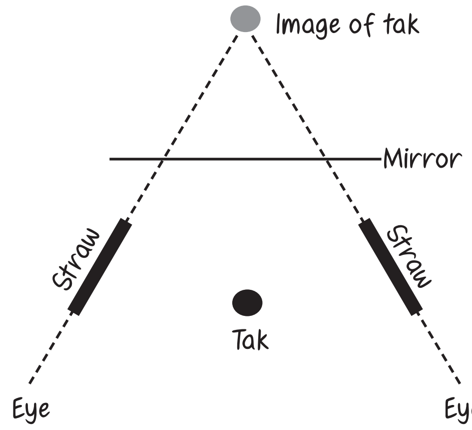
1. Place the basin in the middle of the room and allow the water to settle until the surface is smooth. Get the students to stand around in a large circle so that everyone can see the surface of the water.
2. Drop a stone in the centre and observe.
3. Repeat several times and experiment with the changes you see when you drop more than one stone in at the same time, or when you drop larger or smaller stones.

Explanation

When the stone hits the surface it sets up a series of concentric waves which travel out to the edge of the basin and are then reflected back into the centre.

This is also the way light waves travel, so the students can imagine this is what happens when light is reflected off a mirror.

10.2. Finding the Image in a Plane Mirror



Timing

About 20 minutes.

Materials

- ***Plane*** mirror
- Plasticine or sticky tak (or another small object)
- A clothes peg
- Drinking straws or pencils

Method

1. Set the mirror upright in the middle of a blank page either with sticky tak or a clothes peg.
2. Draw a line across the back of the mirror to show where it is on the page.
3. Place a small piece of sticky tak (or any small object) about 5 cm in front of the mirror and mark its position.
4. *From one side*, position a drinking straw or pencil so that *it points to the image of the sticky tak in the mirror.* (See the diagram.)
5. Mark the position of the straw/pencil.
6. Repeat from the other side. (See the diagram.)
7. Remove the sticky tak, straws and mirror and join up the lines as shown.

Explanation

The straws both point to the position of the *image 'behind' the mirror*. Where the lines intersect is the location of the image.

It should be the same distance behind the mirror as the object is in front of the mirror.

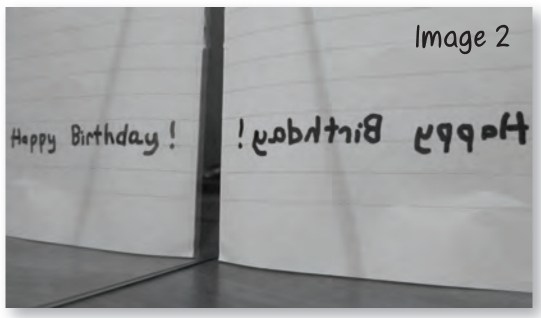
10.3. Lateral Inversion in a Plane Mirror

Timing

30 minutes or longer if the students are having fun and happy to experiment on their own.

Materials

- Paper
- Pens
- Mirrors (1 between 2 students or as many as possible)



Method

1. Have the students work in pairs. Student A holds the mirror at Student B's eye height and holds a piece of paper under B's chin so they can't see their own hand when they try to draw on a piece of paper on the table.
2. Student B tries to write their name while looking in the angled mirror.
3. Now Student A draws a windy road or a simple maze on the paper. Student B, *looking only in the mirror,* tries to trace a line with their pen going from one end of the road to the other without touching the lines. See Image 1.
4. Now, Student A tries writing a message backwards so that when the other person holds it up in front of them, they can read it in the mirror. See Image 2. This is similar to writing your name and then looking at it from behind the paper while holding the paper up to the light.

Interesting Fact!
Small children learn to do this much more quickly than adults do.

Explanation

'Lateral Inversion' is when an object is reflected in the mirror, and appears to be reversed from left to right. When you look in the mirror, and wink your left eye, the right eye of your reflection winks back. When you try to write something when looking in the mirror, it is difficult because you are forming the letters from the opposite side. Some scientists say this is just an optical illusion, since the mirror is just reflecting light back. It is our brains that think the image is the wrong way around!

10.4. Refraction

Timing

About 20 minutes.

Materials

- A transparent (see-through) cup or glass
- A small coin or stone
- A pencil or pen

Method

1. Place the coin or stone against the edge inside the cup.
2. Place a book between you and the cup so that *you can see the cup but not the coin.*
3. Get your partner to slowly fill the cup with water.
4. What do you see happen?
5. Fill the cup with water, put a pencil or pen in, and look at it from different angles.
6. Does it appear to bend at the point where it enters the water?

Explanation

Light travels at different speeds in different materials. It travels faster in a vacuum than it does in air. It travels faster in air than in water and faster in water than in glass.

Since a beam of light has a width, when it strikes an interface of air and water at an angle, the edge that strikes first slows down and the light changes direction. Hence the beam appears to bend at the interface.

10.5. Curved Mirrors and Lenses

Concave and Convex Mirrors

For this advanced activity, if you don't have a curved mirror, you can use a spoon. The outside is called the ***convex*** side, and the inside is called the ***concave*** side (remember, it's the shape of a cave).

If you have a concave mirror, hold it close to your face and observe the image. Is it:

- ***Magnified*** or ***diminished***, that is, do you look bigger or smaller?
- Upright or ***inverted***, that is, is your reflection the right way up or upside down?

While someone else holds the mirror, move further back until the image changes dramatically. What happens to the image?

Do the same for the outside of the spoon, the convex mirror. What do you notice?

To draw a ray diagram, physicists usually imagine two rays coming from the top of the object. One goes through the focal point, labelled F, and one is drawn parallel to the line going through the middle of the mirror. Depending on how far away the object is from F, there will be different results. This explanation comes from: http://scioly.org/wiki/Optics.

Trial 1: (Concave Mirror) *The object (the black arrow) is located beyond the centre of curvature*. The image (the grey arrow) is located between the centre of curvature (C) and the principal focus (F). It is reduced in size and inverted.

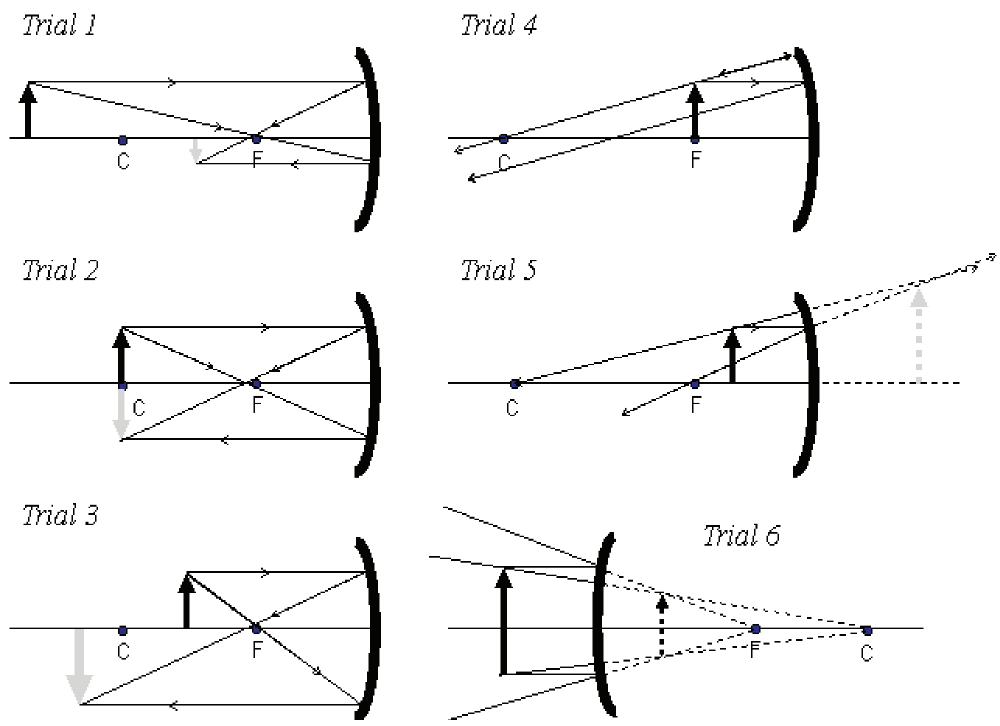
Trial 2: (Concave Mirror) *The object is located at the centre of curvature*. The image is inverted.

Trial 3: (Concave Mirror) *The object is located between the centre of curvature and the principal focus*. The image is located beyond the centre of curvature. It is enlarged in size and inverted.

Trial 4: (Concave Mirror) *The object is located at the principal focus*. No image is formed. All rays are reflected from the mirror as parallel rays.

Trial 5: (Concave Mirror) *The object is located between the principal focus and the mirror*. The image appears to be located behind the mirror. It is enlarged in size.

Trial 6: (Convex Mirror) *All convex mirrors form a virtual image reduced in size*. "Virtual" means the image cannot be projected onto a screen; it is not inverted and it can be magnified.

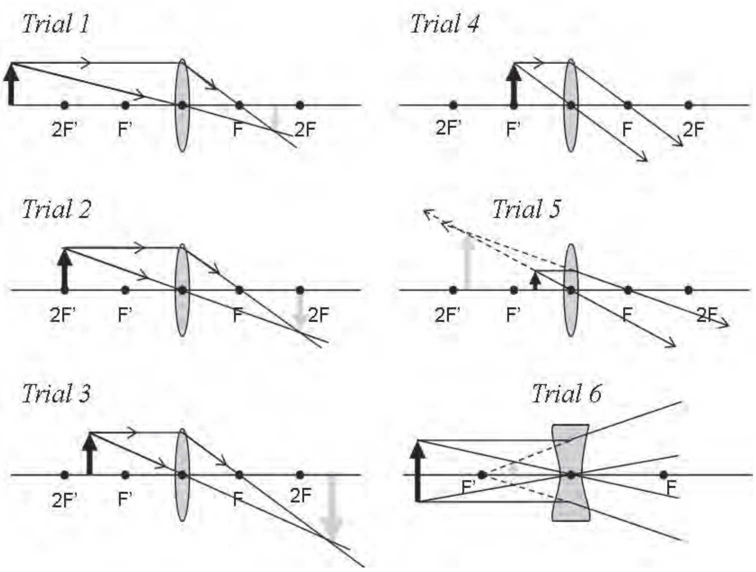


Magnifying Glass (Convex Lens)

A magnifying glass is an example of a convex lens. Ray diagrams can be drawn the same way for lenses as for mirrors.

Experiment with holding the magnifying glass close to an object to try to find the focal point.

Draw ray diagrams showing the positions of the object and images inside and outside the focal point.



Trial 1: (Convex Lens) *The object is located beyond twice the focal length*. The image is located between the focal length and twice the focal length on the opposite side of the lens. It is reduced in size and inverted.

Trial 2: (Convex Lens) *The object is located at twice the focal length*. The image is located at twice the focal length on the opposite side of the lens. It is inverted and the same size.

Trial 3: (Convex Lens) *The object is located between twice the focal length and the focal length*. The image is located beyond twice the focal length on the opposite side of the lens. It is enlarged in size and inverted.

Trial 4: (Convex Lens) *The object is located at the principal focus.* Just like mirrors, no image is formed at this position. All rays are refracted from the lens as parallel rays.

Trial 5: (Convex Lens) *The object is located between the principal focus and the lens*. The image appears to be located behind the object on the same side of the lens. It is enlarged in size.

Trial 6: (Concave Lenses) *All concave lenses form a virtual image, the right way up, reduced in size*.

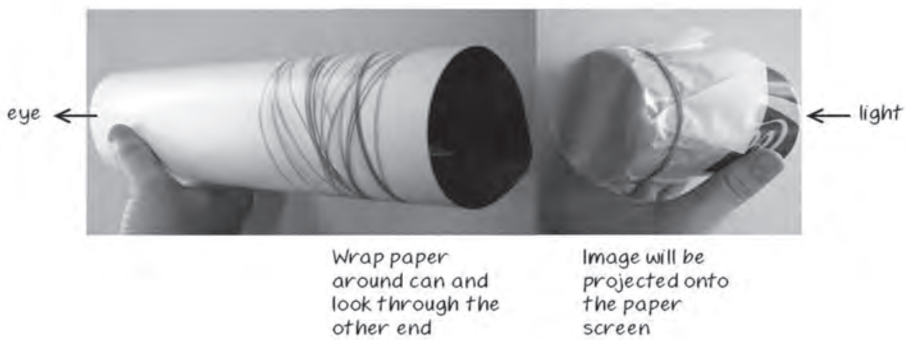
10.6. Pinhole Camera

Timing

30 minutes.

Materials

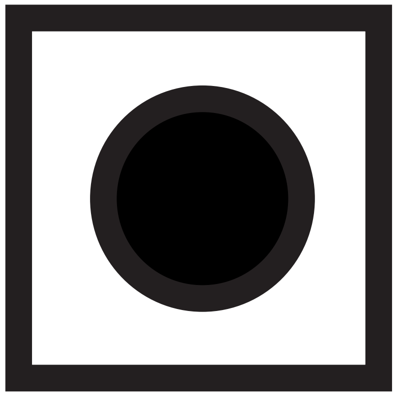
- Empty aluminium can with the end cut off
- Knife or scissors with a pointed end
- Paper tissue or napkin
- Rubber bands
- Sheet of A4 paper



Method

1. With the pointed scissors or knife, make a small round ‘pinhole’ (5-10 mm in diameter) in the end of the aluminium can.
2. Cover the other end with a single sheet of the tissue or napkin and fasten with a rubber band. This makes the ‘screen’.
3. Wrap the A4 sheet around the end of the can with the screen to make a ‘darkroom’. (In the picture above, the darkroom is on the left of the picture.) You will look through the other end.
4. From inside a room, point the pinhole at a window or doorway with the light shining through. Look through the darkroom tube and you should see an image of the window on the screen.
5. Get someone to stand in front of the window or doorway and wave their arms.
6. Are they upright or inverted?

10.7. After Images



The eye acts like a camera (or more accurately, a camera acts like the eye). Instead of a photographic film, or a digital receptor screen, the light sensitive layer at the back of the eye consists of cells that fire off electrical impulses to the brain whenever light falls on them. If you keep looking at the same scene, the impulses get weaker and weaker.

Timing

About half an hour.

Materials

- Blank sheets of paper
- Black markers
- Coloured pencils (red, blue, green and yellow)

Method

1. Instruct the students to each draw a square about 5 cm x 5 cm and draw a solid black circle inside it.
2. Now each student looks at the centre of their circle for one minute.
3. Now they look at a blank sheet of white paper. What do they see?
4. For part two, the students draw a square the same size as above and colour it either red, blue, green or yellow.
5. Next, they cover one half of the square with a piece of paper and look at the coloured half for a minute. Then remove the paper – what happens?
6. Now look at the whole coloured square for a minute, then at a blank sheet of paper. What colour do you see?

Explanation

We have light receptors (photoreceptors) in our retinas that get tired if we stare at one colour for a long time. They respond by ‘resting’ when you look at the white page afterwards. The photoreceptors for the opposite colour, however, are still fresh, so your brain interprets their activity as though you are looking at that opposite colour. If you look at a red square for a minute, when you look at a white sheet of paper you will see a green ‘after image’. If you look at blue square you will see a yellow after image, and vice versa. This is because red and green have paired photoreceptors, while yellow and blue have paired photoreceptors, as do black and white.

11. Heat

11.1. Conduction, Convection and Radiation

Define these three terms with your class first. They are all methods of heat transfer. In *conduction*, the energy is transferred through a solid or a liquid. The molecules have to be touching for conduction to work, but not all materials are good conductors. *Convection*, on the other hand, is heat transfer that can only occur in a liquid or a gas. The molecules of matter need to move for convection to take place. *Radiation* can occur in any matter, or through space. This is the way energy is transferred from the Sun to the Earth. Radiation is any movement of energy in waves, including visible light, sound waves, nuclear radiation, and heat.

Timing

30 minutes.

Materials

- Candles
- Matches or a lighter
- Coke-can burners
- Plastic cups and water
- Screwdriver
- Small stones (3 per group)
- Some food dye powder (not essential)

Method

1. Using the candle as a heat source, get the students to hold their hands beside the flame and notice that the heat can be felt about 10 cm away. This is 'radiant' heat.
2. Now set up the Coke can burner with the plastic cup half full of water on top. If you have food colouring you can sprinkle some in, but don't stir it up.
3. Light the candle underneath, and while the flame is heating the water, you can also test out how conduction works with the screwdriver. Remember the metal will be HOT!
4. Stick three stones to the screwdriver with candle wax as shown in the picture.
5. Ask for a prediction about what is going to happen to the stones if you stick the pointed end of the screwdriver in a flame. Why?
6. Put the end of the screwdriver in the flame and observe what happens to the stones.
7. What happens to the water in the cup? Test the temperature of the surface of the water with your finger every minute. Observe whether anything is happening to the food dye.

Explanation

The water in the cup is being heated from the bottom where the flame is, but eventually the surface of the water becomes warm too. The water is being heated by convection: as it warms, the density is reduced, so the warm water rises and the cooler, denser water sinks down. Convection currents in the ocean and the atmosphere work like this. The food dye helps to see the movement of the water.

The screwdriver is being heated by conduction. The heat is transferred through the solid matter without moving the molecules. The stone closest to the candle will fall off first because the heat travels along the candle, but not through the plastic handle of the screwdriver because it doesn't conduct heat as well as the metal. Metal is a good heat conductor. Wood and plastic, for example, are not.

11.2. Solar Oven

The instructions given here are for the most basic design, but more complicated designs are possible once you have tried the first one. You can get more information about solar ovens and different designs here: http://solarcooking.wikia.com. Below are some examples:

Timing

About 1-2 hours to build an oven but you will need extra time to experiment with the best shape and make adjustments. When your oven is finished, you can try cooking rice or curry in it. The cooking time depends on how efficient your oven is at trapping heat and keeping the heat inside. Cooking rice in a good solar oven doesn't take much longer than cooking rice on a stove, but in lots of places where people use solar ovens, they start the food cooking in the morning, and leave it to cook over the hottest part of the day – when the Sun is directly overhead.

Preparation and Safety

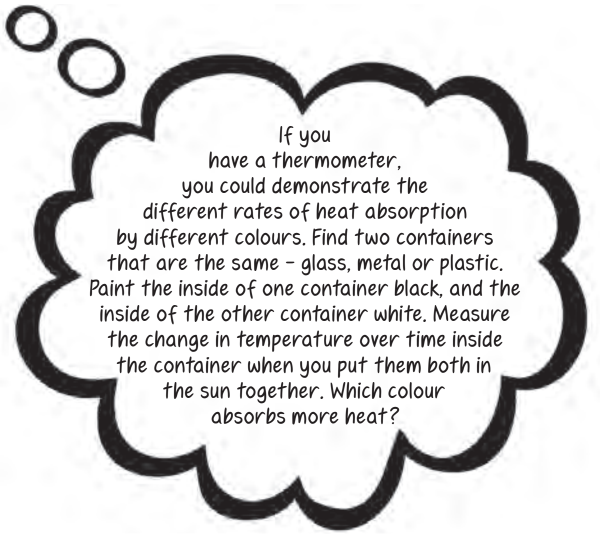
Don't ever look directly at the Sun – you can damage your eyes.

Some designs of solar ovens involve putting reflective material like foil on the inside of an umbrella to make a big mirror. If you experiment with this design, be careful because the heat generated can be more than you would expect!

Eating uncooked meat can make you sick. It is important that you heat food to over 75 ˚C to kill bacteria. Solar ovens easily reach this temperature. If you are still experimenting with your oven, use vegetables until you are confident with cooking times and temperatures.

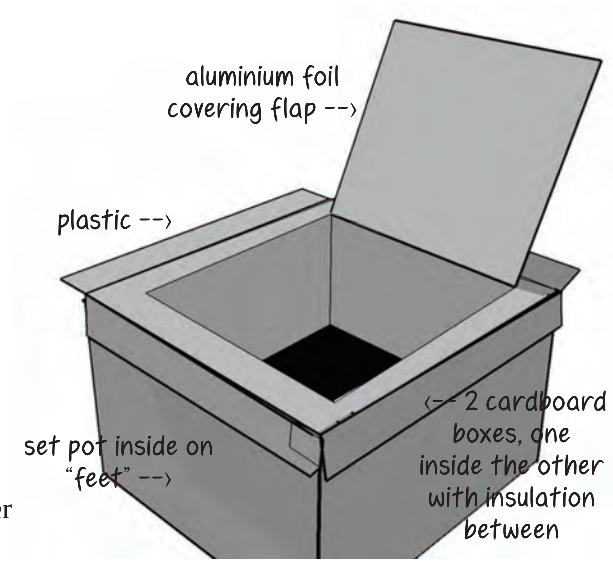
Materials

- 2 cardboard boxes of different sizes
- Some aluminium foil – you can buy this or collect it from packages
- Thick, clear plastic, or if you can't find any, plastic wrap or a clear plastic bag
- A metal cooking pot with a lid. The best type would be black, or you could paint the outside black
- Black paint or fabric. If you are using black paint, try to find 'oven paint' which is non-toxic and heat-proof. Black fabric or black cardboard works just as well.
- Scrap cardboard, newspaper or waste paper
- Tape, glue, staples or small nails and thin pieces of timber
- Scissors and/or a knife for cutting the cardboard



Method

1. The two cardboard boxes need to fit together, one inside the other. The inside of the smaller one (or at least the base) could be painted black, or covered in reflective metal foil to help direct the heat into the pot.
2. In between the two boxes, there should be newspaper, waste paper, or old pieces of fabric balled up and stuffed in. There should be air gaps (don't pack it too tight) because this is the ***insulation***.
3. The plastic lid for the inner box needs to be able to lift off when you put the saucepan in, so one idea is to make a frame out of thin pieces of timber and stretch some flexible plastic over the frame. This could then be placed on top of the inner box when you are cooking, but removed easily. You need this plastic (or glass) lid to let the reflected radiant heat in, and then to trap it inside the oven. The simplest type of clear lid is a clear plastic bag stretched across the space and taped on, but then you might need new plastic every time you cook.



4. The outside box needs to be cut as shown in the diagram. The top parts, which are higher than the inside box, are the 'flaps' – these should be covered in foil to reflect the light into the oven. Cut and stick the flaps on each side; experiment with different angles so that as much heat as possible is reflected into the box.
5. Make some wooden'feet' for the cooking pot to sit on in the oven, otherwise a lot of heat will be lost from the pot where it contacts the base of the oven.

Explanation

Using the heat from the Sun is the most reliable, powerful, environmentally friendly and cheapest way to cook. Many schools and communities in Southeast Asia have been experimenting with oven designs and have found that they work really well in this area. Keep trying out ways to make your oven more efficient.

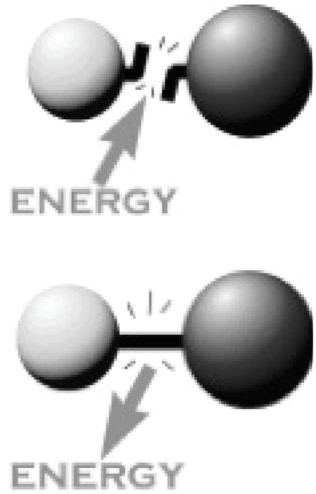
Building this oven follows on from the experiment before, and lessons you have taught about different types of energy and heat transfer. The light energy from the Sun provides a powerful, constant source of energy. When it is reflected off the flaps around the oven, it is concentrated, and the light is absorbed by the black surfaces. The light energy is transferred to heat by this process, and the air in the oven, as well as the food inside the black pot, warm up more and more, the longer they are in the Sun.

The most efficient ovens will trap all the heat and direct it into the pot to cook the food, but if there are gaps around the lid then some of the hot air will be able to escape and the oven will be less efficient. Some heat is also lost through the cardboard, but the layer of insulation tries to make this as small as possible.

Other shapes are possible – a curved surface like the inside of an umbrella can be used to make a 'parabolic' cooker. You can ask the students to draw ray diagrams of the direction the light is reflected from the oven flaps, and to think about how much more efficient curved reflective surfaces would be.

CHEMISTRY

12. Chemical Reactions



12.1. Chemical Reaction Model

When chemicals react, bonds between atoms may be broken (which requires energy), or formed (which releases energy). Many reactions involve both the breaking and then the forming of bonds.

Timing

10 minute starter exercise to introduce chemical reactions.

Materials

- Students
- Paper ‘H’ and ‘O’ labels (you can also do this without labels)

Method

1. Select 8 boys to be Hydrogen atoms and 4 girls to be Oxygen atoms (or *vice versa*) and label them accordingly.
2. Explain that O and H both form molecules with two atoms, that is O_2 and H_2. The students have to pair up to represent these bonds. O_2 has double bonds so they have to join both arms together. H_2 has single bonds so they only need to join one arm to bond.
3. Have other students help to pull the molecules apart and put them back together. It takes energy to break the bonds so the bonded students should hold on tight and make it a bit difficult.

The O and H atoms then reform in a different pattern as shown.

$$\mathrm{H-H + H-H + O=O} \quad \rightarrow \quad \mathrm{H \quad H \quad H \quad H \quad O \quad O} \quad \rightarrow \quad \mathrm{H-O-H \; + \; H-O-H}$$

Explanation

The above demonstration can be written as:

$$2H_{2\,(g)} \quad + \quad O_{2\,(g)} \quad \rightarrow \quad 2H_2O_{\,(g)}$$

This is a good explanation of how chemical reactions work because it is obvious that the numbers of H and O atoms remains the same on each side of the reaction – i.e. matter can neither be created nor destroyed.

You can do the same with:

$$CH_{4(g)} \quad + \quad 2O_{2\,(g)} \quad \rightarrow \quad CO_{2(g)} \quad + \quad 2H_2O_{\,(g)}$$

You can also make molecules using ping pong balls and double-sided tape.

12.2. Polarity of Molecules (or Art with Milk)

Timing

About 10 minutes for the class to watch the colours swirling, plus about 10 minutes for an explanation.

Materials

- Milk
- Dishwashing ***detergent***
- Large flat bowls or disposable containers (1 for each group of students)
- Liquid food colouring (if you can only find powdered food colouring, dissolve some in water before the class). Using two colours works really well.

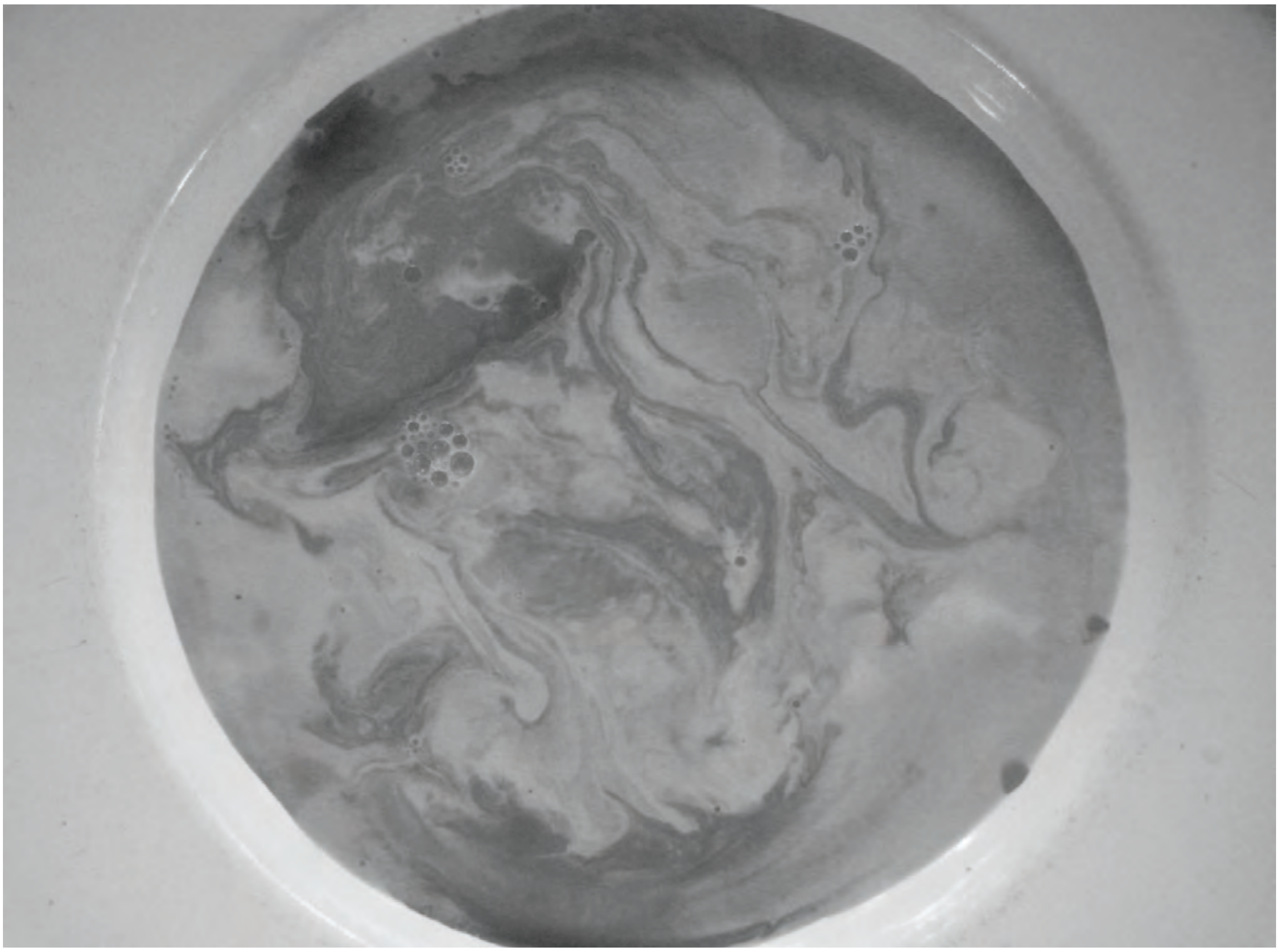
Method

1. Pour some milk into a flat tray and drop in a couple of drops of food colouring. If you have 2 colours, put a drop of each colour at opposite ends of the container.
2. Drop in a couple of drops of dishwashing detergent and watch the coloured milk swirl around.

Explanation

The milk moves because it is made of polar (sugars and salts) and non-polar (fats) molecules and the detergent molecules have a polar and a non-polar end. The like (similar) ends of the molecules repel each other and so the coloured milk and the detergent move around quickly to avoid each other.

Polarity of molecules fits into chemistry at a senior high school level, but this is a fun activity even if students don't completely understand it.



13. Acids, Bases and Carbonates

Summary

Here are 5 experiments you can do in chemistry lessons about acids and bases.

Teach students about the properties of acids (they taste sour, turn litmus paper red, and become less acidic when mixed with bases) and bases (bases feel soapy, turn litmus paper blue and have a high pH). List some common acids and bases and explain their uses (e.g. lemon juice is a weak acid that tastes sour that people like to drink and sodium hydroxide is a strong base that is used to clean drains). As a background to these experiments, you could also cover chemical reactions and writing/balancing chemical equations. Activity **13.3** could be an introduction to the concept of 'reaction rate'.

Use the experiments below to demonstrate –

13.1 and **13.2** – the reaction between a carbonate and an acid, then how to test for CO_2.

13.3 – that reaction rates are affected by heat.

13.4 – pH and indicators. Students gain an understanding of the pH scale by using a cheap, effective indicator.

13.5 – advanced acid + carbonate reaction to demonstrate the stoichiometry of reaction 13.1

Encourage students to predict what will happen (make a hypothesis) before you start the demonstrations, observe what does happen, and then explain why they observed what they did.

13.1. Acid + Carbonate

Timing

About 10 minutes for the demonstration plus 10 minutes if the students do their own experiments. Add 10-15 minutes for explanation and discussion of the results.

Materials

- A teaspoon
- 1 or 1.5 L plastic bottle
- Plastic cup or half of a clear plastic bottle for measuring
- Sodium bicarbonate, also called 'baking soda', $NaHCO_3$
- Vinegar, which is dilute acetic acid, CH_3COOH
- Dishwashing detergent

Preparation and Safety

Make sure your plastic bottle is clean and dry with no label. You can use the measuring bottles from Activity 2.1. This experiment can be done as a demonstration in front of the class, or, if you have enough plastic bottles and other resources, the students can perform their own experiments. The mixtures may bubble over and spill on the table so perform this experiment on a clear bench or outside.

Method

1. Add 1 teaspoon of baking soda to a plastic bottle.
2. Add 1 drop of detergent.
3. Add about half a cup of vinegar, stand back and watch what happens.

Explanation

When you add the vinegar, you should get lots of bubbles of CO_2 – a very obvious chemical reaction. If you use too much baking soda the solution could bubble over and spill on the table, but it is not harmful so don't worry. The salt, called sodium acetate, is dissolved in the water.

The detergent is used to make the bubbles of carbon dioxide bigger and easier to see. If you don't have detergent, you can do the experiment without it, but it won't be as spectacular!

Science textbooks often explain the following reactions:

$$\text{Acid} + \text{Base} \rightarrow \text{salt} + H_2O$$

$$\text{Acid} + \text{Metal} \rightarrow \text{salt} + H_2$$

$$\text{Acid} + \text{Carbonate} \rightarrow \text{salt} + H_2O + CO_2$$

Acids react with carbonates and bicarbonates to give the salt of that acid, water and carbon dioxide.

$$\underset{\textit{Carbonate}}{CO_3^{2-}} + \underset{\textit{Acid}}{2H^+} \rightarrow \text{Salt} + \underset{\textit{Water}}{H_2O} + \underset{\textit{Carbon dioxide}}{CO_2}$$

For the reaction in this experiment, the equation is

$$NaHCO_3 + CH_3COOH \rightarrow NaCHCOO + H_2O + CO_2$$

Sodium bicarbonate — *Acetic acid* — *Sodium acetate (can be called sodium ethanoate)*

Extension

For advanced students, you could explain what's really happening:

When dissolved in water, baking soda separates into sodium (Na^+) and bicarbonate ions (HCO_3^-):

$$NaHCO_3 \rightarrow Na^+_{(aq)} + HCO^-_{3\,(aq)}$$

Vinegar, a weak (5%) solution of acetic acid in water, partially dissociates into hydrogen (H^+) and acetate ions (CH_3COO^-):

$$CH_3COOH \leftrightarrow H^+_{(aq)} + CH_3COO^-_{(aq)}$$

The reaction between baking soda and vinegar is actually two reactions, an acid-base reaction followed by a decomposition reaction. When the two ingredients are mixed, hydrogen ions (H^+) from the vinegar react with the bicarbonate ions (HCO_3^-) from the baking soda to form a new chemical called carbonic acid (H_2CO_3). The carbonic acid formed then immediately decomposes into carbon dioxide gas and water:

$$H^+ + HCO_3^- \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow H_2O + CO_2$$

13.2. Properties of Carbon Dioxide

Timing

An extra 5-10 minutes after Activity 13.1.

Materials

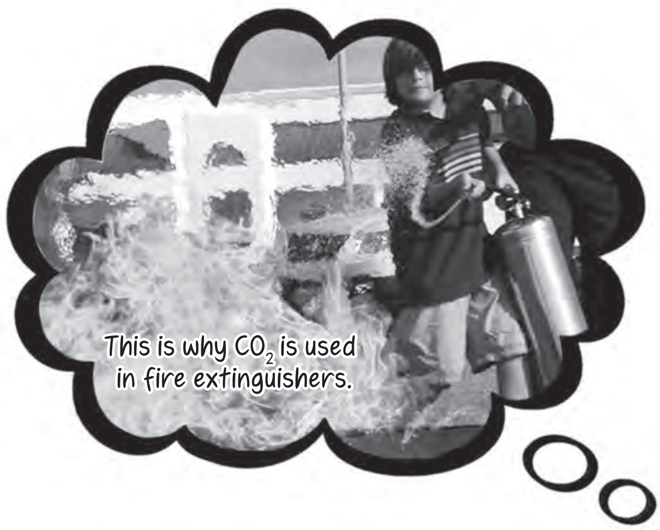
- As in Activity 13.1
- Plastic cup or half of a clear water bottle
- A ***taper*** such as a twisted piece of paper, a bamboo skewer or a thin piece of timber you can light
- A lighter or box of matches (or you could use a gas cooking stove to light the taper)

Preparation and Safety

This experiment takes a bit of practice. You should have a student ready to light the taper once you have poured in the CO_2. Since this experiment involves fire, only trusted, senior students should do this on their own; otherwise, it is a good demonstration activity.

Method

1. Repeat Activity 13.1, but without the detergent. You can use the same bottle, just rinse it to get rid of most of the detergent or else you will have bubbles instead of CO_2 gas.
2. After the reaction between vinegar and baking soda has created lots of carbon dioxide in the bottle, carefully tip the bottle to pour the carbon dioxide gas into a plastic cup or another water bottle with the top cut off (you will have to guess whether it is happening).
3. When you think you have filled the cup with carbon dioxide, test with a taper. If the cup is full of carbon dioxide, the flame on the taper will go out, i.e. ***extinguish***.



You can also pour the carbon dioxide from one cup to the other (just imagine it is water), and compare what happens when you put a lighted taper into a cup filled with normal air and a cup filled with CO_2.

Explanation

CO_2 is heavier than air, so when you pour it, it stays at the bottom of the cup. CO_2 is also colourless and ***odourless***, so you can't see it being poured from one cup to another.

CO_2 does not support combustion, so it will extinguish a lighted match or taper. The oxygen in normal air supports combustion so if you put a flame into a cup filled with normal air it will continue to burn.

13.3. Rates of Reaction

Timing

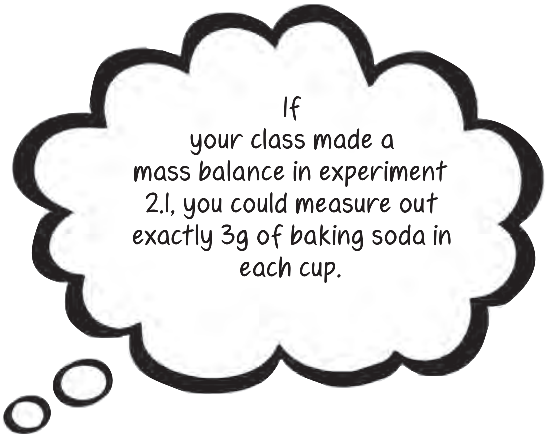
Around 10 minutes for the activity and 10 minutes for the explanation. Add 5 minutes if the students are doing this on their own in groups.

Materials

- As in Activity 13.1
- More plastic cups or half water bottles
- A permanent marker that can write on plastic

Preparation and Safety

Boil some water before class so that you have some hot water available. You can prepare the two solutions of diluted vinegar in front of the class. For diluted cold vinegar, mix vinegar and cold water in a 1:1 ratio. For diluted warm vinegar, mix vinegar and hot water in a 1:1 ratio. If you have lots of cups and enough vinegar, this is a good experiment to have the students do in groups. It is not dangerous as long as you are careful with the boiling water. The mixtures might bubble over and spill so do the experiment on a cleared table or outside.



Method

Students should predict which will react the fastest (i.e. have the most bubbles and finish first). Then have them observe what does happen, and explain the results.

1. Add half a teaspoon of baking soda to three plastic cups.
2. Label the cups A, B and C.
3. To cup A, add half a cup of vinegar.
4. To cup B, add half a cup of cold diluted vinegar (see preparation above).
5. To cup C, add half a cup of hot diluted vinegar (see preparation above).

Explanation

The rate of reaction (how fast the reactants are used up) depends on:

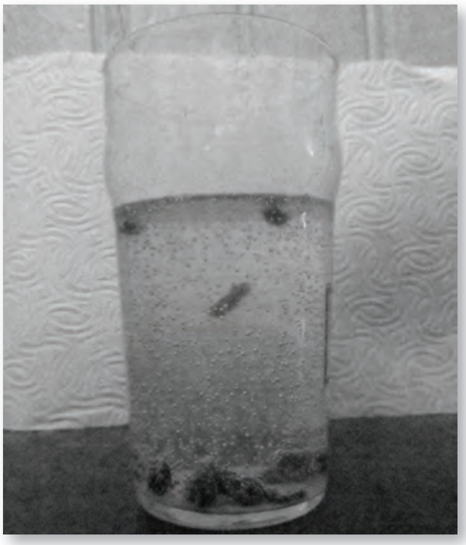
- The surface area (e.g. shredded paper burns more quickly than a thick book).
- The concentration of reactants (e.g. full strength vinegar reacts more quickly than diluted vinegar).
- Temperature – hot vinegar reacts faster than cold vinegar.
- A catalyst – something you add to speed up the reaction that does not actually participate as a reactant or a product.

Explain that this is an example of 'fair testing'. All the variables are controlled except for the independent variables, which are the temperature of the vinegar, and the concentration of the vinegar. The rate of reaction is the dependent variable. Ask the students what would happen if you used hot, concentrated vinegar?

13.4. Magic Sultanas/Raisins

Timing

About 5 minutes to set up, and then it will keep working for about an hour. You can explain how it works in the last 5 minutes of class.



Materials

- Sultanas or raisins
- Plastic bottle or clear plastic cup
- Baking soda
- Vinegar

Method

1. Add a few sultanas or raisins to a plastic cup or bottle of water.
2. Add half teaspoon of baking soda
3. Add a teaspoon of vinegar and wait for a couple of minutes – the sultanas start to move.

Explanation

Bubbles of carbon dioxide attach themselves to the sultanas or raisins which then rise to the surface. At the surface the bubbles escape and the sultanas or raisins sink. They will keep doing this for a long time.

You could joke with your students that the sultanas need to come up to the surface to get air and then they sink again until they need more air!

13.5. Measuring pH

Timing

About half an hour for red cabbage juice preparation, plus 10 minutes to prepare the testing liquids. 15-20 minutes to demonstrate or have groups of students perform the experiment, plus 15-20 minutes to explain the pH scale and other indicators.

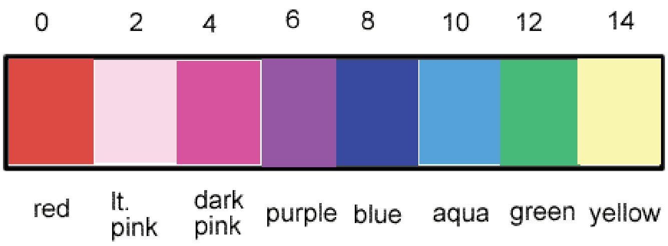
Materials

- A red cabbage or two.
- Samples of different liquids and solutions that you can obtain easily such as soap, vinegar, lime juice, saliva, hair shampoo, toothpaste, tap water, bottled water, sodium bicarbonate, etc.
- The same number of plastic cups or half water bottles as you have samples. If your students are doing their own experiments in groups, you will need more cups, or the experiment will take more time as they wash the cups between samples.
- A colour chart to compare the samples.

Preparation and Safety

To prepare the red cabbage juice indicator, chop a red cabbage into small pieces until you have about 2 cups chopped. Place the cabbage in a saucepan, cover with boiling water, and leave for at least ten minutes until all the colour has come out of the cabbage. Strain out the cabbage and keep the purple liquid. If possible, keep it cold so that it lasts longer. Red cabbages are seasonal so you will probably only be able to do this experiment at certain times of the year.

You might want to prepare a printed version of a table and a colour chart similar to the ones on the right for your students to fill in. Otherwise they can copy them from the whiteboard.



Substance	Colour	pH
Sodium bicarbonate solution		
Vinegar		
Soap solution		
Tap water		
Bottled water		
Shampoo		
Lime juice		
Toothpaste		

Method

1. Add three or four drops of red cabbage indicator to samples of each of the liquids you are testing.
2. Compare the colour of the solution to the colour chart and fill in the table. Pink colours are acidic (low pH) and greenish colours are basic (high pH). Blues are neutral (pH of ~7).

Explanation

You should be able to find lots of information about pH and indicators. This indicator is natural (and many others are made from natural plant dyes too). With senior students, you can discuss the relationship between the pH scale and H^+ concentration, i.e. pH = -log [H^+].

13.6. Preparation of Sodium Acetate and Measuring its pH

Timing

See above for preparation of red cabbage juice. This experiment should take about 20 minutes and can be done by individual students or in small groups.

Materials

- Vinegar
- Sodium bicarbonate (baking soda)
- Metal can burner (see Activity 2.2)
- Plastic cup
- Red cabbage juice indicator

Method

1. Make a metal can burner as described in Activity 2.2.
2. Place ¼ teaspoon of sodium bicarbonate in a plastic cup.
3. Slowly add enough vinegar so that there is just a bit of undissolved sodium bicarbonate left in the bottom of the cup.
4. Carefully tip the top of the solution onto the top of the metal can burner.
5. Place a lighted candle under the tripod and evaporate off the water. You will be left with solid sodium acetate.
6. Dissolve the solid sodium acetate in a small amount of water. Add two or three drops of red cabbage indicator. What is the pH of the solution?

Explanation

This is the formula for the first reaction:

CH_3COOH +	$NaHCO_3$	$\rightarrow$	CH_3COONa	+	H_2O
Acetic Acid	*Sodium bicarbonate*		*Sodium acetate*		*Water*

When sodium acetate dissolves in water, the acetate ion reacts with water to produce a slightly alkaline solution:

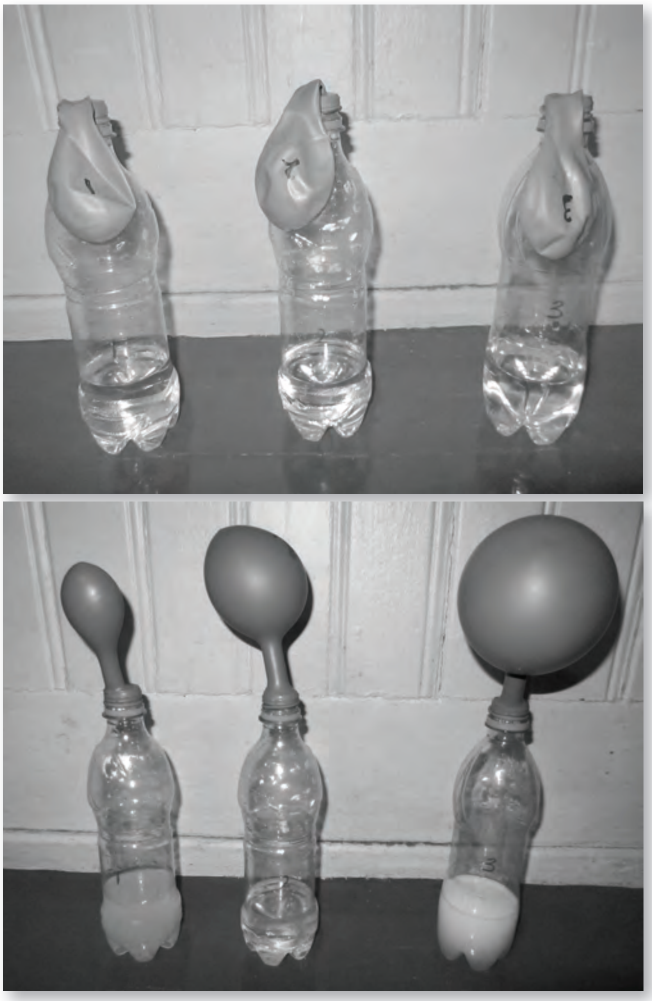
$$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$$

The acetate ion removes a hydrogen ion from the water molecule to form an acetic acid molecule and leaves a hydroxide ion in solution – which is alkaline.

13.7. Advanced Acid + Carbonate: Stoichiometry

Timing

About 20 minutes plus another 20 minutes to explain and have students calculate the stoichiometry.



Materials

- 3 clear plastic water bottles, the same size
- 3 balloons, the same size
- 1 L vinegar
- Baking soda
- Teaspoon and 100 mL measuring cup from Activity 2.1
- Marker pen

Method

1. Label the balloons and the water bottles 1, 2 and 3.
2. Measure and pour 100 mL of vinegar into each bottle.
3. Place 1/2 tsp of baking soda in balloon 1, 1 tsp of baking soda in balloon 2, and 2 tsp of baking soda in balloon 3.
4. Stretch the mouths of the balloons over the mouths of the bottles with the matching numbers, *but do not let the baking soda pour into the bottle yet.*
5. When all the bottles are ready, tip the contents of the balloons into the vinegar. The reactions will start and the balloons should blow up to different amounts.
6. Discuss the reason the balloons are different sizes and have the students calculate the amounts of gas that should have been produced (see explanation below). If you weighed a whole bottle with the balloon attached and the ingredients in place before and after the reaction, what would you discover? (The mass would be the same before and after, because mass is not created or destroyed by the reaction.)
7. If you have covered 'limiting reactants' in classes you could also add a pinch of baking soda after each reaction has finished, and see whether any of the mixtures continue to react.

Explanation

Stoichiometry is the balancing of chemical reactions using real number values. It can be used to calculate the amount of products produced by a chemical reaction. The law of conservation of mass says that "*all atoms that enter a reaction as reactants must finish the reaction in the products, and no atoms can exist in the products if they were not in the reactants.*"

Consider the example of decomposing water into hydrogen (H) and oxygen (O) gas:

$H_2O \rightarrow H_2 + O_2$

Reactants → *Products*

Is this equation balanced? No! There is only one O atom on the reactant side, with two O atoms in the products. This would mean oxygen is formed out of nowhere. To balance the O, we include a coefficient of 2 on the left side. Once the 2 is added, we also have to add a coefficient of 2 to the H molecule on the right to balance that:

$2H_2O \rightarrow 2H_2 + O_2$

The coefficients in this equation indicate that exactly 2 water molecules are needed to form 2 H molecules and 1 O molecule (and both H and O have 2 atoms in each molecule).

For baking soda (sodium bicarbonate) and vinegar (acetic acid), the equation is:

$NaHCO_3 + CH_3COOH \rightarrow CO_2 + H_2O + CH_3COONa$

Check it is balanced with the same number of atoms on each side.

We want to work out how much gas will be produced. The CO_2 gas comes from the break-down of the sodium bicarbonate. From the balanced equation, we can see that the ratio of $NaHCO_3$ to CO_2 is 1 mole $NaHCO_3$/1 mole CO_2 or 1:1. This is called the *mole ratio*. To work out how many moles of gas are produced, we need to know how many moles of $NaHCO_3$ we start with.

We will use the formula: m = n x M
rewritten as: n = m/M

Where m = mass of substance in grams
n = moles of pure substance
M = molar mass of the pure substance in g/mol

Balloon 2: We can assume that 1 tsp of sodium bicarbonate (baking soda) has a mass (m) of 4g (*this is not exactly accurate, but it will work for our example*).

To calculate molar mass, we need to add the atomic weight of each atom in the molecule. Find the atomic weights on the periodic table:

Na H C O_3

Molar mass (M) of $NaHCO_3$ = (1x23) + (1x1) + (1x12) + (3x16) = 84g/mol

Round the numbers, e.g. the atomic weight of Na is 22.9898, rounded to 23

Then use the equation n = m/M = 4/84 = 0.0476 moles of $NaHCO_3$ in 1 tsp baking soda

How many moles of CO_2 will be produced? Remember the mole ratio of 1:1 for this equation. So the number of moles of CO_2 produced by 1 tsp of baking soda is also 0.0476 moles.

Do the same calculations for ½ tsp and 2 tsp to work out the n of CO_2 in each balloon.

For gas volumes, you need to use the Ideal Gas Law, which has the equation pv = nRT

p x v = n x R x T

(pressure) x (volume) = (moles) x (Ideal Gas Constant) x (temperature)

v = nRT/P — R = 0.0821 L-atm/mol-K is the Ideal Gas Constant

v = (0.0476 x 0.0821 x 300)/1 — T = 300 K (at standard lab conditions)

v = 1.17 L for 1 tsp $NaHCO_3$ — p = 1 atm (at standard lab conditions)

i.e. Balloon 2 contains 1.17 L of CO_2 if none escapes (but remember, the balloon is holding the gas in tight, or ***compressing*** it)!

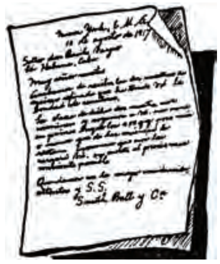
Do the same calculations for ½ tsp and 2 tsp to work out the volume of CO_2 in balloons 1 and 3.

14. Chromatography

Chromatography is the science of separating mixtures. The following experiment uses ‘paper chromatography’ which separates the colours in a solution by using paper and a solvent.

14.1. Who Wrote the Blackmail Note?

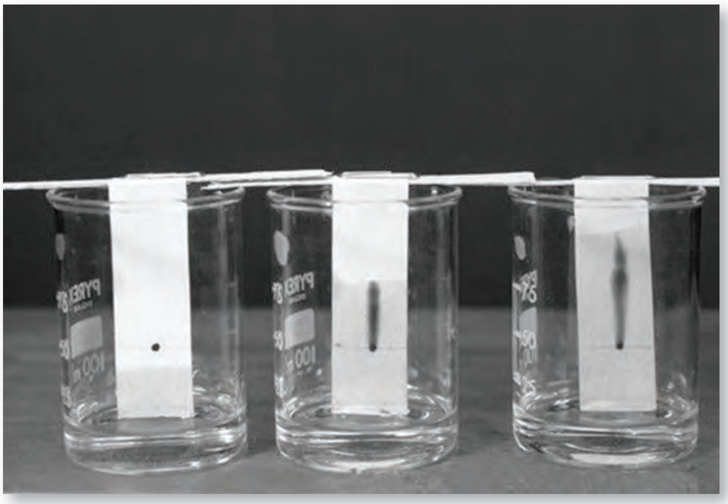
Timing



About 40 minutes.

Materials

- Plastic cups – several for each group
- Water and alcohol mix (50:50). Use methylated spirits or rubbing alcohol.
- Different brands of markers – try to use the same colour but give each group a different brand
- Bamboo skewers
- Paper clips



Method

1. Split the class into groups and give each group one of the marker pens. The group needs to discuss an evil blackmail plan and write a note to another group using their marker.
2. Hand out the blackmail notes to different groups, making sure none of the groups get their own note back, and none of the students tell each other which note was written by whom.
3. Distribute the plastic cups with a little of the water/alcohol mix in the bottom.
4. Each group needs to tear a strip off their note and fix it over the bamboo skewer with a paper clip so that just the end of the paper strip is touching the liquid in the cup.
5. They also need to get samples of the ink from each of the other groups’ pens. Each ink sample can be a dot on a strip of paper, or a letter signifying the name of the group. The ink sample papers are then fixed so that they touch the water/alcohol mix too.
6. The colours separate in different orders depending on the type of marker, so the students should be able to match up one of their ink samples with the ink on the blackmail note.

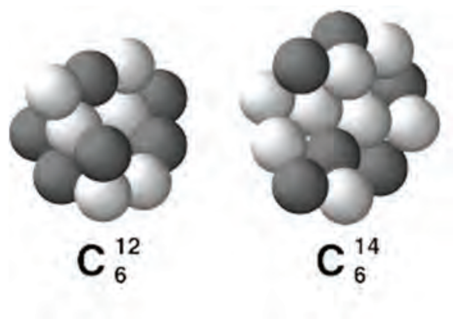
Explanation

As the solvent rises through the paper, it meets the sample mixture which starts to travel up the paper with the solvent. The paper is made of cellulose, a polar substance, and the compounds within the mixture travel farther if they are non-polar. More polar substances bond with the cellulose paper more quickly, and therefore do not travel as far. Different inks have different amounts of these polar and non-polar substances, so they move up the paper at different speeds.

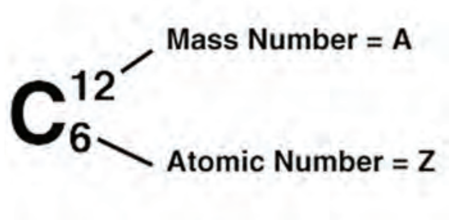
15. Isotopes and Radioactivity

Summary

Isotopes are varieties of atoms of a particular chemical element which have different numbers of neutrons. All atoms of an element must contain the same number of protons, but they could have different numbers of neutrons. The *mass number* of an element is the number of protons plus neutrons in the nucleus, so this is different for two different isotopes of an element. For example, carbon-12, carbon-13 and carbon-14 are three isotopes of the element carbon with mass numbers 12, 13 and 14 respectively. The *atomic number* of carbon is 6 because every carbon atom has 6 protons; therefore, the numbers of neutrons in these isotopes are 6, 7 and 8 respectively.



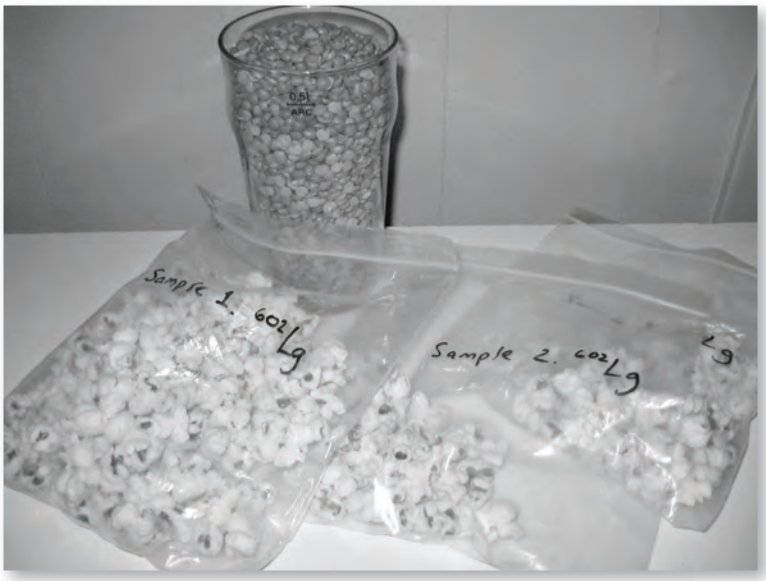
Some isotopes are *radioactive*, which means they *decay*, or break down into smaller parts (usually another atom + smaller sub-atomic particles like electrons or protons). Some isotopes are stable, like ^{12}C (carbon-12), which means it does not decay (and is not radioactive). The concept of a radioactive half-life is demonstrated in this activity. To start with, explain that a half-life is the amount of time it takes a sample of a radioactive element to decay to half the original number of atoms.



15.1. Classroom Archaeology

Timing

About 1 hour, after a lesson explaining radioactivity.



Preparation

This experiment will take some time to set up – you need to create the samples, which are bags of ‘atoms’ which represent the decayed atoms. Write a label on each bag to explain where the sample is from. You can make up your own, they just have to be ***organic*** samples (used to be alive), and keep to an archaeological theme. Here are some examples of labels you could use:

- A dog leg bone found in an old fireplace discovered during the construction of the school
- A scraping of food off the inside of an old cooking pot buried in Shan state
- A wooden arrow found in the grave of a male skeleton in Kayin state
- An ancient leaf ***preserved*** in a peat bog

Materials

- Beaker or large jar
- Uncooked yellow beans, approximately 900 beans (you don't have to count exactly) – these represent atoms of the stable isotope Legumium-600, or ^{600}Lg. (This is not a real element! We have just invented to help demonstrate an idea.)
- 1 type of small edible food items, e.g. dried peas, peanuts, grains of cooked rice, or popped popcorn. You will need about 200 of one type – these represent atoms of the radioactive isotope Legumium-602, or ^{602}Lg. 100 go into the container with the yellow beans.
- 4 plastic sample bags. You should prepare them with different labels as above. Split the other 100 peanuts (or whatever food you are using as ^{602}Lg) between the 4 samples. For example you might put 18 peanuts in Sample 1, 32 peanuts in Sample 2 etc (The numbers don't matter, as long as there are less than 100 in each bag).

Method

1. Put the ^{600}Lg atoms (yellow beans) into the large jar. Tell the students there are 900 atoms in there, but you don't have to count! Add the 100 radioactive ^{602}Lg atoms (peanuts or whatever you decided to use).
2. With the class, count the number of radioactive atoms. Subtract from 1000 to get the number of stable atoms *(900)*. Determine the ratio of the radioactive atoms to the stable atoms *(1:9)*. This is the ratio found in nature of the element 'Legumium'.
3. Ask a student to start the radioactive decay by counting the years passing, and removing (and eating!) 1 radioactive atom every time 10 years passes. Do this 10 times, which is 100 years. What is the decay rate as a percentage for a 100 year period? *(10%)* This percentage decay rate will continue.
4. Fill in a table like the one shown. Some data points are already recorded for you. Continue eating 10% of the radioactive atoms every 100 years for 3000 years and record your results in the table.
5. Have the students plot the data on a graph and draw the curve connecting them. Ask students to work out the half life from the graph (the point where half the original number of radioactive atoms is gone, about 650 years from the graph).
6. Create another graph for the ^{14}C table provided. From the graph, work out:

   a. What is the half life of ^{14}C? *(5700 years)*

   b. If an archaeologist detects 3000 radioactive atoms remaining in a sample, how long since the organism died? (~10000 years old)

   c. If a sample is 2000 years old, how many radioactive atoms would be remaining in the sample? *(~8000)*
7. Show the bags of "radioactive atoms" representing different archaeological samples. Each bag contains only the radioactive atoms from the sample that were found along with the 900 stable atoms, like you had in your original container. Any atoms that have already decayed have disappeared. Have the students count the number of atoms remaining in each bag and use the Legumium decay graph they have drawn to estimate how long ago the organisms died.

Radioactive decay of Legumium-602

Years since death	No of radioactive atoms remaining
0	100
100	100 – (10% of 100) = 90
200	90 – (10% of 90) = 81
300	81 – (10% of 81) = ___
400	
500	
600	
700	
800	
900	
1000	
1100	
1200	
1300	
1400	
1500	
1600	
1700	
1800	
1900	
2000	
2100	
2200	
2300	
2400	
2500	
2600	
2700	
2800	
2900	
3000	

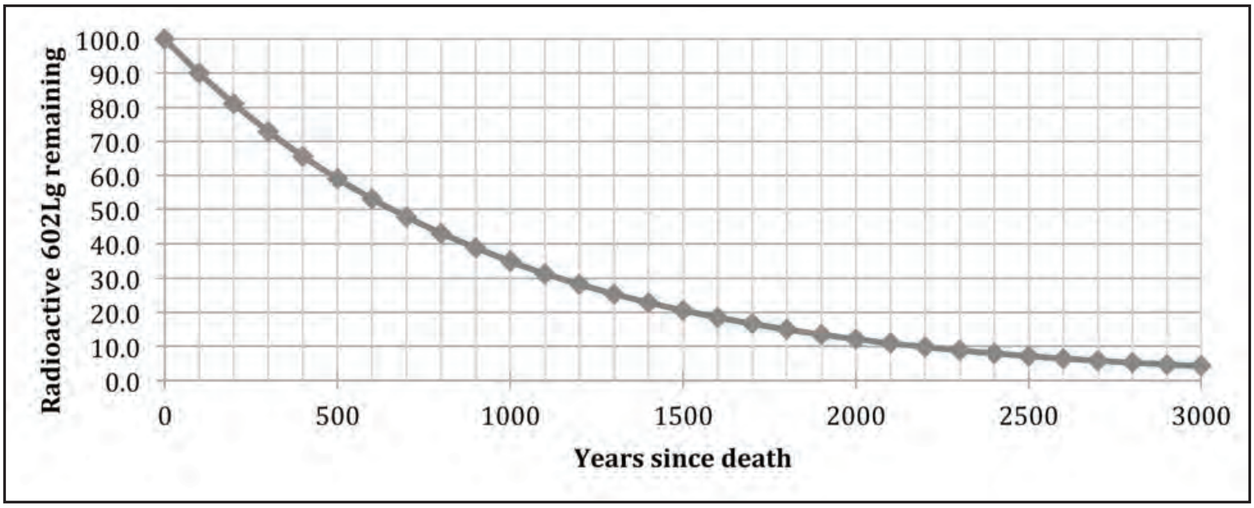
Radioactive decay of Carbon-14

Years since death	No of radioactive atoms remaining
0	10000
5700	5000
11400	2500
17100	1250
22800	625
28500	312
34200	156
39900	78
45600	39
51300	20
57000	10
62700	5
68400	2

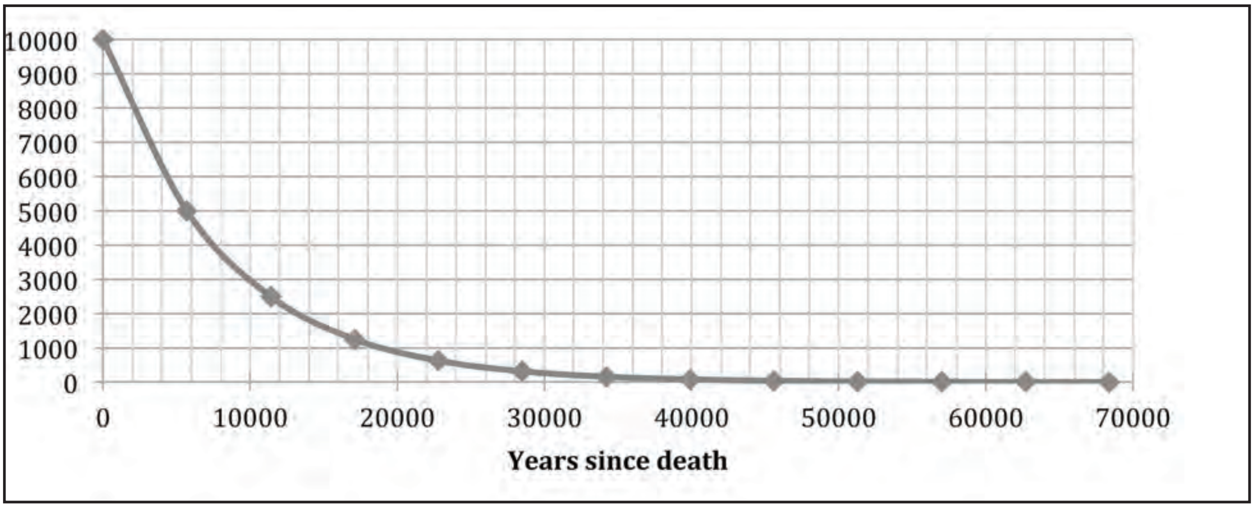
Explanation

This experiment represents how archaeologists 'date' samples using radiocarbon and other radioisotopes. The atoms in this experiment are MUCH bigger than atoms in real life. It is impossible to see real atoms; they have to be 'detected' using a special machine called a *particle accelerator*.

Example of ^{602}Lg graph:



Example of ^{14}C graph:



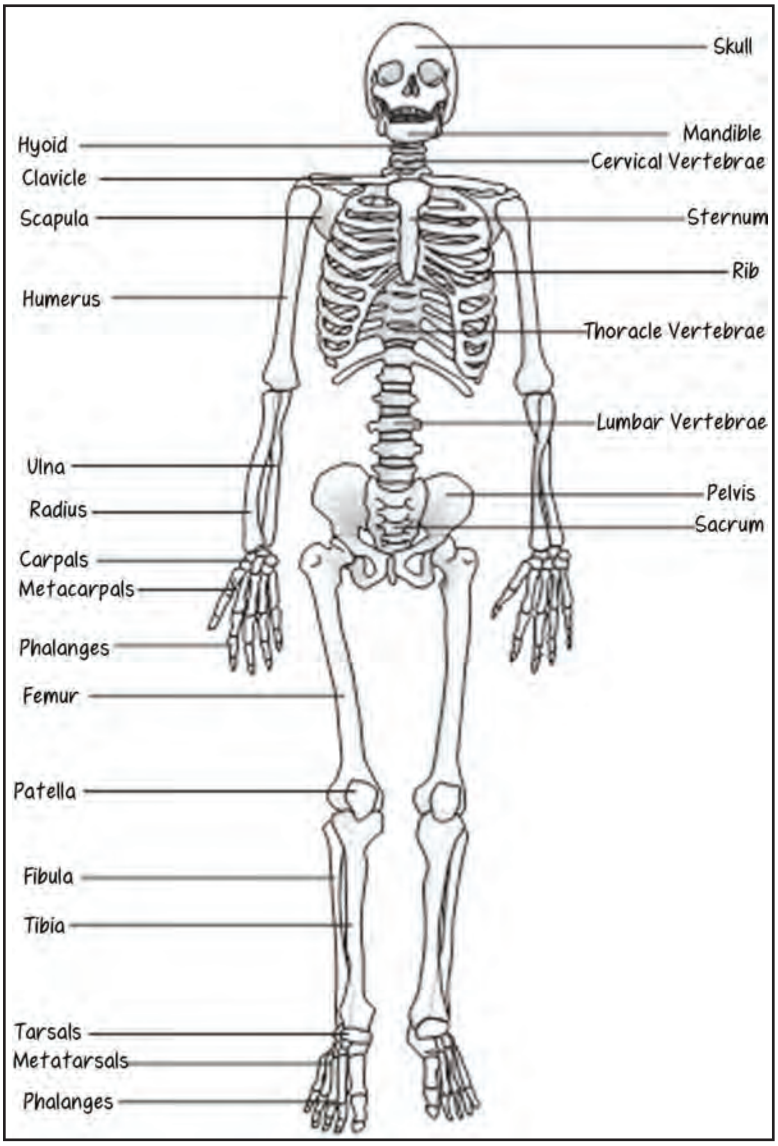
BIOLOGY

16. Animal Bodies

16.1. Human Organ Systems

Discuss with the students why we have a skeleton and what its main functions are:

- Shape
- Protection of internal organs
- Support of our organs and flesh
- Movement by attaching to muscles
- Storage of minerals, such as calcium
- Blood production in the bone marrow



For an advanced class, use the diagram provided to teach some of the scientific names for the bones.

Timing

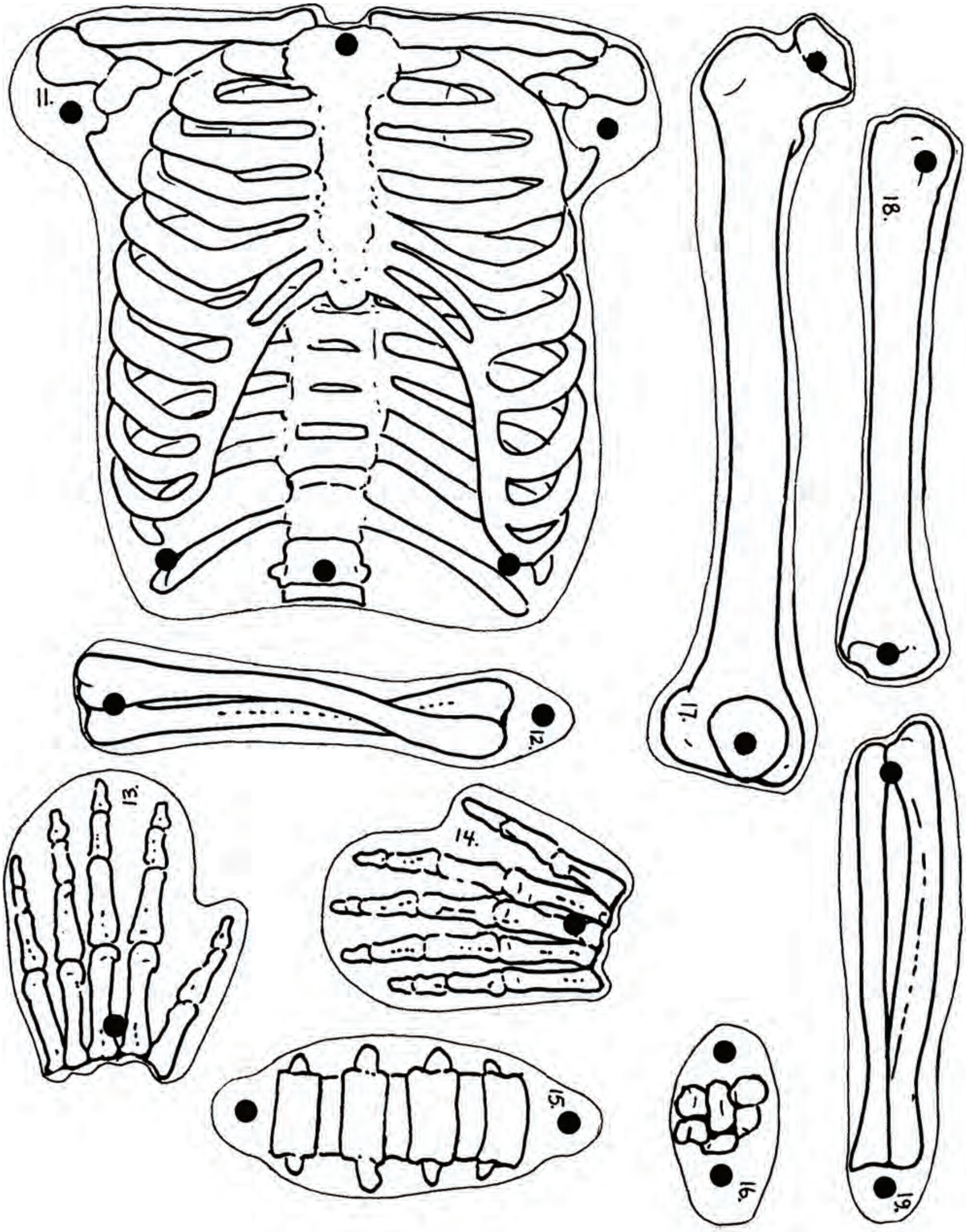
About 30 minutes to colour, cut out and put together the skeleton.

Materials

- Scissors
- Stapler or tape
- Photocopies of attached diagrams of the human skeleton and digestive system

Method

1. Have students cut out the shapes of the organs and staple or tape them together according to the numbering systems on the diagrams.
2. Use this as an introduction to your lessons about the human body.
3. You can use any organ system to teach students about how the smallest building blocks are the organelles, which make up the cells. Each different type of cell makes a different type of tissue, for example, bone cells make bone tissue. There are different types of bone tissue, for example the marrow inside is different to the strong bone material outside. Use a chicken bone to demonstrate. Different tissues combine to make organs, and different organs make up organ systems.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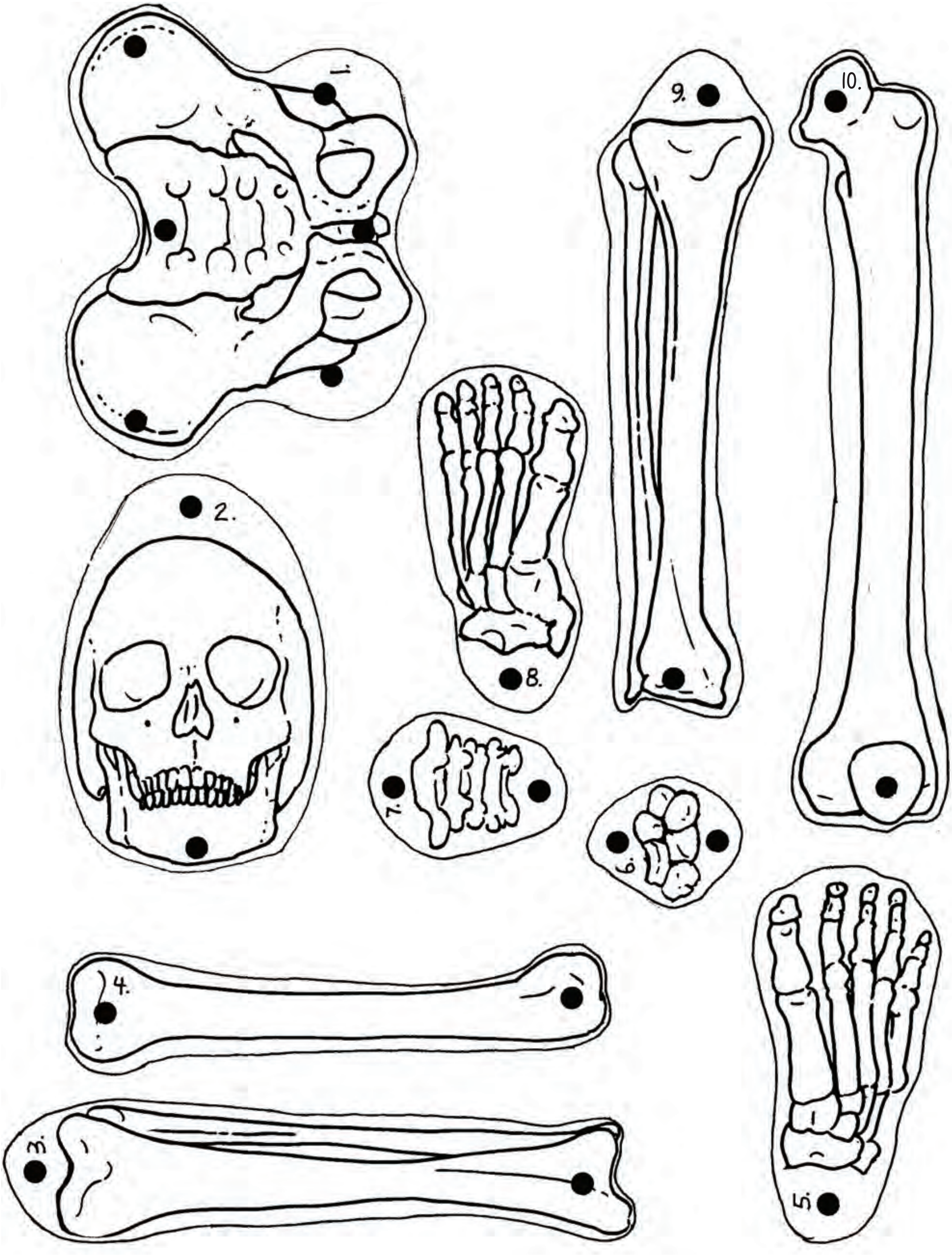

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2.
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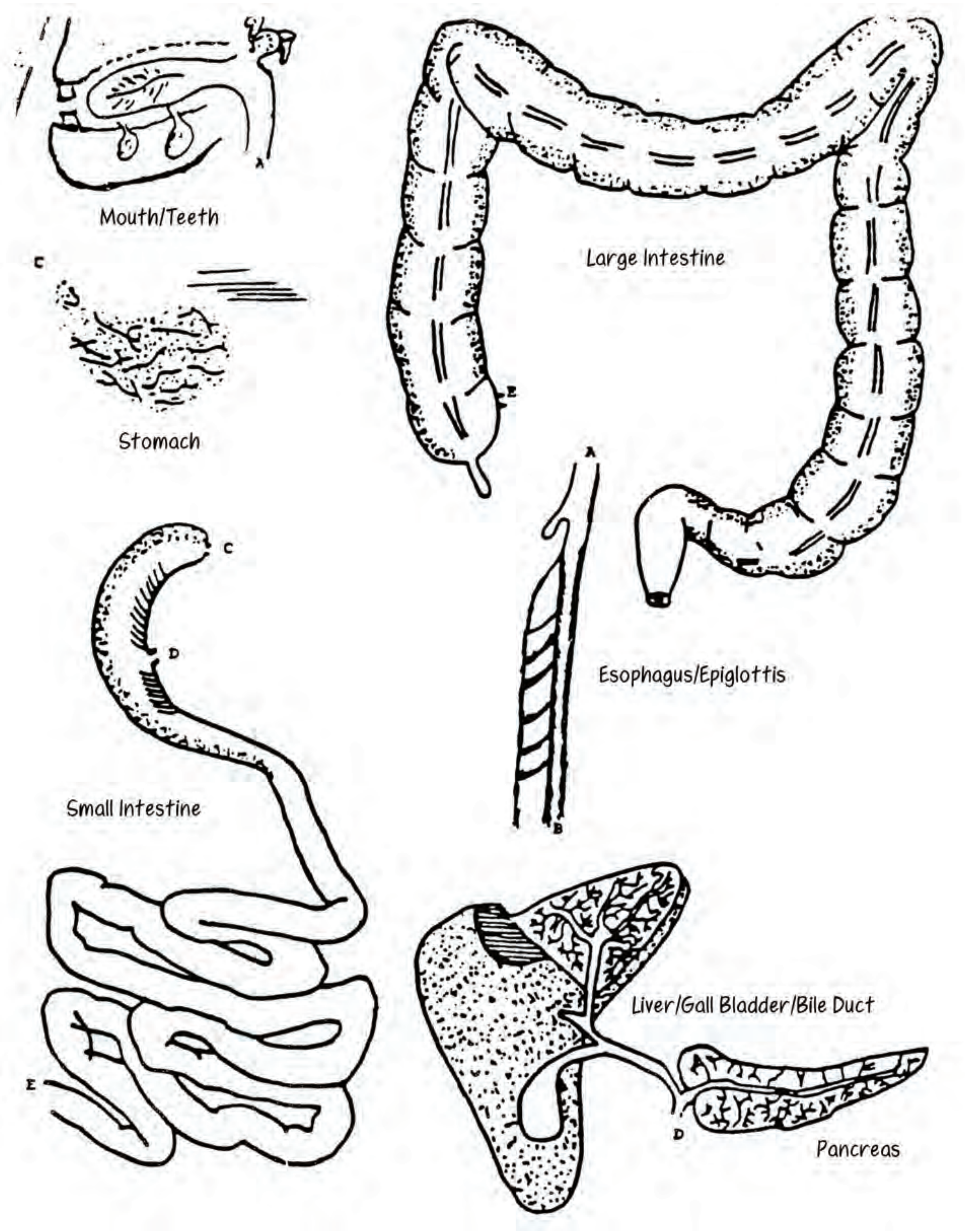

Mouth/Teeth
Stomach
Large Intestine
Esophagus/Epiglottis
Small Intestine
Liver/Gall Bladder/Bile Duct
Pancreas

16.2. Spiders and Insects

Spiders and insects are both animals. They both have exoskeletons (skeletons on the outside). This is because they are both in the Order Arthropoda.

Spiders have two body parts (head and abdomen), eight jointed legs, and a spinneret (the organ at the tail that spins a web).

Insects have three body parts (head, thorax and abdomen) and six jointed legs on the thorax. If they have wings they are on the thorax.

Timing

About an hour to teach about classifying the different animals, giving the students plenty of time to sketch and describe their animals properly.

Materials

- An insect or a spider in a jar
- A magnifying glass (one per pair of students, if possible)

Preparation and Safety

The day before class, instruct the students to bring in an insect or a spider. To collect the animals, they should place the jar or cup over the top, and slide a piece of paper underneath. They should not try to catch animals with their hands since some can bite or sting.

Method

1. Each student should study their insect or spider using the magnifying glass. Count the number of legs and the segments of each leg. Does it have antennae? Does it have wings and, if so, how many? If it is a spider, is it a hunting spider (with big fangs) or does it catch its prey with a web (pointy 'spinnerets' at the tail)?
2. Examine and describe the mouth parts.
3. Identify the 'spiracles' that the insect or spider 'breathes' through – these are small holes mostly along the abdomen.
4. Each student should make a labelled drawing of their animal.
5. Compare the drawings or draw somebody else's animal.
6. Release the spiders and insects outside when you are finished; do not kill them!

Extension

Conduct a classification exercise with the students so they group the pictures depending on the characteristics of the animal.

You could also have the student collect other invertebrates and draw them and classify them: crabs, worms, snails, etc. This is a good experiment to have the students practise drawing a pie chart.

17. Plants

Summary

There are lots of experiments you can do to demonstrate how plants grow, respond to ***stimuli***, and produce their own food from sunlight through the process of photosynthesis. Here are just a few.

17.1. Plant Growth

Timing

Part of a lesson over several days or weeks. You could have the plants growing in the classroom and spend the first 5 minutes of every lesson observing changes. 30 minutes for setting up the experiment in the first lesson.

Materials

- Plant seeds like peas or beans
- Clear plastic cups or half water bottles
- Paper towel or cotton wool
- Cardboard box
- Scissors
- Marker pen
- Soil for the optional second part

Name	Conditions	Observations Day 0	Observations Day 1
A	Control		
B	Dark		
C	Dry		
D	Light stimulus		

Method

1. Label 4 plastic cups with the marker pen – A, B, C, D
2. Make a table for the students to copy that explains the labels.
3. In each of the cups place some bunched up paper towel or cotton wool. Sprinkle some water on it so it is just damp but not soaked. Do not put water on the paper towel in cup C.
4. Put four seeds in the paper towel in each cup, just near the surface.
5. Cup A is the control: it gets water, sunlight and fresh air. Put it near a window or somewhere it gets sunlight.
6. Cup B gets darkness so you need to find a cupboard or a small room where it doesn't get exposed to any sunlight.
7. Cup C needs to be beside the control, but never get any water (or if you want to, you can water the seeds until they germinate, and then stop watering it).
8. Cup D goes into a special cardboard box that you can make. Put the cup at one side of the box, and cut a hole in the lid at the other side of the box. When the seeds germinate, the plants should grow sideways towards the light. Put this box next to Cup A as well.
9. Have the students describe the conditions in the table under 'Observations Day 0'. Every lesson, check that A, B and D are still damp, sprinkle more water on if not, and have the students observe any changes to the seeds and seedlings – these observations will be for Day 1, Day 2, etc. This is a good experiment for students to practise writing a lab report, with sections called Aim, Hypothesis, Method, Results, Discussion and Conclusion. They can also measure the growth of each plant every lesson, and draw a graph to compare the growth under the different conditions. The students can also gently remove the seedlings from the cups and examine them, draw them and label them.
10. Once the seedlings have grown a few leaves and the students have had a chance to observe the roots, you can move them into soil, and keep them growing under the same conditions. At this point, you could experiment with different fertilisers, different types of soil, or put some plants into soil and leave some in the damp paper – how long can they grow like that?

Explanation

Anything can happen in this experiment! You can adapt it depending on what you have been teaching, and the level of the students. Some of the seeds might not germinate, but that is normal. The final conclusion is that plants are getting energy from the Sun to grow (not something they are absorbing from their roots, although they also use nutrients from soil to help keep them healthy). They need water and carbon dioxide to conduct photosynthesis, so the seeds growing without water and the ones growing in the dark will not grow as well as the control. Cup D should demonstrate that plants respond to the stimulus of light. They can grow towards light. You can also show this by turning one of the cups upside down (but without blocking the plant's access to light and air), and it will grow in a bent shape towards the Sun.

If you are using 'dicot' seeds, you will be able to see the two seed-covering leaves when the plant first germinates. A 'monocot' would only have one seed leaf. Beans, peas, tomatoes, cucumbers, etc. are dicots, but grasses, coconuts and other palms are monocots. If you have studied this in class already, you will be able to get the students to observe the other characteristics of monocots and dicots, e.g.: Monocots have a tap root, parallel veins in their leaves, and an odd number of petals on their flowers. Dicots have no tap root, a network of veins in their leaves, and an even number of petals on their flowers.

17.2. Starch and Photosynthesis

Starch goes black in the presence of iodine. If you can get some iodine from a pharmacy, you can test different materials for starch, which can tell you which materials are made by plants.

Timing

About half an hour.

Materials

- Iodine solution (iodine crystals dissolved in alcohol or potassium iodide solution)
- Drinking straw
- Dish or tray to test items on
- Selections of – rice, banana, bread, cake, biscuit, orange peel, paper, sugar, plastic, wood and anything else

Method

1. Using the drinking straw as a ***pipette***, add a drop of iodine solution to each of the samples you have.
2. Which ones turn black, showing the presence of starch?

Explanation

Starch is a complex carbohydrate produced by green plants. Plants produce starch to store the energy that they produce through photosynthesis.

18. Cells

Once the students know how to draw plant and animal cells, you can use the two experiments below to help them understand more about DNA, and explain how water is transported into and out of a cell through the process of osmosis.

18.1. DNA Extraction

Timing

45-60 minutes

Materials

- 1 onion
- A knife and chopping board
- Salt
- Warm water
- Mortar and pestle
- Plastic funnel or sieve
- Coffee filters or a piece of scrap fabric
- Dishwashing liquid
- Cold methylated spirits (store in fridge)
- Glass beakers, plastic cups or water bottles with the tops cut off

Preparation

You can reduce the class-time for this experiment by chopping and mashing the onion before class, but the students enjoy participating in this as well, so if you have time, do the whole experiment in class and give different students different responsibilities.

Method

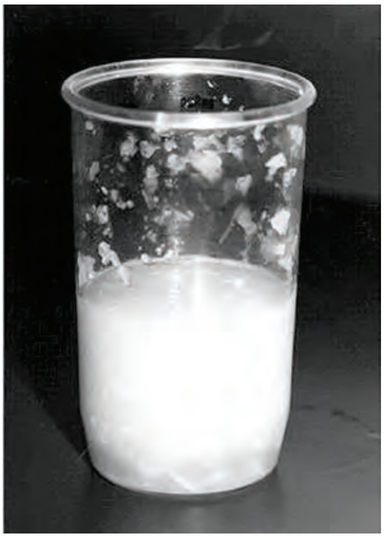
1. Finely chop half an onion.
2. Dissolve 1 teaspoon of salt in 200 mL warm water (2/3 boiling, 1/3 cold).
3. Add enough salty water to cover the onion.

Step 1

Step 2

Step 3

4. Mash gently until onion pieces are pulped up.
5. Pour the mixture through the coffee filter paper in a funnel, or use fabric as a strainer to separate the solid parts out of the onion mixture.
6. Measure 50 mL of onion mixture and pour it into a clear cup or beaker.



Step 4

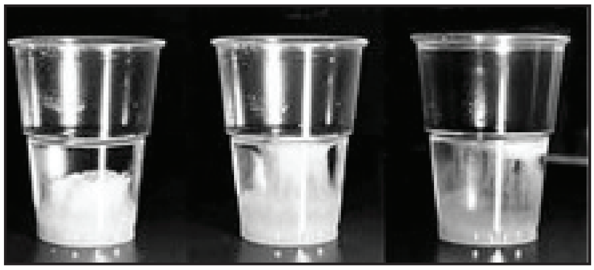
Step 5

Step 6

7. Add 2 tsp of dishwashing detergent to the 50 mL of onion liquid. Stir gently.
8. Measure out 100 mL of methylated spirits. Add it very slowly to the onion detergent mix.
9. Wait for 5 minutes and the white 'snotty' strands of DNA should float up into the methylated spirits.

Step 7

Step 8



Step 9

10. Keep experimenting if it doesn't work the first time. It might work better if you cool the water down after dissolving the salt, or mash the onion better. You can try different fruits and vegetables too!

Photos from http://museumvictoria.com.au/scidiscovery/dna/howto.asp

Explanation

Mashing onion – To break up the structure of onion into as small pieces as possible (even single cells), for the action of the dishwashing liquid.

Adding dishwashing liquid – Dishwashing liquid is a 'detergent', which breaks down the structure of the cell membrane (and the nuclear membrane around the nucleus), causing the cell contents, including the DNA, to spill out. Breaking up cells like this is called cell 'lysis'.

Addition of salt – The positively charged ions of salts (Na^+) protect the negatively charged DNA. In high salt concentrations, alcohol (methylated spirits) causes a shape change in the DNA molecules, causing them to stick together.

Addition of alcohol – DNA is soluble in water. The addition of alcohol and salt causes DNA to precipitate. The precipitation reaction is better if the methylated spirits is cold. Other parts of the cell remain in solution in the liquid underneath the DNA and alcohol.

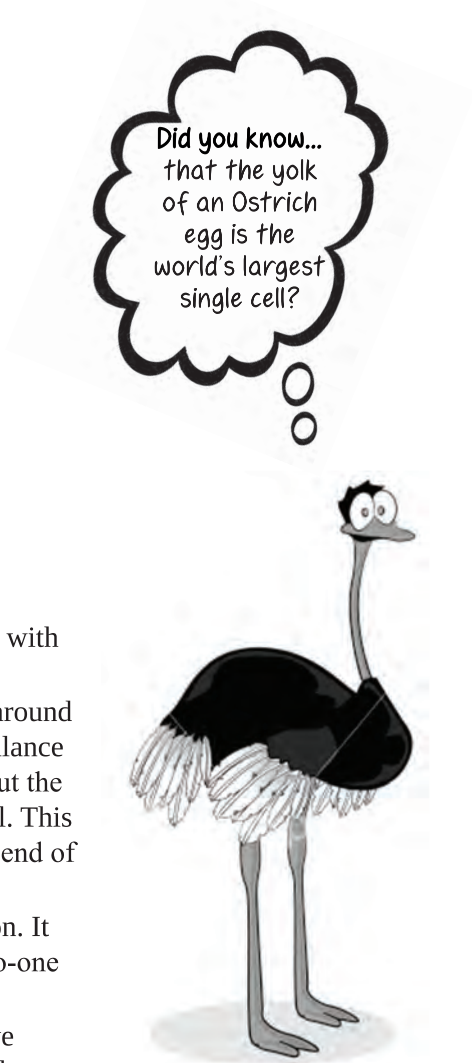
18.2. Egg Osmosis

The following experiment can be used for demonstrating osmosis, a special type of diffusion that happens in cells. This is an important concept in biology but you can also teach diffusion and osmosis as a part of chemistry.

Explain that eggs are a single cell – the female sex cell of a chicken. In fact only the yolk is the cell; the rest is nutrients that the growing embryo would use if the cell were fertilised, but it is easier for students to understand osmosis using this experiment if they think of the whole thing as a cell.

Timing

About 15 minutes in class on 2 consecutive days, plus a 3rd day if you are going to do the extension as well. For advanced students you can explain what you will do and have them come up with a hypothesis about what will happen to the egg at each stage.



Materials

- 1 egg
- 1 half water bottle or large plastic cup
- Marker pen
- 300 mL of vinegar
- A piece of string
- The mass balance from Activity 2.1
- Sugar syrup (for extension only)

Method

1. *Day 1*. Measure 300 mL of vinegar into an empty water bottle with its top cut off. Mark the level the vinegar is at.
2. Take a chicken egg and measure the circumference (distance around the middle) with a piece of string. If you have made a mass balance in Activity 2.1, you could also measure the mass of the egg. Put the egg into the vinegar. You will see bubbles forming on the shell. This is the weak acid, vinegar, eating away at the egg shell. By the end of the day you'll have just an egg and no shell.
3. *Day 2*. Carefully remove the egg from the vinegar with a spoon. It will be firm but soft. Let the students touch it but be careful no-one presses too hard and bursts the membrane.
4. Measure the amount of vinegar left in the bottle (it should have decreased). Have the students describe what has happened and re-measure the circumference and mass.

Explanation

The egg ***swells*** because of the process of osmosis. The ***concentration*** of water outside the cell (egg) is greater than inside, so the water from the vinegar moves into the egg (i.e. down a concentration ***gradient*** from highest to lowest concentration). The change in size of the egg and the change in level of the vinegar should convince the students that the water has gone into the egg.

Only water can move across the semi-permeable membrane of a cell. Other molecules are too big. You can explain that the cell membrane is like a filter or a fly-screen, only '***permeable***' to molecules that are small enough to fit through the holes.

If you measure the circumference, the volume of the egg (v) is proportional to the radius (r) cubed:

$V_1 \propto r_1^3$ $\qquad\qquad$ $V_2 \propto r_2^3$

Extension

To further demonstrate the process of osmosis, you can put the large, swollen egg from Day 2 into a strong solution of sugar:

1. Make a very concentrated mix of sugar (lots of sugar in water, or you can buy sweet coloured drinking cordial) and again, measure 300 mL or some known amount of sugar mixture into the container.
2. Carefully place the swollen egg that you took out of the vinegar into the sugar syrup and leave for another 24 hours.
3. The egg will lose water to the sugar solution and shrink because the concentration of water inside the egg is higher than the concentration of water in the syrup.
4. Have the students measure the circumference and the mass of the shrunken egg. Have them describe what it looks like and try to explain what has happened.

19. Ecology

Natural selection is the evolutionary process by which the best-adapted (or 'fittest') individuals in a particular environment survive. The longer an organism survives, the more likely it is to reproduce and pass on its inherited traits. Some organisms are adapted to their environment because they have inherited the ability to camouflage themselves. A predator organism can avoid being seen by its prey, or a prey organism can avoid being seen by its predator. Other organisms have specially adapted body parts that allow them to be very successful predators or defend themselves well against predators. The two activities demonstrate these ***adaptations***.

19.1. Newsprint Camouflage

Timing

About half an hour, not including the class time to explain natural selection and adaptation.

Materials

- 1 newspaper
- 1 sheet of coloured paper
- Scissors

Preparation

Before the class, you will need to prepare the two types of 'organisms'. To do this, cut out 50 small squares of newspaper, and 50 of coloured paper for each group of 8 students in your class. All the organisms should be about the same size, about 2 cm x 2 cm.

Method

1. Split the class into groups of 8 and assign each group member a number from 1-8. If you don't have enough organisms for more than 1 group of 8, you can have the groups do the exercise one after the other, or have one group demonstrate and the others watch.
2. Place a sheet of newspaper on the ground and have all the group members stand around it with their backs to the newspaper. Explain that the newspaper is the '***habitat***' and the students are the 'predators'.
3. Arrange the 50 newspaper organisms and 50 coloured organisms randomly in their habitat, but make sure they are not overlapping.
4. When you are ready to start, the teacher calls out the numbers from 1-8 randomly. When a student's number is called they have to quickly turn around to face the habitat and grab the first organism they see, then turn away again.
5. After each student has grabbed about 8 organisms, have them count the number that are coloured and the number that are newspaper. Tally the results in a table and have the students explain their results.

Student	Colour prey	News prey	Total
1			
2			
3			
4			
…			

Explanation

Because the newspaper print organisms have the same pattern as their habitat, they are harder for the predators to see and they are taken less often than the coloured organisms. Over many generations, the number of newsprint organisms would increase and the number of coloured organisms would decrease, because fewer coloured organisms would survive long enough to pass on their genes.

The story of the peppered moths

Peppered moths are a small speckled moth with two colour variants – dark and light. Researchers discovered at the start of last century that the dark coloured variant was becoming more common, until eventually there were hardly any light coloured moths at all. The explanation was that pollution as a result of the industrial revolution was making the bark of the trees darker, and so the dark coloured variants were able to hide better from predators. The light-coloured moths stood out from the dark tree bark and were eaten more often, which meant that they weren't able to pass on their genes to the next generation. Later, when pollution was less of a problem, the light coloured moths were able to increase in numbers again.

19.2. Bird Beak Adaptation

Bird beaks are a great example of how different organisms are adapted for different environments: depending on the type of food available, different birds have evolved different 'tools' to allow them to hunt successfully.

Timing

About an hour, depending on how involved the students get.

Materials

- 'Beaks' such as chopsticks, spoons, strainers or slotted spoons, pliers or nutcrackers, eyedroppers, straws, envelopes, tongs
- 'Food' such as cooked rice, loose leaf tea, a chicken bone with some meat on it, sunflower seeds, popped popcorn, small dried fish, some coloured water
- 'Habitats' such as a small thin tube to contain the coloured water (nectar), a glass of sugar or salt (representing soil) to hide the gummy worms in, a glass of water to soak the fish in and another to float the tea in
- Pictures of real bird beaks that match your activity 'beaks'

Here are some examples below. Students should get creative and come up with many more types of beaks to match real bird beaks and habitats.

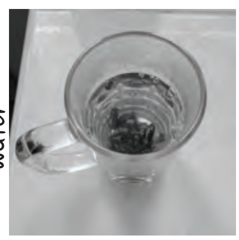
"Beaks"

Real Birds

Habitats

"Nectar"

Tea leaves in water



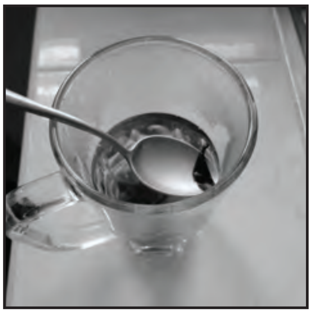
Preparation and Safety

This experiment can take a long time to set up, and may involve some research to find pictures of different bird beaks to match the tool 'beaks' you have available.

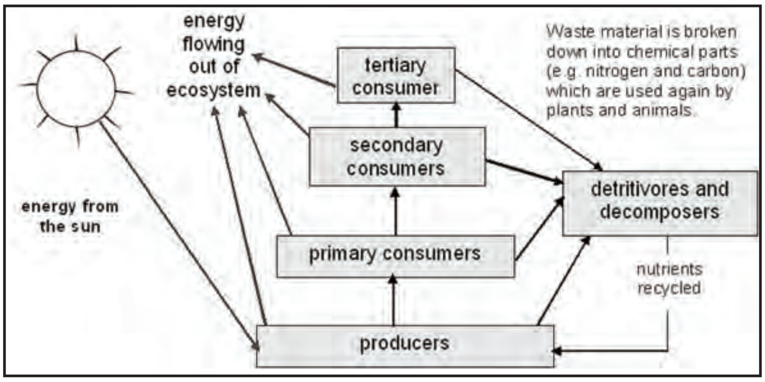
For each food you will need to put it in a habitat so the beaks represent the way that birds gather their food.

Method

1. Set up each habitat with one type of food inside it.
2. Let the students experiment with using different tools to get the food out.
3. Students should get creative and come up with many more types of tool 'beaks' to match real bird beaks and habitats.
4. You could set up races between different student 'birds' and get the other students to help decide which beak is best adapted to each food type.

19.3. Classroom Food Web



Timing

One lesson, 30-40 minutes depending on the class's interest and how much information you have to discuss.

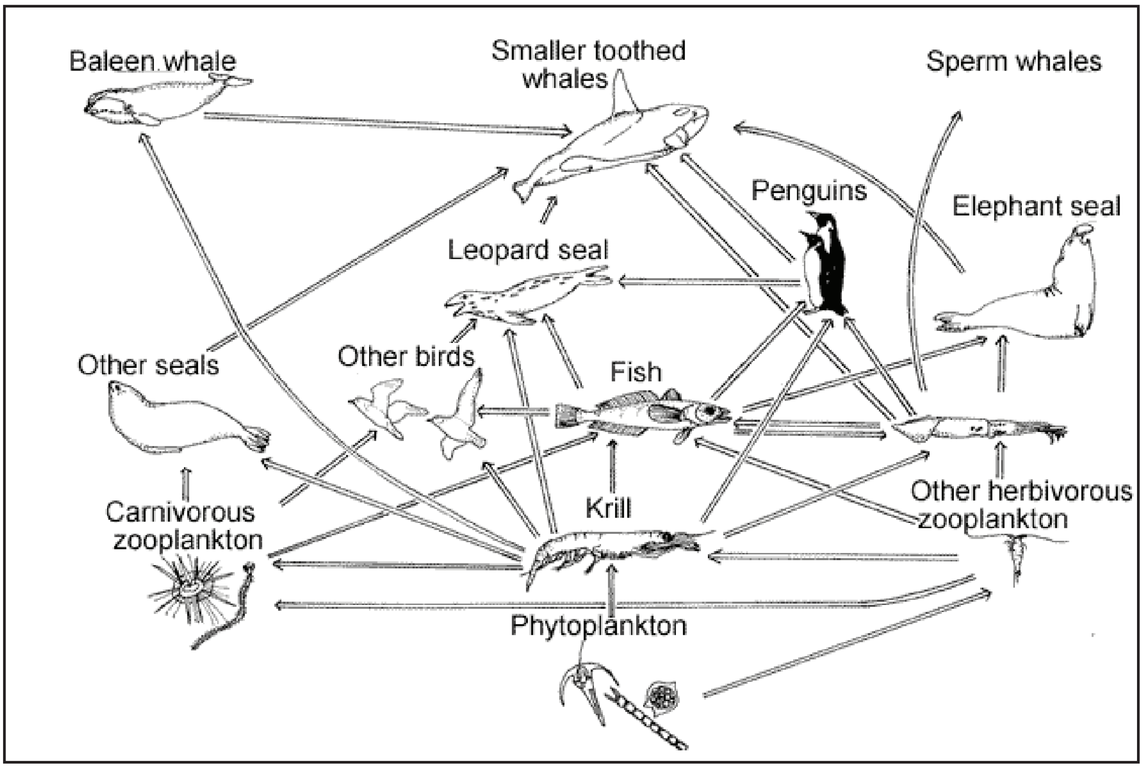
Materials

- String
- Marker pens
- Cardboard (stiff paper) or paper, cut into rectangles to make name tags

Method

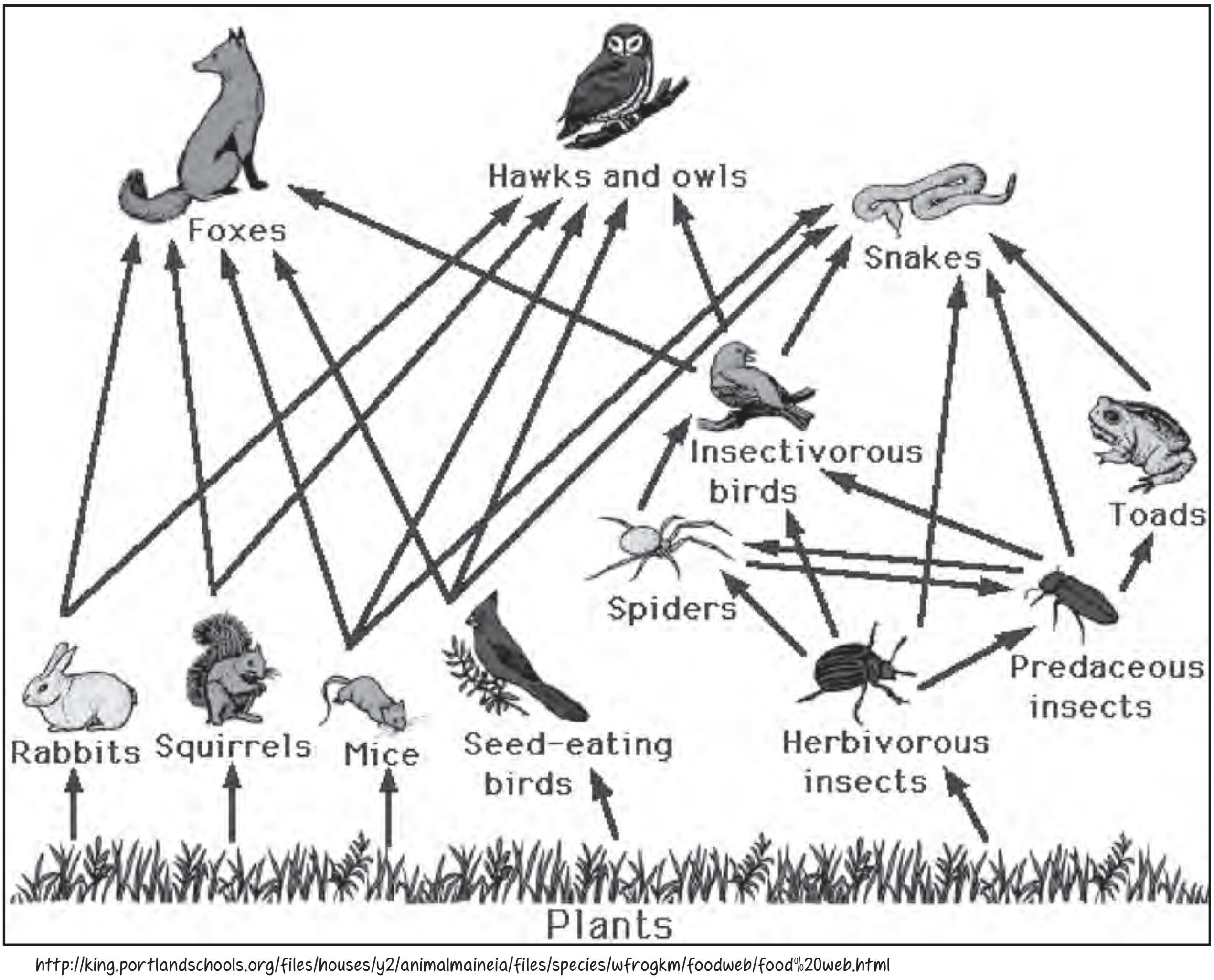
1. Choose an ecosystem that you have worked on in class, for example, a marine ecosystem, or a forest. Discuss the terminology and the trophic level pyramid above.
2. Assign each student a level: Producer, 1st order consumer (herbivore), 2nd order consumer (carnivore or omnivore), 3rd order consumer (carnivore or omnivore), decomposer (detritivores).
3. Have the students decide on an organism in the food web that fits in to the level you have assigned them. For example, the 'producers' must all be plants, but they could be different types of plants that become food for different types of animals. Each student writes his/her organism on the card and hangs it around their neck.
4. Now use the string to connect each part of the food web to the part that eats it. Some people should only be connected to one or two others, but some people might be connected to lots of other people. It should look messy and complicated!
5. Lead a discussion about what would happen if one of the organisms disappeared. Would the predators change to other foods? What would then happen to their alternative foods? What would happen if there were no alternative foods? How do humans influence this ecosystem? What role does the Sun have and where would the Sun fit in? The teacher could be the Sun and join on to the right place in the food web (feeding the green plants and algae).

Southern Ocean Food Web



http://www.coolantarctica.com/Antarctica%20fact%20file/wildlife/whales/food%20web.htm

Forest Food Web



http://king.portlandschools.org/files/houses/y2/animalmaineia/files/species/wfrogkm/foodweb/food%20web.html

Glossary

Accurate, Accuracy – တိကျသော၊ သေချာသော, တိကျမှုသေချာမ – Accuracy is a measure of how close a measured quantity is to its *actual* value. Precision is a measure of the reproducibility of results, or how close repeated measurements of the same quantity are to each other.

Adaptation – မွေးစားခြင်း၊ ပတ်ဝန်းကျင်နှင့်လိုက်လျောညီထွေရှိလာအောင် ပြုမူနေထိုင်ခြင်း ရှင်သန်ရန်နှင့်မျိုးပွါးရန်အတွက် အဆင်ပြေ လိုက်လျောစေသော လက္ခဏာ – An adaptation is a trait (feature) of the body or behaviour of an organism that allows the organism to be better suited to its environment.

Aggregate – စုစုပေါင်း၊ စုစုပေါင်း ပမာဏ (adj – စုပေါင်းထားသော) – To aggregate items is to group them together. An aggregate can also be a joined group of separate parts.

Attribute – ရလဒ်ကိုအကြောင်းအရင်းနှင့်ဆက်စပ်ပြသည်။ လူတစ်ဦး(တစ်ဖွဲ့တစ်ခု)ရဲ့အရည်အသွေးကို ဆုံးဖြတ်သည်။ – သက်ဆိုင်သည်။ အကြောင်းရင်းအဖြစ် မှတ်ယူဖေါ်ပြသည်။ – An attribute is a feature or trait. It can be physical (appearance) or related to a process.

Collate – အစီအစဉ်အတိုင်းစီသည်။ နှိုင်းယှဉ်သည်။ စနစ်တကျ စုစည်းစီစဉ်သည်။ – To collate a group of results is to collect and combine them in order to compare or analyse them.

Compressing, Compression – စုပေါင်း၍ ဖိညှစ်သည်။ ဖိနှိပ်၍ လိုအပ်သော ပုံစံဖြစ်ရန် ပုံသွင်းယူသည်။ – The process or result of becoming smaller or pressed together. In lateral waves, compressions are parts of the waves where the molecules are squeezed together and have higher density.

Concave – ခွက်ဝင်နေသော ပစ္စည်း၊ မျက်နှာပြင်။ e.g. Concave mirror – မှန်ဘီလူးခွက် – Curved like the inner surface of a sphere or bowl. Something can be more concave than something else if it is more tightly curved (i.e. a smaller sphere). The inside of a satellite dish is concave.

Concentration – အာရုံစူးစိုက်ခြင်း၊ ပြင်းအား၊ အရာဝတ္ထုတစ်ခု၏ အလေးချိန်။ – The amount of a solute dissolved in a solvent. For example, if sugar is my solute and water is my solvent, if I disolve 1 kg of sugar in 2 L of water, I have a concentration of 0.5 kg/L. Dissolving more sugar gives a higher concentration (more concentrated) and adding more water "dilutes" the solution.

Conducted – from *conduction* – အပူဖြတ်ကူးခြင်း(အရာဝတ္ထုများမရွေ့) ထိတွေ့ဆက်ဆံသည်၊ ဆက်သွယ်ပေးထားသည်။ e.g. conductor – အပူ(သို့) လျှပ်စစ်ဖြတ်ကူးနိုင်ရန် အတွက် ဆက်သွယ်ပေးထားသည့် ပစ္စည်း။ – Conduction is the transfer of heat from a warm place to a cool place. It occurs *through* matter, but doesn't require movement of the matter, unlike in "convection" which requires the particles of matter to move to transfer the heat (and therefore can only happen in a liquid or a gas).

Convex – ခုံးနေသော ပစ္စည်း၊ မျက်နှာပြင်။ e.g. Convex mirror – မှန်ဘီလူးခွက်။ – Curved surface like the outside of a sphere or bowl. The back of a spoon is convex.

Detergent – အစွန်းချွတ်ဆေး၊ အညစ်အကြေးများဖယ်ထုတ်ရာတွင် ရေဖြင့် ရော၍ သုံးရသော ဓါတုဗေဒ ဆေးတစ်မျိုး။ A type of chemical that is used for cleaning. A molecule chain of detergent has one end that attracts water and one end that attracts fats and oils. This allows the fats and oils to mix with the water so they can be rinsed away.

Diminished – ပိုမိုသေးငယ် လျော့ပါးသွားသည်။ – To be made smaller, but to retain the same basic shape.

Displaced – ဖယ်ထုတ်သည်။ နေရာမှ ဖယ်ရှားခြင်းခံရသည်။ ဖယ်ထုတ်ခံရသည်။ အစားဝင်နေရာယူခြင်းခံရသည်။ – To be moved out of the way by something else.

Elastic – ဆန့်နိုင်ကျုံ့နိုင်သော။ ရှုံ့နိုင်သော။ – A property of matter that allows a substance to regain its shape. E.g. when you stretch a rubber band and then release it, it will return to its original shape, so it is elastic.

Estimate – အကျိုးရလဒ်(သို့) ကုန်ကျစားရိတ်ကို ခန့်မှန်းတွက်ချက်သည်။ – A prediction about a result. It is sometimes called an 'educated guess', but an estimate can also be very accurate if you know a lot about what you are expecting in the results.

Expand – ပြန့်ကားလာခြင်း၊ ကျယ်လာခြင်း – The process of growing bigger, but retaining the same shape.

Extinguish – ဖယ်ထုတ်သည်။ မီးငြိမ်းသည်။ မီးငြိမ်းသည်။ အဆုံးသတ်စေသည်။ – To put out a flame.

Gradient – ဆင်ခြေလျှော၊ လျှောစောက် – The slope between two points, measured as rise/run. In maths, if you think about two points on an x/y graph, the gradient is the (change in y)/(change in x).

Habitat **–** တရိစ္ဆာန်များမှီတင်းနေထိုင်ရာနေရာ။ သဘာဝဇာတိ ရပ်မြေ – The environment in which an organism lives.

Immersed – မြုပ်ရုံလေးနှစ်သည်။ – Completely dipped or submerged in liquid.

Infinite – တိုင်းတာ၍မရသော(မရလောက်အောင်ကြီးမားသော) အကန့်အသတ်မရှိသော၊ အဆုံးမရှိသော။ – Something that is infinite has no end, or no maximum size.

Insulation – အပူနှင့် လျှပ်စစ်ကို ကာကွယ်ပေးခြင်း။ Insulator – အပူ၊လျှပ်ကာပစ္စည်း – Protection against heat or electricity. A substance that is an insulator is a bad conductor of heat or electricity.

Inverted – ဇောက်ထိုး ပြောင်းပြန်ဖြစ်စေသည်။ ဆက်သွယ်မှုကို ပြောင်းပြန်ဖြစ်စေသည်။ – Upside down or reversed.

Laterally **–** ဘေးတိုက်ဖြစ်သော။ – relating to the side of something. In the context of something being laterally inverted it means being flipped along the lateral plane (as opposed to the vertical plane).

Magnified – ပုံကြီးချဲ့သည်။ ပြင်းထန်စေသည်။ – When something appears larger than it actually is.

Mass – အစိုင်အခဲ၊ အတုံးအခဲ၊ အစုအပေါင်း – A property of matter that is measured in kilograms. In everyday English, we often refer to mass as ‘weight’, but it is more accurate to think about mass using the equation F=ma (see 6.2). The higher an object’s mass (the heavier it is) the more inertia it will have.

Mass Balance **–** ချိန်ခွင်၊ အရာဝတ္ထုများ၏ ဒြပ်ထုပမာဏကို ချိန်တွယ်သော ပစ္စည်း။ – Instrument for measuring mass that works by balancing two plates hanging from a central support. To operate the balance, you put a known mass on one side and slowly add the unknown mass to the other pan until the support is horizontal between the pans.

Odourless **–** အနံ့မရှိသော။ – Does not have a smell (odour).

Organic – သက်ရှိများ၏ ကိုယ်အင်္ဂါနှင့်သက်ဆိုင်သော၊ စနစ်အကျဖြစ်စေသော။ – A carbon-based substance, i.e. any material derived from a living organism.

Permeable **–** စိမ့်ဝင်၊ စိမ့်ထွက်နိုင်သော ပမာဏ။ – A substance that can be penetrated (permeated) – it has holes that allow some gases or liquids to pass through. Something impermeable would not allow any gases or liquids to pass through.

Pipette **–** ဓာတ်ခွဲခန်းသုံးဖန်ပြွန် – a plastic or glass tube that can suck in and hold a liquid. It is often possible to measure an exact amount of liquid with the pipette.

Plane – ဘာမှမရှိသောနေရာ။ ဘာမှမရှိသော။ – A plane is a flat, two-dimensional space. Think about the horizontal plane and the vertical plane of your body – they are imaginary surfaces that would be perpendicular to each other. When you are standing up, the horizontal plane would be parallel with the ground, and the vertical plane would be parallel with your spine and perpendicular to the ground.

Preserved – မူလ အနေအထားအတိုင်းရှိနေစေရန် ထိမ်းသိမ်းထားသည်။ – to maintain in a perfect or unaltered condition; to save for later.

Rarefactions – အလင်းပြန်ခြင်း – The parts of a wave where the molecules are spaced far apart – they are the opposite points in the wave to the compressions.

Saturated – ပြည့်ဝပျော်ရည် – A solution that is at its maximum capacity for a solute. For example, a solution of salt and water is saturated when no more salt will dissolve in the water.

SI unit – နိုင်ငံတကာသုံးအတိုင်းအတာများ နိုင်ငံတကာသုံး အတိုင်းအတာယူနစ် – The International System of Units (abbreviated SI from the French *Système international d’unités*). This system provides international standards for 7 units of measurement: Metres (m) for Length, Kilograms (Kg) for Mass, Seconds (s) for time, Amperes (A) for electrical current, Kelvin (K) for temperature, Candela (cd) for luminous intensity and Moles (mol) for amount of a substance.

Stimuli – လှုံ့ဆော်သည်။ နှိုးဆွပေးသည်။ – A stimulus (plural *stimuli*) is something that causes a response. For example, touching something hot is a stimulus that triggers you to move your hand away.

Superimposed – အပေါ်မှာထပ်ပေါင်းသည်။ အရာဝတ္ထု တစ်ခုခုကို အပေါ်မှ ထပ်မံ ဖုံးအုပ်ထားသည်။ – When something is placed or lain over the top of something else.

Swell **–** ပွလာသည်။ ပွတက်လာသည – Grow larger.

***Taper* –** တစ်ဖက်သို့ချွန်သွားသည်။ n – မီးတောက်ကူးရန် ဖယောင်းလူးထားသည့်မီးစာ၊ သွယ်ပြောင်းရှည်လျှားသည့် ဖယောင်းတိုင်။ v – အစွန်းတဖက်သို့ အဖျားရှူးသွားသည်။ – A piece of wood or paper (or traditionally, a candle wick) that is used to move fire from one place to another, for example, to light one candle with another.

***Tripod* –** ခြေသုံးချောင်းထောက်စင် (သို့)ခြေသုံးချောင်းထောက် စားပွဲ – A frame with three feet that supports the weight of another object.

***Thermometer* –** အပူချိန်တိုင်းကိရိယာ **–** An instrument for measuring temperature, usually made out of glass with a bulb containing alcohol or mercury which expands a known amount when heated.

***Valid* –** တိကျမှန်ကန်သော။ ခိုင်မာသော။ အကာအကွယ်ပြုနိုင်သော။ ဥပဒေအရလက်ခံနိုင်သော။ သက်တမ်းမကုန်ဆုံးသေးသော။ **–** When an idea or result is logical and follows from the evidence.

Velocity – အလျင် **–** A measurement of the speed of an object and its direction of motion. Velocity is measured in metres per second squared ($m.s^{-2}$).

Weight – ကမ္ဘာမြေကြီးဆွဲအား။ အလေးချိန် – Mass times gravity, measured in newtons. An object with a mass of 1 kg will have a weight of 9.8 N on Earth, but a lower weight on Mars where gravity is weaker.

Materials List

General Materials Needed for all Sections

- Candles
- Paper and/or cardboard (white and/or coloured)
- Paper clips
- Pens
- Plastic bags
- Plastic bottles
- Clear plastic cups
- Scissors
- String
- Tape and/or glue
- Water

General Science

- Aluminium cans
- Cooking plates/dishes
- Ice blocks (or large ice cubes)
- Lighter
- Rulers or other centimetre measuring device
- Thin pieces of bamboo
- Coloured pencils (optional)
- Graph paper (optional)
- Thermometer (optional)
- Stopwatch (optional)

Physics

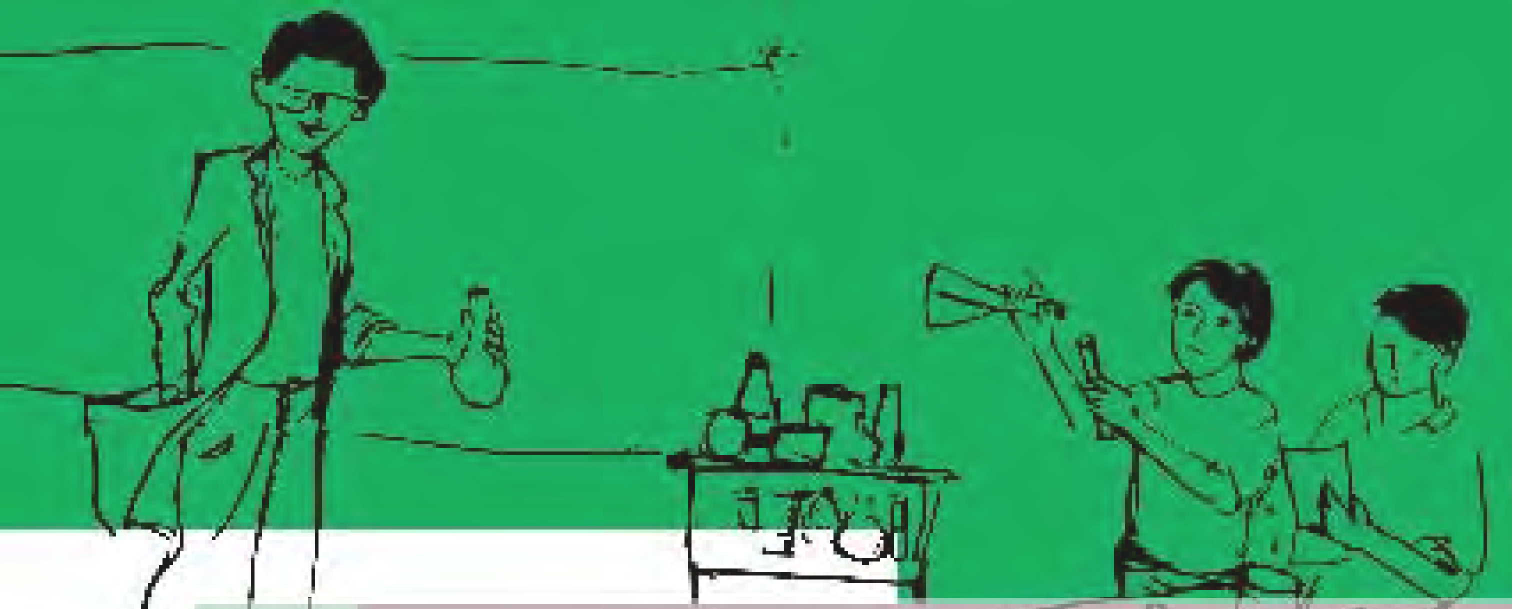
- 200 mL measuring cups or bottles
- Aluminium foil
- Balloons
- Battery packs
- Beam in ceiling or a hook on a door frame
- Black paint or fabric
- Blocks of wood or flat stones
- Cardboard boxes of different sizes
- Cardboard inserts from toilet rolls
- Cardboard or plastic tray with raised edges
- Clothes pegs
- Coke can burner (can be made in 2.2)
- Concrete wall at least 2 metres high
- Conducting/Insulating dough (tap water, bottled water, flour, salt, vinegar, vegetable oil, sugar)
- Copper fuse wire or any insulated electric wire
- Drinking straws
- Eggs
- Empty aluminium cans
- Flashlight with batteries
- Food dye powder (optional)
- Heavy glasses or bowls exactly the same size
- Knife or skewer
- Large basin
- LED lights
- Marbles (of different sizes)
- Matches or lighter
- Metal cooking pot
- Paper towel or napkin
- Pen lid
- Pieces of bamboo
- Ping pong balls
- Plane mirror
- Plasticine or ‘sticky tak’ or ‘blue tak’
- Rubber bands
- Rulers or other centimetre measuring device
- Screwdriver
- Stones
- Sweets or cooked rice
- Wooden desk
- Stopwatch (optional)
- Thick clear plastic (optional)

Chemistry

- 200 small edible food items (peanuts, popcorn)
- 900 yellow beans
- Alcohol
- Baking soda
- Balloons
- Different kinds of markers
- Different liquids and solutions (e.g. soap, vinegar, lime juice, saliva, toothpaste, shampoo, etc)
- Dishwashing detergent
- Large flat bowls or disposable containers
- Large Jar
- Lighter or matches
- Liquid food colouring
- Metal can burner
- Milk
- Permanant markers
- Red cabbage
- Sultanas or raisins
- Teaspoon
- Twisted paper, bamboo skewer or thin piece of timber
- Vinegar

Biology

- 'Bird beaks' (see page 69)
- 'Bird food' (see page 69)
- 'Bird habitats' (see page 69)
- Cardboard boxes
- Coffee filter or piece of scrap fabric
- Cold methylated spirits
- Dish-washing liquid
- Drinking straws
- Eggs
- Insect or spider in a jar
- Iodine solution
- Knife and chopping board
- Magnifying glasses
- Mass balance (can be made in 2.1)
- Mortar and pestle
- Newspaper
- Onions
- Paper towels or cotton wool
- Photocopies of diagrams of human skeleton and digestive system from handbook
- Pictures of bird beaks (see page 69)
- Pieces of rice, banana, bread, cake, biscuit, orange peel, paper, sugar, plastic, wood and anything else
- Plant seeds of peas or beans
- Plastic funnel or sieve
- Salt
- Vinegar
- Soil (optional)
- Sugar syrup (optional)
- Stapler (optional)



Activities for the Science Classroom contains over 50 activities and experiments to help science teachers bring their classes to life. The four sections of the book - **General Science**, **Physics**, **Chemistry** and **Biology -** give ideas for demonstrations, experiments and other activities, which teachers can use to help students understand key scientific concepts.

All the activities were selected with busy teachers in mind: they require few resources and the instructions are simple.

Activities for the Science Classroom also includes:

- a full glossary of scientific terms, with Myanmar translations
- a materials list for each section, to help teachers prepare their experiments

Activities for the Science Classroom and many other resources can be downloaded free of charge from our websites:

curriculumproject.org educasia.org

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