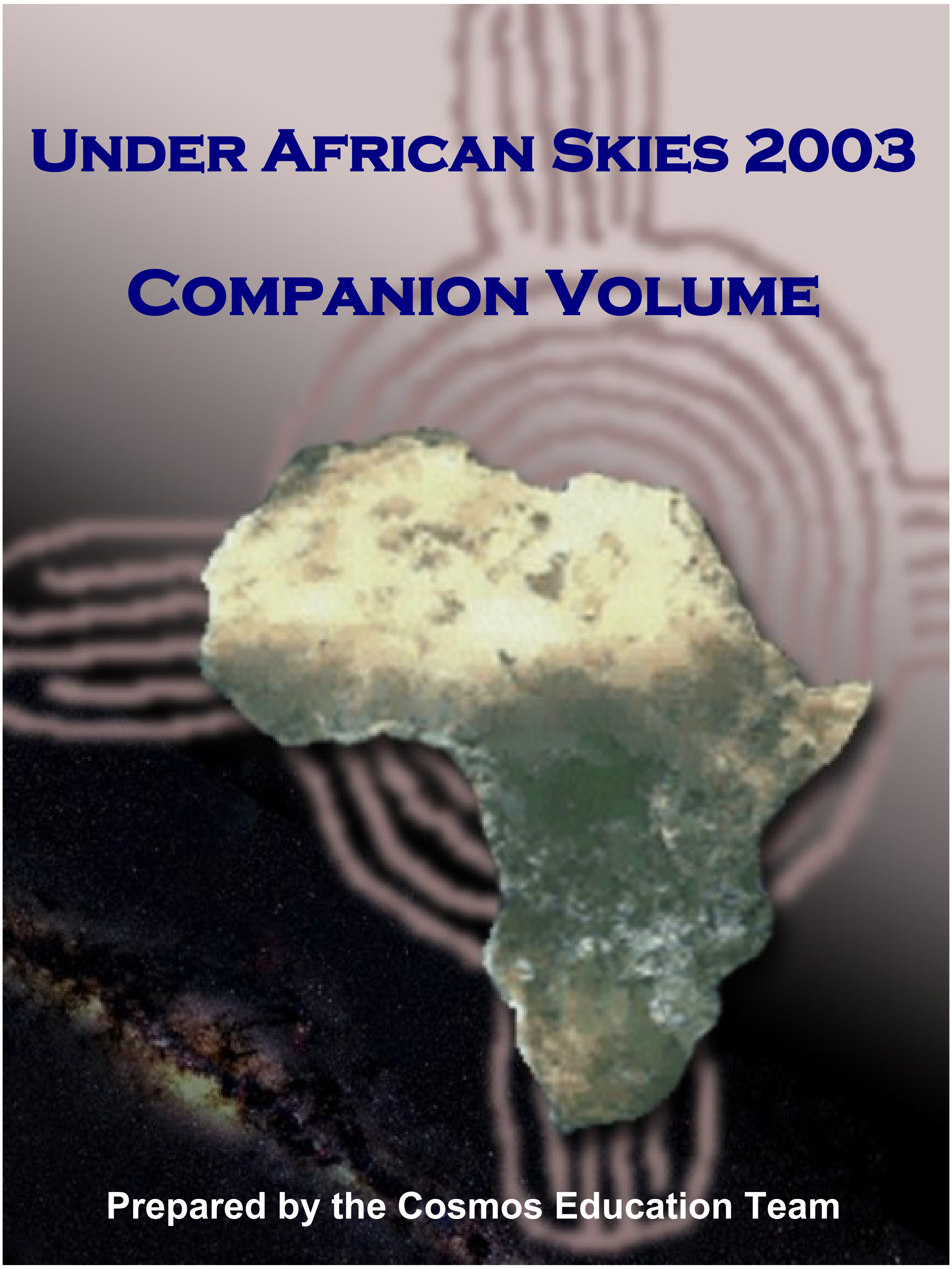

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Introduction

Cosmos Education is an international charitable organisation dedicated to science and technology education in developing countries around the world. Our work consists of two components: working directly in schools to help students and teachers in the classroom, and delivering educational resources, books, and materials to the schools in our education network. Along with teaching about science and technology, the Cosmos Education team addresses the issues of sustainable development, appropriate technologies, the environment, and health. We focus on interactive, hands-on activities.

Our organization is run and managed by an international team of dedicated graduate students, scientists, and educators. Our headquarters are in Stanford, California, USA, and we have representatives in over one dozen different countries.

It has been our great pleasure to present at an enormous variety of schools, and also a challenge to tailor our material to most adequately suit the needs of the students and teachers to whom we present. One set presentation cannot possibly be appropriate to all audiences, as the circumstances vary so widely; on a few occasions we have had almost an equal number of volunteers as students, on other occasions we have had three volunteers in front of several hundred students!

For this reason, we present here a collection of fun demonstrations, from which units for the subjects covered can be constructed. The demonstrations have in many cases been developed either from scratch or from existing experiments by Cosmos Education volunteers, and been adapted to suit the purposes of our venture. In some cases we also provide information for introductory discussion with the students.

We hope you find this volume useful and enjoyable!

Will Clarkson
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Why Bother with Science?

We realise that not all in our audiences will become leading scientists, doctors, or engineers in their careers, but some might! Everyone employed in science today can trace their interest back to one or a few events that really got them excited about learning and pondering the mysteries of the Universe. By exciting our audiences with science, we hope we can inspire students to continue with their studies and to think seriously about becoming the future scientists, doctors, engineers and teachers of their community.

But this is only partially why we do what we do. The members of Cosmos Education spend weeks on the road, giving presentations to pupils from all backgrounds and in all conditions. We do this because we believe that science education is the surest route to improving health and empowering people and cultures around the globe.

Science is important because it encourages us to keep asking questions. The heart of all science is the critical method of thinking: looking at cause and effect, creating a hypothesis, testing a theory, experimenting, and changing one's ideas and beliefs based on the results. From the results come more questions, and thus the cycle begins again. The world of science is constantly changing and growing as we make new discoveries and create new ideas. Science education is important because it provides the foundation on which young minds can view the world with a critical and inquisitive eye.

We are all familiar with questions that can be asked scientifically: for example, "is the Earth round?" However, there are many very important questions in life that require scientific thinking but that are not related to a particular scientific question. For instance: "How should I treat this wound? Can you catch AIDS just from kissing?"

Science education is vital for a future of sustainable development and a peaceful, healthy integration of people and cultures around planet Earth. The world in which we live is changing rapidly and many of those changes are being made possible through science and technology. The future generations need to be able to understand and decide what is right for them and what works for their village, their city, their country, their planet, and their cosmos.

Our chief aim is to provide a positive experience in science for our audiences. We hope they will start to realise that one doesn't have to be a professional scientist to ask scientific questions. Perhaps they will go home and start to ask questions. Maybe some of those will be questions that are not easily answered, which spark curiosity and inquiry. If this is the case, we will have done what we set out to do.

Presentation Material

"...this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known"

Carl Sagan describing the image of Earth from space,
in his book 'Pale Blue Dot'

In many cases our team is faced with far more students than we can work with in classroom settings; there have been occasions when three volunteers are faced with three hundred or more students in an assembly hall. In these cases we create an educational show. We begin with some fun attention-grabbers to engage the enthusiasm of the audience. This section is a synopsis of the material we often cover in these presentations to larger audiences.

Our Global Team

We begin by introducing ourselves. Our team consists of students and young professionals from all over the world. We believe the global nature of our team is a major strength; students see our talented, diverse, international group working and co-operating side by side as equals. We aim to be role models for the generations to come.

Figure 1: A Global Team

All members of Cosmos Education share a common enthusiasm for science and a deep conviction in the value of science education to a community. We feel that, at an individual level, the critical thinking developed through science education is vital for survival and success in the modern world. It is a vital ingredient for empowering people through cooperation. It is also vital when dealing with day-to-day questions; from buying and selling at the market to planting and irrigating crops, science and critical thinking are the keys to success. It is also fun! Science gives us the tools for exploring and learning about the beauty of the world around us. Remember: *The most important thing in science is to ask questions!*

Your Place in the Cosmos

The Cosmos is everything. From the smallest particles that make up the atoms in your body to the largest stars in the most distant regions of the Universe - the Cosmos is the connected network of everything that ever was and everything that ever will be. You are part of the Cosmos.

The Universe is so big that we have to invent a new distance scale to talk about it. We'll begin with our neighbourhood in the solar system. Hold an orange in one hand at the front of the classroom. Now, if the Solar System shrunk so the Earth was the size of this orange, how far away would the moon have to be? The answer is about 60 orange radii, or roughly three metres. Now what about the Sun? The Sun would need to be about 23,000 orange radii away, roughly one kilometre distant. The universe is clearly a very big place!

It just so happens that the moon is exactly far enough away from the Earth that, if it travels in front of the Sun from our point of view, it is big enough to completely block out the Sun. This is called a *total solar eclipse*. The first solar eclipse of the third millennium A.D. (June 21, 2001) was visible from Southern Africa, with the shadow tracking through Mozambique, Zambia, Zimbabwe and Angola. The Sun is far bigger than the Earth; if the Earth were an orange, the Sun would fill the classroom and the moon would be a small pebble.

The Earth is only one of nine planets that make up our *solar system*. In order of distance from the Sun, these planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. The nearest planet to the sun, Mercury, bakes at only 2/5 the distance from the sun as that of the Earth, while the farthest, Pluto, shivers its way through an orbit about 40 times farther out.

The orbits of the planets, to scale. On the left are the inner planets ,below are the orbits of the outer planets.

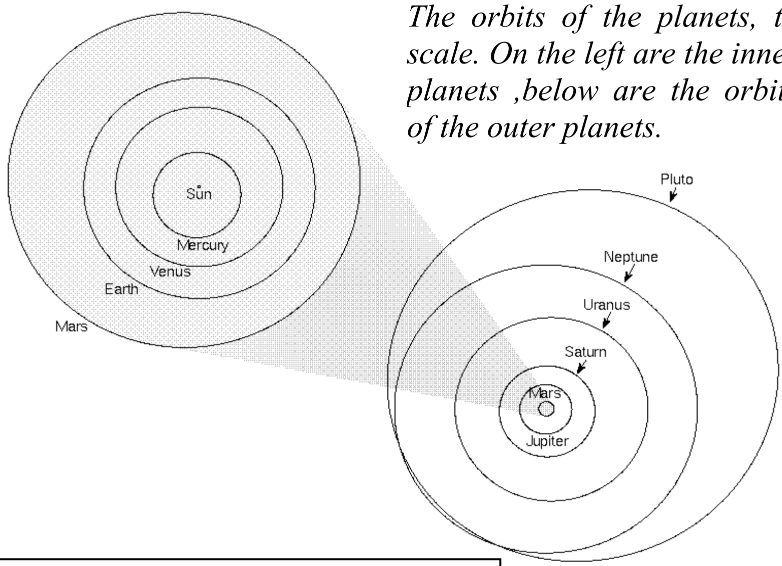


Figure 2: the Scale of the Solar System

The distance between stars is even vaster. Imagine we now scale our solar system model so that the Sun is now the orange and the Earth a tiny pebble, and we place this Sun in Nairobi. To represent the nearest star, Alpha Centauri (part of a triple star system), by another orange, you would have to place it some 50 *million* orange radii away from the Sun, or somewhere near Cape Town (~3000 km away). The distance between stars is so huge we measure it not in kilometres but in *light years.*

Think of a thunderstorm. You see the lightning strike before you hear the sound. This is because light travels much faster than sound. In fact, light is the fastest thing in the Universe; in one *second* it travels a distance equal to seven and a half times around the Earth. The nearest star is so far away that light takes 4.3 *years* to reach us. Even this distance is a tiny step into the wider Universe. There are roughly

10,000,000,000,000,000,000,000 stars in the Universe, and the Universe is roughly ten billion light years across.

Keeping the Planets Up

The moon and all small satellites travel around the Earth, but do not fall into it. The Earth and the other planets in turn go round the Sun, but do not fall into that either. In turn, the Sun goes round the centre of the Milky Way Galaxy, but has not been measured to be falling into the centre. How does this come about?

To demonstrate this, we need a small object like a mango or potato. Now we throw the mango a short distance. It traces a curved path in the sky as it falls. Now imagine throwing the mango a further distance. The path is still curved, but if you were standing in the middle you would see a straight-line path. Now imagine that you have a very strong arm and can throw the mango all the way from where you are standing to Hawaii. The path of the mango is still curved, but it almost follows the curve of the Earth. But you're not satisfied, so you throw the mango as hard as you can – and this time it falls all the way round the Earth and hits you in the back of the head! You have just made the mango *orbit.*

The path of the mango is the key; the *gravity* of the Earth pulls it downwards, but if the mango is going fast enough, by the time the mango has fallen down a bit, the surface of the Earth has curved away beneath it by the same amount. One of the most important principles in science is Newton's First Law, which says that to make something change the way it moves, you need to apply a *force* on the object. The Earth's gravity is the force that makes the Moon change direction, but it is travelling so quickly that the Earth can never pull it down to its surface. This is exactly the same mechanism that makes the Earth go round the Sun but never crash, and the Space Shuttle orbit the Earth.

We know that weight has to do with gravity's force acting on a given mass, but when people talk about the "weightlessness" experienced in space, they don't mean that there is no gravity in orbit. In fact, gravity is the single most important force in the vast distances of space. It determines the nature of the Universe on all scales larger than a few metres. The astronauts are all experiencing gravity, but the shuttle is falling round the Earth in exactly the same way they are, so they don't fall to the spacecraft floor. Imagine putting a brick on some scales in a boat on top of the Victoria Falls and then pushing the boat over the edge of the falls. As the boat falls, the reading on the scales will go to zero, as every object in the boat falls the same way.

Cycles and Life on the Earth

The law of gravity, which we have just introduced, is an example of the *laws of physics*: descriptions of the Universe that we use to tell us about the way things will behave. For example, the laws of physics can help us design and build the engine of a car or a bridge across a river. As far as we know, everything in the Universe can be described by these laws of physics.

Despite the vast size and age of the Universe, there is only one place on which we know there is life; planet Earth, our home. There are many planets and distant worlds to explore, and perhaps someday we will discover life beyond Earth, but for now Earth is our only example of a planet with life. What is it about Earth that makes it possible for life to exist and evolve?

Life needs certain basics to sustain itself: a source of energy, a mechanism to convert this energy to other forms, and an environment within which this process can take place. On Earth, almost all of the organisms we see around us depend on the Sun for energy. When you eat meat, your body releases energy that is stored chemically in the meat. The animal whose meat you are eating once ate plants, converting energy stored in starch and sugars in the plant to storage in its own body. The energy stored in the plants comes from the conversion of energy in sunlight.

Some organisms do not depend on the Sun for their source of energy. For instance, in the deepest depths of the ocean there exist life forms that use energy and chemicals from geologically active regions of the seafloor as an energy source.

The Water Cycle

While different sources of energy for life are possible, there is one general rule of living things for which no exception has yet been found: all organisms must have access to liquid water at some point during their life. The human body, for example, is roughly 70 percent water, because it is made up of cells that need water to function. If you do not get enough water you very quickly run into problems. Very little water is actually created or destroyed on the planet Earth; instead it is continually recycled in the *water cycle.*

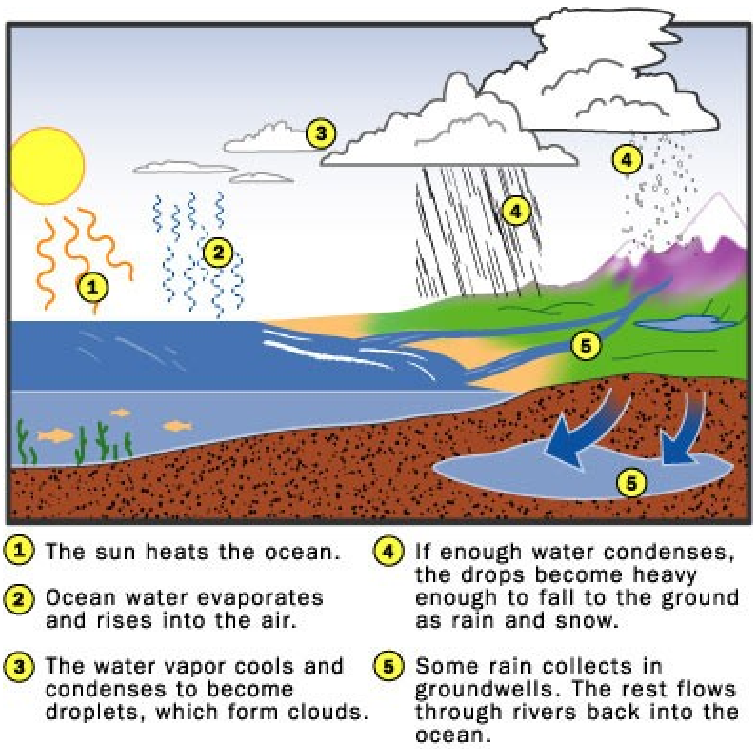


Figure 3: The Water Cycle

We'll begin with the main supply of water to the surface: the clouds. The clouds form by water *evaporating* from the surface. Most of the vapour comes from large bodies of water like the seas and oceans. Then water rains out of the clouds to reach the surface. Here several things can happen to it, depending on where it lands. If it lands on material like soil, it is absorbed into the ground. Here it can either sink further to underground rivers or be taken up in the roots of plants. If it lands on harder material, it pools into puddles and evaporates back up or, if in the right place, runs to a river and flows along the surface. All water in rivers travels downhill, slowly changing the face of the Earth by erosion as it does so. The rivers finally flow to the seas and oceans, replenishing the water lost by evaporation. Life on the surface depends completely on this continuous supply of water.

<u>The Carbon Cycle</u>

Another vital cycle is the carbon cycle. Made from carbon and oxygen, carbon dioxide is one of the gases in the atmosphere. We breathe it out as a waste gas, but it is vital to the functioning of plants on the Earth. Plants store energy from sunlight in starches and sugars. The way this energy is stored is called *photosynthesis*. A side effect of this process is the production of oxygen in the atmosphere, which animals need to breathe. The way in which plants figure into the carbon cycle is vital to animal life on the Earth.

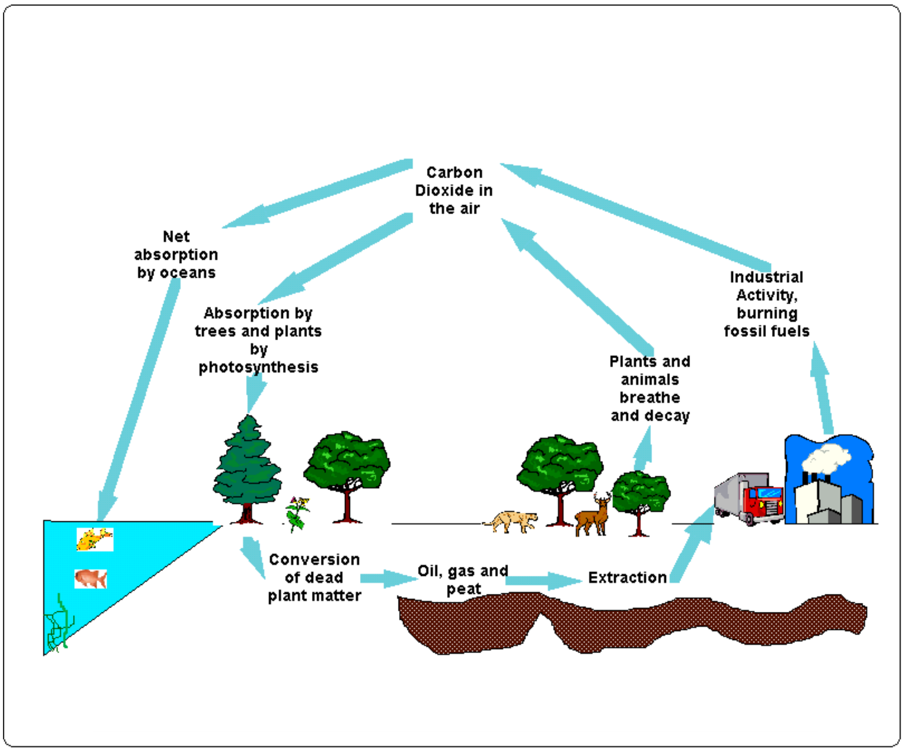


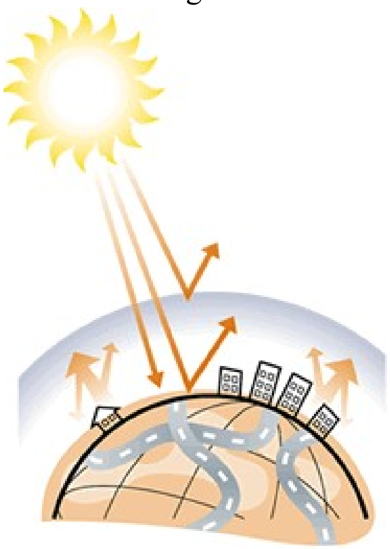
Figure 4: The Carbon Cycle

The main producers of carbon dioxide on the planet Earth are volcanoes. When molten rock beneath the Earth's surface pours onto the surface, huge quantities of carbon dioxide are produced. Another major producer of carbon dioxide is breathing animals, which inhale oxygen and exhale carbon dioxide. If this carbon dioxide were allowed to build up too much, this animal life would die.

There are two main processes that destroy carbon dioxide. Water can absorb the carbon dioxide to form a mild acid (acid rain), and plant life uses the carbon dioxide and gives out oxygen as a side effect. The balance between the creation and destruction of carbon dioxide preserves the cycle, and life continues.

The Greenhouse Effect

The exploration of the solar system has taught us that we are very lucky to have an atmosphere with the right balance of gases in it. The atmosphere does more than provide chemicals that allow us to breathe; it also regulates the temperature of the planet Earth. This is the *greenhouse effect*; the atmosphere traps in some heat received from the Sun, allowing the surface to be hot enough for water to exist as a liquid without freezing.



Human activity causes the atmosphere to trap more heat than otherwise, raising the temperature of the surface.

Figure 5: Enhanced Greenhouse Effect

This greenhouse effect is in a state of delicate balance. Too much of the wrong kind of materials in the atmosphere can lead to it trapping in too much heat. Imagine wearing clothes in which you are comfortable in the direct sunlight. Now imagine putting on another three layers of clothing. You would quickly get too hot because the clothes trap too much heat.

We have an example of a planet for which the atmosphere naturally became too good at trapping heat – the planet Venus – which has a surface temperature hot enough to melt lead. Venus is thought to be the victim of a "runaway greenhouse effect," and serves as warning to us here on Earth not to upset the balance.

On Earth, we do not expect a runaway effect like that on Venus, at least not immediately. But evidence is growing that we are starting to tip the balance. Carbon dioxide, carbon monoxide, and methane are all greenhouse gases that make the atmosphere better at trapping heat. They are also belched out in enormous quantities as a side effect of our current technology.

So why is an accelerated greenhouse effect so bad? There are many consequences, but let us consider the oceans for a moment. If the temperature of the Earth's atmosphere rises by even a couple of degrees centigrade, as most climate scientists believe will soon occur, then the surface of the Earth will have to absorb more energy. Oceans cover approximately 3/4 of the Earth's surface and thus the water of the oceans would absorb much of the excess heat. When water absorbs heat it expands. Try leaving a plastic bottle of cold water out in direct sunlight. Come back in a few hours and feel the pressure in the bottle. The water has absorbed energy and expanded, increasing the pressure inside the bottle. If the water in the oceans absorbs energy and expands, the sea level will rise. Rising sea levels pose a serious threat, since a large proportion of the Earth's population lives in coastal regions.

In addition to the heating and expansion of the oceans, one source of water we have not yet mentioned is the ice caps and glaciers, in which billions of tonnes of water are locked away from the oceans. The West Antarctic Ice Sheet, for example, holds 3 million cubic kilometres of fresh water. According to some estimates, if it were to melt the sea level would rise 6 meters and thus coastal cities would be threatened. This doesn't sound like much, but the flooding will place some five percent of the Earth's surface under water, leaving millions homeless. More importantly, the parts of the Earth on which crops can be grown will change, destroying millions of livelihoods and leading to starvation.

War as the Enemy

The Solar System also provides us with another warning, at the other end of the spectrum in temperature. Astronomers have long known that fierce dust storms occur now and then on Mars that prevent us from seeing the surface for weeks or months. In the 1970's one of these dust storms erupted while the Viking spacecraft were active; two on the surface, two in orbit. The temperature at the surface dropped dramatically during the dust storm because the dust blocked the heat from the sun. This shows us dramatically that if too much dust is pumped into the atmosphere, catastrophic cooling can occur.

So how might enough dust be kicked up on Earth to block out the Sun? Dust usually settles out of the atmosphere fairly quickly, in geological terms. Falling at about 1 millimetre per thousand years, this dust eventually builds into sedimentary rocks, which preserve the hard parts of animals as fossils. But this process is extremely gradual; dinosaur fossils, for example, are found under rock that corresponds to at least 65 million years of dust settling and other contributing processes. Something catastrophic has to occur, which for all of history until the last fifty or so years, meant either asteroid impact or volcanoes. Now there is a new threat: nuclear war. The combined arsenals of the nuclear powers currently in existence (USA, Britain, France, China, Russia, India, Pakistan, Israel and possibly North Korea) are easily sufficient to create nuclear winter severe enough to cause agriculture to break down, leading to mass starvation. For the first time, humans are capable of bringing about their extermination without natural causes. Our survival depends on living together. War itself has become the enemy.

Surviving in Space

Imagine you are about to go on a mission to Alpha Centauri, the nearest star. You are a member of the first humans to venture outside the solar system, and you must plan your journey. What sort of challenges will you face?

Remember that light takes 4.3 years to reach us from Alpha Centauri, and nothing can travel faster than light, including your spacecraft. This means you need to survive for at least 4.3 years on the spacecraft. You might swing by a couple of the planets in the Solar System to adjust course or accelerate, but for 99.999 percent of the journey you will encounter nothing outside the spacecraft except for a few atoms of hydrogen.

Humans are very delicate beings to support. This makes it much harder to send people into space than crewless spacecraft – which is why we have so far made only very small steps into space, no farther than the Moon. Humans have many requirements. We need fresh, breathable air, clean water that will not give us disease, a way to get rid of our wastes, and food to eat. None of this can be found on the way from Earth to Alpha Centauri. Everything you eat must be stored or made on the spacecraft. Everything you excrete must be disposed of. Packing enough food and waste storage would take up enormous space and mass, which would make your spacecraft too expensive to launch.

Figure 6: Some things an astronaut takes in and gives out

Try to think of some ways in which you could make your spacecraft as efficient as possible, with as little waste as possible. What about the air? Should you install one enormous tank with oxygen to breathe and another to store the carbon dioxide your crew breathes out? Or is this too wasteful? There must be a better solution. You might want to set up your own water cycle, in which the water used is cleaned and made drinkable again. You might want to use plants to convert the carbon dioxide you breathe out back into oxygen, also providing food as a side effect. Your crew of astronauts may well include a farmer, to keep the crew fed and alive.

<u>Spaceship Earth</u>

In fact we are already astronauts, all 6 billion of us, and we travel about a billion kilometres around the sun each year. The Earth itself is a giant spaceship. Evolution has solved all the problems of recycling the materials we need, and except for a little dust, some radiated heat and our television signals, ejects no waste into space.

Figure 7: Spaceship Earth

We are all bound together in the same system. Whatever happens to some of us affects all of us. It is for this reason that we as a species need to look after our planet in a more effective way than we have been doing in the past. The last two hundred years have seen industrial revolutions that produced many damaging effects: pollution from factories, pollution from millions of automobiles and trucks, plastics and garbage that does not easily decompose…the list goes on. These are just a few of the ways in which we have altered the system of cycles that was once in perfect balance.

The Future – Sustainable Development

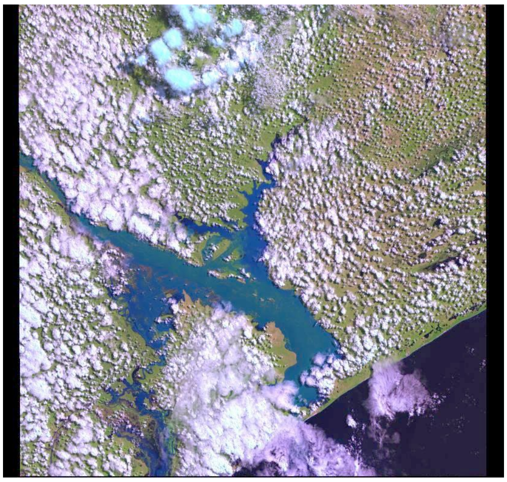
Luckily, there is hope. As the new millennium begins, we are beginning to see new technologies being developed that are cleaner, more efficient, and safer for humanity and the environment. Materials such as paper, plastics, rubber, and metals are suitable for recycling and reusing. New ways of harnessing energy are becoming possible. Instead of burning oil, we can use solar power or wind power. Instead of driving a vehicle that runs on diesel or regular petrol we are starting to see cars that run on electricity and thus release no harmful gases to the atmosphere. In addition, we are starting to see more inventions directed toward conserving energy. For instance, some of the light bulbs being produced today last much longer and use much less energy than the light bulbs produced just ten years ago.

Energy is the big problem of our age. Everyone seems to want more devices, which of course require some form of energy; from cars and buses to televisions and computers, we are all using much more energy than any previous generation on Earth. This demand for energy is driving us out of balance with the Earth and forcing the cycles of life to be pushed out of balance. The solution to this problem has two parts: 1) We must learn to live in a way that minimizes our individual energy demands and 2) We must work hard to create new and better ways for meeting the energy needs of the future generations.

Humanity is young and while our first inventions and technologies were dirty and inefficient, there is hope that the future generations of scientists and engineers will be able to develop ideas that are safe for us and better for the environment. Young students of today hold the future of our planet in their hands. You are a critical part of the solution.

Portraits of our World

Natural Dramas



Flood in Mozambique The picture on the left shows a lake at its normal water level. The picture on the right shows the lake at a time of flood; it has swelled to many times its original size. Both pictures are to the same scale, and the white dots are clouds seen from above.

Storm Chain, just Southeast of Bermuda in the Atlantic Ocean
When storm fronts march across the ocean, the replacement of warm, moist air by cool, dry air leads to massive chains of thunderstorms like these. These storms can be huge, reaching heights of some eight miles. These storms will blow out before reaching land, but will make life very difficult for anyone on the sea in their path.

Sakura-jima Volcano,Kyushu, Japan
The white streak in this picture is not a strip of cloud. It is a plume of ash thrown up by this volcano, which makes up the island in the center of the photo. Just to the left of the volcano is a blue-grey region covering about the same area in the picture. This area is the port city of Kyushu.

<u>Water of Life</u>

Valley of the Kings, Southern Egypt
If you are familiar with the Bible, you will have read about the area in this picture. The narrow blue ribbon is the river A wide band of fertile area surrounds it. All life on the surface of the Earth needs liquid water to thrive. No water, no life. This is shown dramatically in this picture. Move more than ten miles away from the river and the landscape turns to desert.

Great Barrier Reef, Queensland, Australia
The light areas in the middle of this picture are coral reefs. Coral reefs are enormous complexes of undersea life forms that form a central part of an undersea ecosystem. The reefs in this picture are about thirteen miles from the Australian coast, which makes these reefs about ten to twenty miles in length.

Guadalupe Island, Mexico
Guadalupe Island is a volcanic island that is now a wildlife preservation area. This picture shows the effect the volcano has on the clouds. As clouds hit the island from top left, they rain out onto the island, creating a lush and fertile climate.

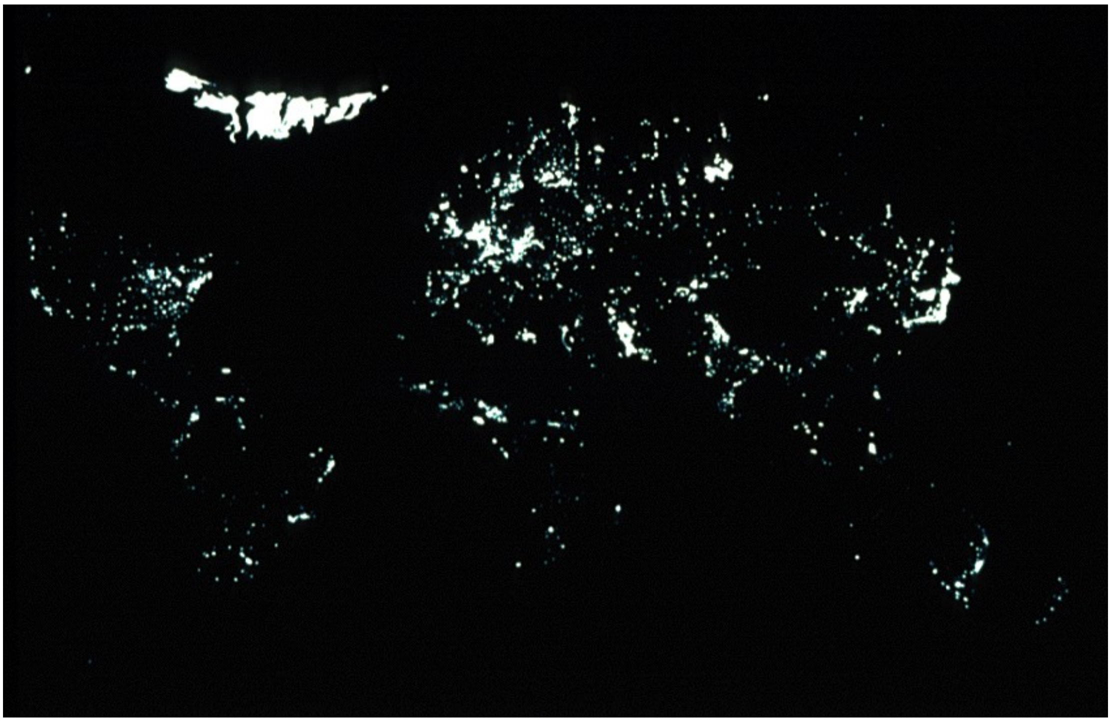
Mountains and Craters

Mount Kilimanjaro, Tanzania:
At 5985 metres in height, this is the tallest and most famous mountain in Africa. There are actually three peaks in the centre of this mountain, but lava flows from the central volcano (now extinct) have filled the gaps between the peaks, making them hard to pick out. The white features in this picture are clouds, *below* the top of the mountain.

Ngorongoro Crater, Tanzania:
In the centre of this image is Oldeani Volcano. The volcano is thought to have collapsed, leaving the round feature in the top right of this image. This is the Ngorongoro crater, a fertile valley ringed by steep walls. These walls make it hard to get to the crater floor, making it a natural refuge for wildlife. Ngorongoro is part of the Great Rift Valley, thought to have been the cradle of humankind.

Signs of Humanity

Imagine you are an interstellar explorer. Your job is to seek out new life and new civilizations. You have detected the stray radio and TV signals leaked out from an otherwise uninteresting planet, and have decided to investigate. What sort of signs would you look for to indicate the presence of a global civilization?



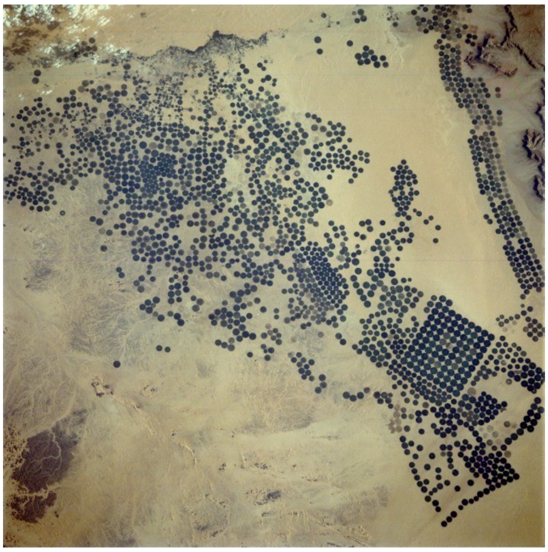
The Earth by Night: At night, the Earth glitters with signs of a civilization. Our towns and cities light up the Earth. Can you find your home? Africa is in the bottom middle of this picture, the Americas are to the left and Australia is on the bottom right. The bright feature on the top left is the Aurora, light given off by charged particles from the Sun as they hit the Earth's magnetic field. Only half the Earth is in night at any time, so this image was made from several different images.

Our Technology

This photo shows at least three hints that something interesting lives here. The land is divided into patterns, which suggests farming technology. In the bottom left, we can see a town and roads, suggesting at least the level of technology for mass transport. Finally, from bottom right to middle left, there is the vapour trail left by a jet airliner. Its shadow is seen in the top of the picture.

El Paso, Texas, USA
This picture shows the features of a major city, laid out beneath the mountains to the left. Major roads run through the centre of the picture. At the base of the mountains is the square-grid pattern of streets with houses. In this false colour image, vegetation looks red-brown, like the sports area in the centre of the top half of this picture. On the right side of the picture are factories and office buildings.

Irrigated Agriculture, Saudi Arabia
The land in this picture is naturally too hot and dry for crops to grow. The inhabitants found a way to grow crops anyway, by irrigation. The circles in this picture are fields that are kept fertile by having water dripped on them from artificial wells. Sprinklers rotate about the well, supplying much needed water to the crops. In this way, the land is made to support a much larger population than it otherwise could.



Irrigation and a Town
More irrigated fields are visible in close-up here. (Note that not all irrigated fields have to be circular). In the fields, parallel lines can be seen where the land has been tended. In the top middle of this image, an oval shape can be seen, possibly a running track of some sort.

Everyone You Know

Voyager 1 detection of Planet Earth, taken from the outer edges of the Solar System

Careers I – Class Discussion

Objective: To discuss with students their ambitions and how they can translate their desire to do career x into plan of action for the next 5 years or so.

Materials: Something to make notes so all the students can see it, e.g. blackboard or large piece of paper.

Method This module is entirely discussion based; the whole point is to excite students and to get them to think about where they *want* to be in ten years or so.

(1) What do you want to do?

- Create a clean space on the blackboard, enough to write down ten jobs and tallies for each
- Ask the students what they want to do when they grow up. If you only get ten or so answers, write up the jobs on the board. If you get many more than this, pick a few and focus on them. For jobs where there is more than one volunteer, tally the numbers of volunteers for each job on the board.
- If you have a group that doesn't want to say anything or is shy, you can break the ice by either telling them what you want to be when you grow up, or you can pick two students and ask them what they want (e.g. eldest/youngest, biggest/smallest).
- If you do end up picking a few volunteers, pick at least as many girls as boys.
- If a student says a job that seems unusual or unrewarding to you, don't ask them why they want to do it; that will put the student on the spot and discourage others from participating. You'll probably be able to tell from the reaction of the rest of the group if the person is being serious or not!

(2) How to get there from here

- Pick the first job on the list you have made. Ask the students to tell you how the person who said it would best go about getting that job.
- Now ask the students what someone who is doing this job would have studied at school to get where they are. Include university degree if applicable. Write up the subjects on the board.
- In several cases you'll get jobs that don't need advanced qualifications, e.g. footballer.
- Note that we're not trying to get everyone to do science until they're 22: the point is to get them to stay in school a bit longer.

(3) Some examples of subjects and jobs:

- **Sciences:** doctor, agricultural specialist, pilot, astronaut, farmer, nurse, conservationist
- **Languages and humanities**: lawyer, journalist, newscaster

CAREERS II – Some African Success Stories in Science

One of the most interesting aspects of undertaking the Under African Skies venture is the chance to hear the point of view of the students. One preconception we frequently encounter is the idea that science is an activity pursued only in the more wealthy nations. This is a misconception we make efforts to correct. Our team includes many African science and engineering students – male and female - who are themselves well on the way to obtaining exciting careers at the frontier of scientific research.

To help to support the case that science is not just a profession for Mzungus, we provide here four examples of Africans who have successfully pursued science as a career and, in doing so, improved the prospects for all Africans.

(1) Professor Wangari Muta Maathai

Wangari Muta Maathai was born in Nyeri, Kenya, in 1940. She was trained in biological sciences and became the first woman in Kenya to receive a doctorate, from the University of Nairobi, where she also taught veterinary anatomy. She became chair of the Department of Veterinary Anatomy and an associate professor in 1976 and 1977 respectively, being in both cases the first woman in the region to attain these positions.

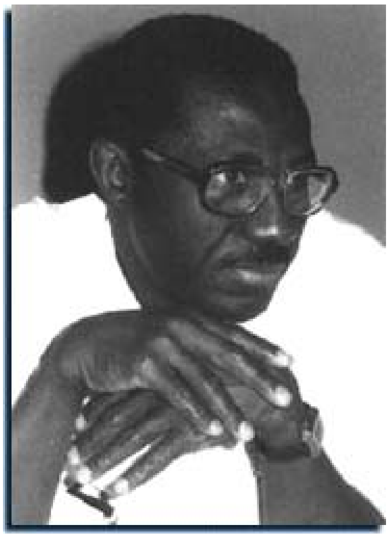
Professor Maathai is the founder of the Green Belt Movement of Kenya, one of the world's most successful programs to combine community development and environmental protection. The movement has enhanced the self-reliance and self-confidence of tens of thousands of people living in poverty.

Starting with a small tree nursery in her own back yard, Wangari Maathai launched Kenya's Green Belt Movement in 1977. A grassroots organization composed primarily of women, the Green Belt Movement aims to curtail the devastating social and environmental effects of deforestation. Beyond curbing soil erosion, the Green Belt Movement has also strived to help the rural Kenyan people become self-sustaining in their use of fuel wood and to give them an income-generating activity.

There are now 5,000 grassroots nurseries throughout Kenya, generating income for some 80,000 people, and over 20 million trees have been planted. The Green Belt Movement conducts seminars for those interested in replicating its model. It has expanded its operation to 30 countries in Africa and has created an international chapter to work outside the continent.

Wangari Maathai's passionate efforts to defend the environment, women's rights and democratic reform have earned her numerous awards, including the Africa Prize for her work in preventing hunger. However, she has also earned considerable criticism for speaking out against government policy and leading followers in acts of civil disobedience. She has been beaten and even imprisoned – but even though she is past 60, Wangari Maathai shows no intention of backing down. When the opposition party swept to power in Kenya’s December 2002 elections, she joined the government, and is currently the deputy Kenyan environment minister.

(2) Dr. Ebrahim M Samba

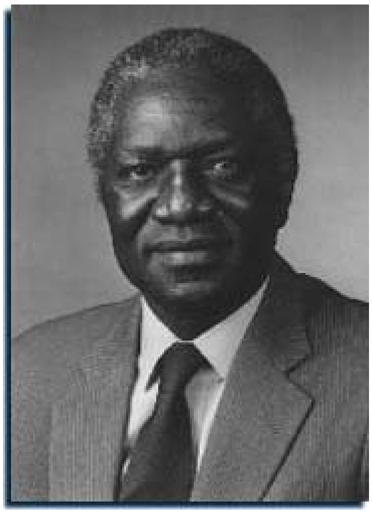


Dr. Samba is currently the Regional Director for Africa for the World Health Organisation. He won the 1992 Africa Prize for his exceptional leadership in the management of the Onchocerciasis Control Program (OCP), a program to eradicate river blindness cosponsored by the World Health Organization, the Food and Agriculture Organization, the United Nations Development Programme and the World Bank. Begun in 1974, OCP has sought to control transmission of the disease-causing parasite passed by the black fly by reducing the black fly population, as well as seeking medical treatment for the disease. Dr. Samba took command of the program in 1980, and has succeeded in delivering rapid, cost-effective benefits to millions of West Africans in a short period of time by promoting cooperation between UN agencies and West African nations.

Dr. Samba has been described as a "new kind of leader for Africa – a non-political statesman." Managing a staff of 800 scientists, physicians, field staff and pilots (97 percent of whom are African), he has led the most successful inter-country health project in Africa into its final stage in eradicating river blindness. He has been instrumental in stimulating funding for the search for suitable drug treatment for the disease. Despite political conflicts within and among the countries of the affected region, the OCP's reputation for honesty and efficiency under Dr. Samba's tenure has enabled the OCP to continue to operate across borders, unimpeded by political constraints.

Fertile river valleys that had become uninhabitable because of black-fly infestation have again become suitable for habitation and cultivation. Food security in the region has been improved, as nearly 25 million hectares (61.8 million acres) of river valleys throughout the 11 affected countries are being made safe for human settlement. The U.S. Agency for International Development estimates that the amount of cultivable land recovered by the program could feed as many as 10 million people each year.

(3) Professor Thomas Odhiambo



Professor Thomas R. Odhiambo, an entomologist by training, was one of the world's leading scientists and a pioneer in establishing Africa's indigenous scientific capacity. As founding director of the International Centre of Insect Physiology and Ecology (ICIPE), his research focused on developing sustainable solutions to the pressing need for increased food production and improved health in rural communities.

Aware that scientific research needed to be a high priority if significant economic and social development were to be achieved, Professor Odhiambo in 1967 proposed the idea of international research institutes located in tropical zones of developing countries. At a time when some criticized such a development as premature, Professor Odhiambo personally garnered the necessary talent and resources from scientific academies and foundations worldwide to establish ICIPE, which focuses on developing low-cost technologies and improving traditional methods that can be adopted by Africa's small farmers.

In 1985, Professor Odhiambo's efforts to develop and promote scientific expertise among Africans led to the establishment of the African Academy of Sciences. As its first president, he worked to achieve its objectives, which include: identifying outstanding scientific talent within the continent; promoting the utilization of this talent in national development; and advancing the partnership between scientific and political leaders in building Africa's future.

He was the first professor and head of the department of entomology at the University of Nairobi and was the first dean of the faculty of agriculture. Hundreds of young African scientists, inspired by Professor Odhiambo's leadership, have dedicated themselves to the solutions of Africa's problems.

Among his many honours are the Albert Einstein Medal, 1979; the Gold Mercury International Award, 1982; the Gold Medal Award, International Congress of Plant Protection, 1983; and the Honorary Doctorate of Science of the University of Oslo, 1986. ICIPE was awarded the Alan Shawn Feinstein World Hunger Award of Brown University in 1986. The author of more than 130 papers and monographs, Professor Odhiambo has also written six children's books designed to educate, inspire and entertain the children of Africa.

After a long life as one of the architects of African science, Professor Odhiambo succumbed to liver cancer on May 26th, 2003. He leaves behind a legacy of exceptional contribution to research and institution-building.

(4) Dr. Khotso Mokhele

Dr. Mokhele was born and raised in Bloemfontein, RSA, where he obtained his primary and junior secondary education. After graduating from Moroka High School in 1973, Mokhele obtained a BSc (Agriculture) degree from the University of Fort Hare and won the Massey-Ferguson Award for the best student in Agriculture. As a recipient of the prestigious Fulbright-Hays Scholarship, Mokhele entered the University of California, Davis, where he later obtained MSc and PhD degrees in Microbiology. Subsequently, he was awarded Post-doctoral Fellowships at the Johns Hopkins University School of Medicine, Baltimore, Maryland and later at the University of Pennsylvania, Philadelphia.

Mokhele returned to South Africa in 1987 and held teaching and research posts at the University of Fort Hare (1987 – 1989) and the University of Cape Town (1990 - 1992). Mokhele became President of the National Research Foundation (NRF) in July 1999. He was also President of the former Foundation for Research Development (FRD) since April 1996, following his appointment as an FRD Vice-President in 1992.

An active participant in several national and international organisations (including UNESCO and the South African Council for Higher Education), Dr Mokhele is currently chairman of the Board of Directors of the Southern African Large Telescope (SALT). Under construction at the Sutherland site and expected to become operational in 2005, it will be the largest single-element optical telescope in the southern hemisphere, and will observe objects so far away that the light left them when the Universe was 10% of its current age and galaxies were just beginning to form.

Mechanics I

(1) Newton's Laws -- Building and Launching a water-rocket

For more information, see Beginner's Guide to Model Rockets, NASA Glen Research Centre, http://www.grc.nasa.gov/WWW/K-12/airplane/bgmr.html

Aim: To demonstrate Newton's three laws of motion in an exciting way
Intro: You are strongly advised to do this investigation with at least one other instructor, for crowd control issues; this demonstration usually provokes a strong reaction in the class!! We are going to discuss, then dramatically demonstrate, Newton's three laws. You might already have a water rocket kit available, but building one is a good class project.

Rocket engines are **reaction** engines. The basic principle driving a rocket engine is Newton's Third Law: "to every action there is an equal and opposite reaction." Put basically, the rocket throws matter out of one end and the reaction throws the rocket in the other direction. But the rocket is actually a good demonstration of all three of Newton's famous laws of mechanics. Before it is launched, the weight of the rocket is balanced by the upwards force of the ground on the rocket. There is no net force on the rocket, and thus it does not accelerate (Newton's second and first laws). To get the rocket to accelerate upwards, a force must be provided that is greater than the weight of the rocket, so the net force is upwards (Newton's second law).

This force comes about from the conservation of momentum and Newton's Third Law. Momentum = mass x velocity. Force is just the rate of change of momentum, which means Newton's Third Law is a consequence of momentum conservation. Before the launch the rocket has zero velocity and hence zero net momentum, and the water has zero velocity and hence also zero momentum. Conservation of momentum states that at any point in its flight, the total momentum of all ejected water in one direction must exactly balance the momentum of the rocket and any water still in the rocket, to add up to zero and hence conserve momentum. This means that the rate of change of momentum of the water stream out of the back of the rocket is balanced by an equal rate of change of momentum – a force – on the rocket, in the other direction. This is what forces the rocket upwards. Once there is no more water to eject, there is no more reaction force pushing the rocket skywards, and so the only force on the rocket is gravity. By Newton's second law this causes an acceleration downwards and the rocket ends its flight the same way a brick might; by following a ballistic trajectory.

Materials:

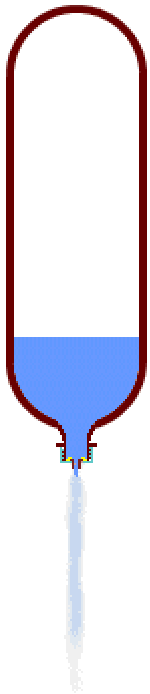
Rocket Body: plastic bottle, anything from 250 ml to 2.5 l
Connector: plastic pen, bottle top, tape
Fins: 1st Option: none -- 2nd Option: plastic bottle (1.5-2.5 l) -- 3rd option: plastic bottle, tape
Bicycle / car pump

Procedure:

(A) Try to get students to name all three Newton´s laws, and briefly explain the laws. Intro section of this module can be used as a background material for discussion.
Try asking a question for each to see if they really understand it, e.g.

- Why is the rocket at rest on the ground if the engine is idle (off)?
- But if gravity is acting upon the rocket, why does not it, according to the first law, move?

Encourage the students to consider some examples of Newton's laws in action, in nature. For example, if they have ever seen a fire hose in action they know it requires a lot of force to stop the hose from recoiling. Or if they've ever tried to throw something heavy, and felt the recoil push them backwards. Or an even simpler example: pushing against a wall!

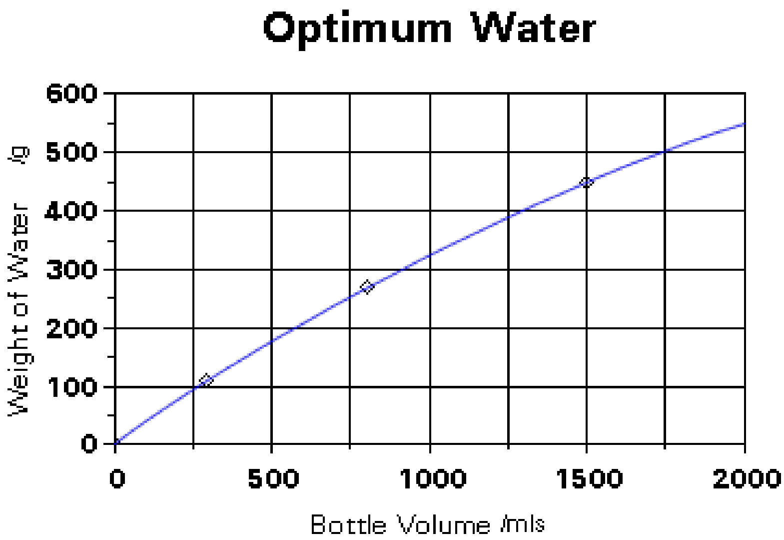


This unit can be performed either with a pre-prepared water rocket, or you can get the class to build one as a class project. This will require a minimum of 90 minutes. If you have a pre-prepared water rocket, skip to step (C).

(B) Construction

For most basic water rocket, one only needs a rocket body, a connector, and an air pump. Also, for reasons of safety, and to keep reasonably dry, a basic launcher is needed.

Body: For the most basic design a plastic bottle should be used, without any modifications. Put the water into the bottle *before* attaching the connector to its mouth. The optimum amount of water to pour into the bottle, to achieve maximum range, is shown in the following chart:



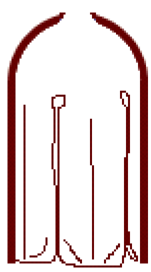
Connector This is the most basic design for a connector to the pump. It is not elegant, nor can it withstand a lot of pressure, but is very easy to build.

Disassemble the plastic pen. Make a hole in the middle of a bottle top, using a knife or a sharp drill. Diameter of the hole should be a bit smaller than the diameter of the pen. Push the body of a pen through a hole in the bottle top, and tape them together.

Launcher: This can be anything that will hold the water rocket in vertical position while air is pumped into it. For example, a simple construction from a few wooden sticks would do initially.

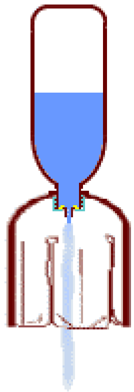
Fins: Fins are essential for guidance (you can discuss with the students why this is), which means if you are doing this demonstration in a reasonably built-up area, you should attach some to the bottle rocket. The hard part is fixing the fins to the rocket; the connection will have to withstand many times the weight of the rocket due to the acceleration at launch.

You can create a fin set that will cause the rocket to spin, and thus stabilise (again this can also be discussed with the students), out of the top half of a second plastic bottle. There are two methods to do this:



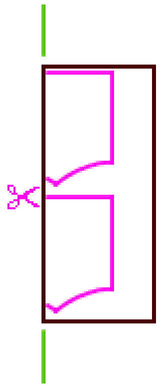
Fin method 1: First, cut off the neck of the bottle so that the resulting hole will only just fit over the screw thread of the rocket bottle – ideally it should be so tight that you have to screw it on.
Use a hot soldering iron *(*or hot nail in a pair of pliers*)* to melt four to six holes through the side of the bottle, evenly spaced, approximately where the sides straighten out from the neck. Cut from these holes, down the bottle to the bottom of the bottle to for equally sized flaps.

Then, fold along each of these flaps so that they form a V in cross-section and look more like fins. As it is impossible to get the nozzle in perfectly straight, you can make the rocket rotate during the flight by turning the corners alternately in and out (as in the diagram on the right) so that it will spiral during the flight therefore cancelling out the effects of all but the most badly aligned nozzles.



Fin Method 2: This method involves making separate fins and attaching them to the outside of the bottle with large amounts of tape. Cut out the part of the bottle with the straight sides and cut along one side. Flatten this bit out and fold it back on itself so as to cancel out the tendency to curl.

Make a template of the fin shape that you want (sized so that you will get two out of each bottle with a minimum of waste) and cut them out. (Template pictured at right). Fasten the two sides of each fin together by taping the edges.



Cut out three or four thin pieces of tape and position them on the rocket where you want the fins to go, repositioning as appropriate. Put lengths of tape on each of the fins and position them on the rocket. Be generous with the tape, as the fins will have to withstand a lot of acceleration. Finally, put down some extra straps of tape around the fins to stabilise them.

Preparing the rocket for launch: Insert the business end of the pump into the pen-top rocket nozzle. The connection should be as watertight as possible. Now place the rocket on the launcher, and move the pump far enough from the launcher that there is just a little slack in the connecting pipe.

(C) This is a spectacular demonstration and requires a large amount of space for the rocket to come down in and the water exhaust to spray. A school playing field is ideal. Assemble the group in a wide circle surrounding the rocket, at least fifteen metres away from the rocket. You are strongly advised to do this investigation with at least one other instructor, for crowd control issues; this demonstration usually provokes a strong reaction in the class!!

(D) Now recap Newton's three laws; pick student volunteers to tell you what they are. This can be a neat way to keep the attention of students; if there are any that aren't paying attention, pick them to tell you the laws! Note: this is not as straightforward a demonstration of Newton's third law as it at first appears, because the rocket is changing its mass significantly as it ejects its propellant. However, Newton's law still applies in this case.

(E) Now use the pump to increase the air pressure in the rocket. It will take some time before the pressure reaches the point at which the rocket will activate. You can ask the students at this point why increasing the pressure in the air pocket of the rocket doesn't just compress the water into ice. If you have never done this before, you should be the one who pumps the rocket, or ask for a volunteer who doesn’t mind getting slightly wet!

(F) After some pumping, the rocket will launch into the sky. This usually causes a strong reaction in the students; make sure they watch the rocket to see where it comes down!

Mechanics II

Contents:

1. Oscillations
2. Centre of Gravity and Stability
3. Can Race – Rotational Energy
4. Balloon rockets – Newton's Laws

(1) Oscillations

Aim: To get the students to investigate simple harmonic motion
Intro: The students may have noticed many objects have a tendency to return to their original location after they have been moved slightly. They have probably also noticed most objects not only return to their original position but continue too far, so that they may swing back and forth several times before they come to rest. If given one strong push, a pendulum will move back and forth because the earth's gravity is pulling down while the rope is making the pendulum move in a partial circle. When the pendulum has returned to the starting point, it can't go down any more, but still has a lot of momentum to use up, so it moves beyond the centre and up on the other side until gravity slows it down and pulls it back to the centre, but it still has too much momentum and so forth. This whole operation is periodic: each complete swing takes the same amount of time, regardless of how far the pendulum moves. When the arc of swing is large, the swing moves quickly, when the arc is small, the swing moves slowly. The amount of time it takes the swing to complete its cycle depends on the length of the rope and nothing else. In this activity the students investigate the nature of oscillations about a point. Quantitative discussion of damping is postponed for future work!

Materials: String
Scissors
Items to use as pendulum bobs, e.g. plasticene

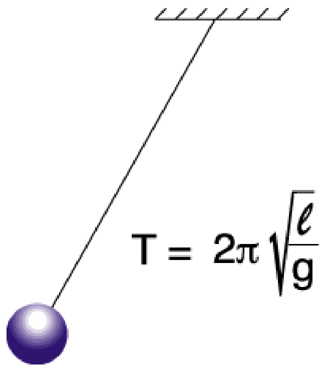
Procedure:

(A) Discuss oscillation with the students. The simple pendulum is a good archetype to use, and can be made by tying string onto just about anything heavy enough to keep the tension in the string. Ask the students what the forces are on the weight of the pendulum. If they are older you can go into components of the motion; the vertical component of the tension in the string balances the downward force of gravity, but the horizontal component of the string's tension is not balanced by any other force; thus there is a restoring force towards the equilibrium point.

(B) Divide the students into groups of 3 or 4. Have the students conduct an investigation into various pendulum properties. For example, the mass of the bob can be varied, as can the length of the string and the amplitude of the oscillations set up.

(C) Discuss with the groups individually how they should go about investigating the properties of the pendulums. If they are investigating the effect of varying the string length on the period of swing, for example, should they also vary the other properties at the same time as the length? How should they go about making sure their experiments are repeatable?

(D) You can also challenge the class to explain why the pendulum doesn't swing forever if they don't keep driving it. Does this vary with the mass of the bob? How about its cross sectional area?



(E) If the group is advanced, you can challenge them with systems of dual pendulums. A weakly coupled pair can be set up by hanging pairs of pendulums from a taut horizontal string, for example. This investigation will now explore normal modes, and the way energy of oscillation can transfer from pendulum to pendulum on a timescale that is long compared to the vibration period.

(F) At the end of the session, bring the students back together to discuss the results.

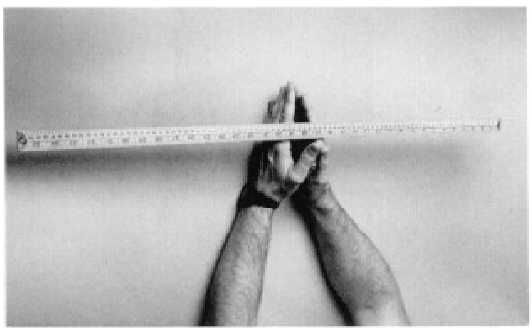
(2) Centre of gravity

Aim: To explore stability to tipping
Intro: When we calculate the behaviour of an object under gravity, we can simplify matters dramatically by imagining that the mass of the object, distributed in some complex real-world way, is actually all placed at a single point. The location of this point is the centre of gravity. For every situation on Earth outside a physics laboratory, the centre of gravity of an object is to all intents and purposes as the centre of mass of the object. We introduce the concept of the centre of gravity and its influence on the stability of objects to tipping; as long as the centre of gravity is over the base of an object, the object will not tip over.

Materials: Stick, plasticene
Plastic water
A book or other suitable bracing object
A pen that writes on plastic, or some masking tape

Procedure:

(A) Discuss with the students the concept of stability to tipping. If we place a pencil vertically on its point, will it remain in the same configuration for long? What about if the pencil is placed on its side? Ask the students why this happens. Now explain the concept of the centre of gravity; you can replace the mass distribution of an object by a point mass at the centre of gravity when calculating the behaviour of an object. This unit will explore this concept further.



(B) Now we investigate how the centre of gravity depends on the distribution of mass. This requires the ruler or stick and the plasticene. Divide the students into groups of two or more. Have one student support the ruler / stick between two hands, so that the side of the hands support the ruler. Now get the student to slowly slide his/her fingers together, without letting the ruler tip over, until they meet. The meeting place is the centre of gravity of the ruler (see diagram).

(C) Now put a weight of plasticene on one end of the ruler and repeat the process. Where is the centre of gravity now? Has it shifted towards the mass or further away? This should demonstrate to the students that the centre of gravity follows the mass distribution. (Note: this is a convenient point to discuss the concept of balancing moments with the students if you wish).

(D) Now we apply this to the stability of tipping bodies. This sub-activity needs the plastic bottle, and a generous amount of the plasticene. We begin with the empty bottle. We will be attempting to tip the bottle over, which is easier to accomplish if the base is restricted from slipping; this can be accomplished by placing the book by the base of the bottle and tipping towards the book. Get the students to find the centre of gravity of the bottle with the method described above, and mark it on the bottle with the pen or a small piece of masking tape.

(E) Now the students should attach a large amount of plasticene to the side of the bottle, near the base. Have them repeat the process of finding the C of G and tipping test. Was the bottle easier or harder to tip? What about if the plasticene is placed at the top of the bottle? What about the amount of mass that is added? You can get the students to set up an investigation into this if you want.

(F) Bring the class back for discussion; ask them what they found about how far they have to push the bottle to tip it as the mass and its distribution is varied. Place this in a wider context by discussing stability to tipping in the everyday world; for example, why are few buildings wider at the top than at the bottom?

(3) Can race

Aim: To demonstrate angular momentum to the students and its effect on the motion of objects.
Introduction: Discussion with the students: briefly recap motion under gravity, (i.e. $F = ma = mg$) thus expect all objects with similar cross-sectional areas to undergo the same acceleration if they have similar cross sectional areas and thus similar air resistance. You can demonstrate this with a golf ball and table tennis ball if you like, or a lump of rock and screwed-up piece of paper. Thus, we might expect that if we have cans of different mass, but similar shapes and materials, we should expect them to roll down an incline with the same acceleration. In this unit we see if this is indeed the case. It isn't, because of course the mass distribution of the can affects the redistribution of gravitational potential energy into rotational and translational kinetic energy.

Materials:

- 2+ Cans filled with food of different kinds, *or*
- 2+ Jars with lids, some stones, some water.

- A plank of wood, at least ~0.5m in length, at least 3 times as wide as the cans or jars are high.
- Some books or other objects to stack to create the incline

Note: In terms of radius, height, shape and smoothness, the cans or jars should be as similar to each other as possible.

Procedure

(A) If you are using cans, they should contain foods that have very different mass distributions (e.g. one solid, one thin liquid; like one containing tuna and one containing soup). If you are using jars, fill one with water, one with rocks (preferably large enough so that there is no mobility of the rocks in the jars). Of course you should make sure the lids are tight.

(B) Set up the incline. This should be at an angle steep enough for the cans to roll, but shallow enough so that they take a few seconds to cover the length of the plank.

(C) Now challenge the students to suggest which can / jar will reach the bottom first. Have them try it, by holding the cans / jars at the top of the incline and letting go. If your plank is wide enough you can do this at a straight race, otherwise you will need a way of timing the time of travel of the cans. Challenge them to explain what happened!

(D) Wrap up with a discussion of energy conservation and rotational energy. The gravitational potential energy stored in the cans at the top of the incline is released into rotational kinetic energy (rotating about the centre of mass) and translational (the centre of mass moving down the plank). Because energy is conserved, the translational kinetic energy plus the rotational kinetic energy must add up to the gravitational potential energy at the top of the slope. In the case of the solid distribution, the mass of solid must rotate with the can. This means the energy of rotation of the system is that of the can plus the solid mass, leaving behind a fraction as translational kinetic energy.

In the case of the liquid, however, only the layer next to the edge of the can needs to be accelerated; the inner material does not have to move with the can. This results in a smaller fraction being converted to rotational energy, so the translational kinetic energy of the can is greater than in the solid case, and the can reaches the bottom first.

(4) Balloon Rockets

Aim: To investigate how pushing material in one direction causes an impulse in the other direction
Intro: The physics of the balloon rocket is very similar to that of the water rocket (see intro to Mechanics I above). The difference is that in this case the air is being forced out of the back of the balloon both by gas pressure and the elasticity of the balloon wall. However the explanation in terms of Newton's three laws does of course hold for the balloons! Activity (i) aims to touch on the idea that the reaction in the direction of travel is maximised if the exhaust comes out in a highly organised manner, all in the same direction (you can bring in vector components if you wish!), and to

demonstrate that this is indeed more or less the case for the balloon rocket. Activity (ii) is a fun activity to illustrate the way the balloon rocket works.

Materials: (i) A basin, some water, some space to splash, a balloon, (ii) a balloon, a drinking straw, some string, some masking tape
(ii) Several metres of string, a drinking straw or pen-top, some masking tape, a balloon

Procedure:

(i) Engine test

Have the students do the following:

(A) Inflate a balloon, but do not let go of it or tie the end. What would happen if you did let go? What would happen if you pricked a hole in the other side of the balloon now? Why is this the case?

(B) Hold the balloon at an angle of ~45 degrees, with the end of the neck pointing into the water a few centimetres above it.

(C) Keep hold of the balloon, but now let the air out through the nozzle. This might make a noise; this is fine! Watch the water in the basin. What happens to the water that is directly in the path of the nozzle?

(D) What about the water that's nowhere near the path of the nozzle – is this disturbed by the air rushing out of the balloon?

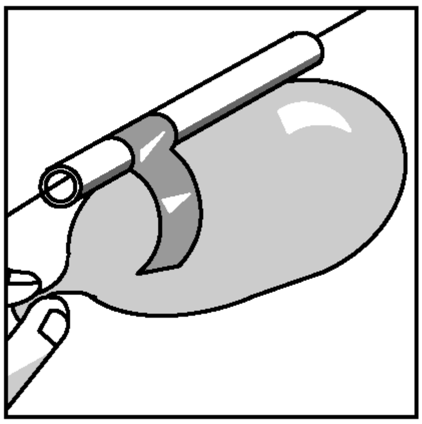
(ii) Sending a Message by Rocket

(A) Tie one end of the string to a chair, door knob, or other support.

(B) Put the other end of the string through the straw.

(C) Pull the string tight and tie it to another support in the room.

(D) Blow up the balloon (but don't tie it) Pinch the end of the balloon and tape it to the straw. You're ready for launch.



(E) Let go and watch the rocket fly! You can experiment to figure out how to make the rocket go farther and faster.

FLUIDS AND FLIGHT

Contents:

(1) Surface Tension

Aim: To illustrate surface tension and some of its properties
Intro: Within water, at least a few molecules away from the surface, every molecule is engaged in a tug of war with its neighbours on every side. For every "up" pull there is a "down" pull, and for every "left" pull there is a "right" pull, and so on, so that any given molecule feels no net force at all. At the surface things are different. There is no up pull for every down pull, since of course there is no liquid above the surface; thus the surface molecules tend to be pulled back into the liquid. It takes work to pull a molecule up to the surface. If the surface is stretched - as when you blow up a bubble - it becomes larger in area, and more molecules are dragged from within the liquid to become part of this increased area. This "stretchy skin" effect is called surface tension.

Materials: **(i)** cup or water bottle, spill container, jug or tap, some water, a ruler
(ii) a water container, some water, a paperclip and a fork,

Procedure:

(i) Filling the cup over the brim

If inside a classroom, use a larger container and place the cup inside it, to catch spills (a shallow bowl or tray is best).

(A) Challenge the students to fill the cup or water bottle as full as possible with water. Suggest 3+ students per experiment.

(B) Once the bulge has formed in the surface, challenge the students to break it. They can drop small objects into the container to push the bulge out, or can gently fill with more water.

(ii) Pond Skaters

Several kinds of insect and even some lizards are able to use surface tension to walk on water. Here we make an artificial pond skater out of a paperclip.

(A) The paperclip should be waterproofed to some extent so that water will not stick to it and break the tension. This can be done by rubbing the paperclip against your head; the natural oils in your skin will help to waterproof the paperclip.

(B) Lay the paperclip on the fork, and use the fork to slowly lower it into the water. The weight of the paperclip will be supported by the surface tension of the water.

(2) Air Pressure

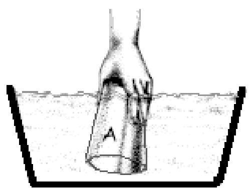
Aim: This set of activities explores the manifestations of air pressure.
Intro: In a gas, the forces between atoms and molecules are very weak, which allows them to move quickly around the gas, occasionally suffering random collisions with each other. If the gas is in a container, the collisions of particles with the container walls cause a force to be felt by the container; gas pressure is this force divided by the area of the surface in contact with the gas. "Keeping Water Out" explores this pressure by using it to maintain air bubbles in open containers underwater.

Items on the surface of the Earth also feel a pressure due to the air above them – *air* pressure. This pressure is caused by the weight of the air pressing down on the Earth, the ocean and on the air below. Earth's gravity, of course, causes the downward force that we know as "weight."

Materials: **(i)** A basin, two cups or glasses, a water supply
(ii) A rod, a pencil, two balloons, tape, two cans, a work surface
(iii) An expendable wooden ruler, some newspaper, a hammer or other striking implement

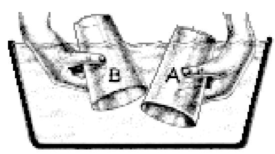
Procedure:

(i) Keeping Water Out



(A) Fill the basin close to the top with water. Leave enough room so that you can put both your hands in the basin and nothing overflows.

(B) Push cup A straight to the bottom of the basin as shown (right). Do not tip the cup. Does the cup fill with water?

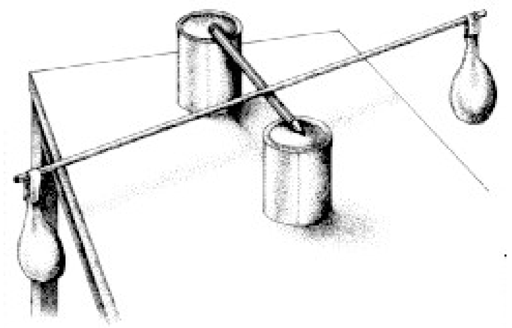


(C) Keep holding cup A under the water. Push cup B under the water on its side. Notice the air bubbles. Where did they come from?

(D) Move cup B above cup A as shown above. Slowly tip the opening of cup A toward the opening of cup B. Where do the air bubbles come from? What happens to the water in cup B? What takes the place of the water?

(ii) Weighing Air

(A) Make a balance like the one shown below, as follows: lay a pencil across two cans. Tape two empty balloons to the dowel rod. Balance the rod on the pencil.

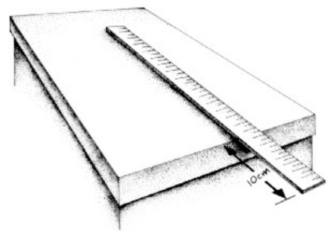


(B) Remove one balloon and blow it up. Tie the mouth of the balloon so no air escapes. Tape the balloon to the end of the dowel rod. Ask the students what they expect to happen when you replace the rod on the balance.

(C) Ask the students which balloon is heavier. How do they know? What is causing the extra weight?

(iii) Breaking a stick with air

A wooden ruler is the ideal stick for this but you may not want to break one in front of the students. This one will require demonstration.

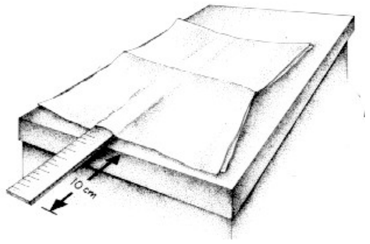


(A) Have the students arrange the ruler so that ~1/3 of it is sticking over the edge of the table.

(B) Now tap it gently with another hammer. Ask them what happens. Why does the ruler fall off the edge of the table without resistance?

(C) Now place the newspaper over the portion of the ruler that is still on the table.

(D) Repeat step (B) above. Try again using more force. Ask the students to explain what happens. Discuss with them why the ruler can now be broken. Is it the weight of the newspaper or air pressure on the newspaper?



(E) The students can carry out an investigation to answer this question if they're not convinced. Does the size of the newspaper affect the force of the air pressure on it? How should they go about finding out?

(3) Buoyancy

Aim: To introduce the students to the way buoyancy works.
Intro: Buoyancy is what makes a piece of wood float in water. It is also what makes a battleship float on the high seas, or a block of steel float in a pool of liquid mercury. The first principle of buoyancy is very simple: (1) *If a solid immersed in a fluid*

weighs less than an equal volume of the fluid, the solid will float. Another way of saying the same thing is, if a solid has a lower density than a fluid, the solid will float in that fluid.

If the first condition is met, then the level at which the solid will float is determined by the second principle: (2) *A floating object will displace its own weight in a fluid.* Thus, the percentage of the solid immersed in the fluid will be equal to the density of the solid divided by the density of the fluid.

Materials: Glass or other transparent water container
Weight with some sort of hole in it
A cork
Paper clip
Marker or masking tape

Procedure:

1. Fill glass with water to level that will float the cork with the lead attached.

2. Attach weight to cork using paper clip bent to insert into cork and through hole in weight

3. Float cork and lead

4. Mark water level on glass with the marker or masking tape

5. Ask question of children as to what will happen to the water level when the lead is disconnected from cork and allowed to rest on the bottom of the glass with just the cork floating

6. Disconnect lead and observe the results

(4) Bernoulli and Flight

Aim: To explore how moving air and pressure relate to each other to provide lift.
Intro: This is Bernoulli's theorem in its simplest form: *When the speed of a fluid increases the pressure decreases.* Notice that this is a statement about the relationship between the change in speed of a fluid parcel and the change in its pressure.

The case study given in this unit illustrates the use of this principle to cause lift in the following way: Air flows over an airplane wing that is convex on the top and flat below (activity (ii)). The flat bottom of the wing is parallel to the velocity of the airplane. The air a great distance in front of the airplane is at atmospheric pressure.
The air speeds up as it flows over the top of the wing. Why? The same amount of air must flow through every cross sectional area so when the air flows through a smaller area over the top of the wing it must speed up. (This is due to the conservation of mass flow, no air is created or destroyed.) When the air in front of the wing speeds up as it passes over the wing its pressure must drop. Thus the air flowing over the wing has lower than atmospheric pressure. The air flowing along the bottom of the wing travels at the same speed and so remains at atmospheric pressure. The combination of

atmospheric pressure below the wing and lower pressure above leads to a net upward force called lift.

Materials: **(i)** Sheet of paper
(ii) A can (preferably full), two small pieces of paper, two large pieces of paper, a metre ruler.

Procedure:

(i) Making paper lift

Have the students do the following:

(A) Cut a paper strip about 3 centimetres (cm) wide and 20 cm long from a sheet of paper.

(B) Hold the paper under your lower lip as shown at right. How do you think the paper will move as you blow over it?

(C) Now blow over the paper. How did it move? Did the paper lift or fall?

(D) Cut another paper strip about 3 cm wide and 20 cm long. Hold the short ends of the paper at each side of your mouth as shown above. How do you think the strips will move if you blow between them?

(E) Now blow between the strips of paper. Did the strips move away from or towards each other?

(ii) Designing a wing

Have the students do the following:

(A) Place two tiny pieces of rolled-up tissue behind a can. Ask a teammate to blow toward the front of the can as shown. What happened to the tissues? What made them move? Did they move at the same time?

(B) The arrows around the can in the diagram show how the air splits into two streams to pass around the can. You know that the air travelled the same distance around each side. You know that the tissues moved at the same time. What can you guess about the speed of the air? If the speed was the same on both sides, what do you know about the pressure? Why?

(C) Cut a sheet of 8 1/2" x 11" paper in two. Fold one piece in half. Tape one edge 2.5 cm from the other edge as shown to make a model wing. Repeat Step 1 but use the model wing shown. Now insert a ruler and blow directly at the fold. How does the tissue move?

(D) Use string and a ruler to measure the top and bottom of the wing. Which is longer? The air moved over the longer distance of the curve in the same time it moved over the flat side. Over which side did it move faster? Which side had the lower pressure?

(E) Further investigation: Does increasing the height of the curve on the model wing increase lift? How could you find out? Try it! What did you find out?

(iii) Further Discussion

There are some interesting digressions you might want to discuss with (or be led to discussing by) brighter students. One is that there is another obvious reason the shape of the wing causes the plane to lift, namely the following: air does not like to make discontinuous changes in its direction of flow. Thus air parcels that have been following the convex shape of the upper wing will be heading downwards when they reach the back of the wing, and will thus flow towards the ground upon leaving the trailing edge of the wing in commercial jetliners. (In activity (ii) the convex upper part is deliberately ended before the flat lower wing ends, to remove this effect somewhat and ensure the Bernoulli lift is really the force at work here).

This means the wing is forcing air groundwards, and by Newton’s Third Law, the reaction causes an upwards force on the plane. Doesn’t this also cause lift? The answer is *yes* - this mechanism does also work alongside the Bernoulli lift of activity (ii), and in fact it is the only significant lift mechanism at “low” speeds (below ~ 1/3 the speed of sound, or ~400 km/h). In this regime, the airspeed is too low for the Bernoulli effect to produce sufficient lift to keep modern jetliners in the sky. This is one reason why we use paper for the wing material in this unit; no student could blow quickly enough to lift a solid wooden wing! The air follows the convex upper surface of a wing so closely because of an effect named after a Romanian aircraft engineer named Henri Coanda, who in 1910 noted with some concern that flame and burnt exhaust from the front of an aircraft he was flight testing was being guided along the body of his aircraft and into the cockpit! Theoretical discussion of the Coanda effect is usually covered in graduate level aeronautical engineering studies, and is used by professional aircraft designers when building real jetliners. However, an analogy can be easily demonstrated – pour water out of a cup so that the water runs along the side of the cup rather than falling straight to the floor.

Sound

Contents:

(1) Drum and grit: vibration

Aim: To show students that sound is sent from an object as pressure waves in air, starting off as vibrations of a surface.
Intro: At its most basic level, "Sound" is a form of energy that is produced when something vibrates. This vibration is then transmitted through a medium by vibrations in that medium; this is true for gases, solids and liquids. In the case of air the vibration is transmitted as a pressure wave. This activity aims to demonstrate that sound sources do indeed send out sound by vibrating. We do this with the help of a cheap abundant indicator that a surface really is vibrating – grit.

Materials:

Grit
Drumstick (can be makeshift)
Drum with light-coloured surface, or
Clingfilm or freezer bag, jar, elastic band that fits tightly on the jar

Procedure:

(A) Discussion: Remind them that we are surrounded by air. Can we see air? How do we know it is there? (e.g. trees move, breeze felt on face, we can breath in and out). Introduce the suggestion that sound is a "vibration" in the air. If this word is new to them, explain that vibration means the same thing as "shaking" but that scientists prefer it.

(B) There may be a drum to hand; if it has a light coloured surface it will be useful for this demonstration. Otherwise build one by stretching the clingfilm tight over the mouth of the jar and fixing it in place with the elastic band. The surface of the drum must be taut enough to produce a sound when struck.

(C) Spread the grit thinly over the surface of the drum. This will be the indicator of vibration of the surface.

(D) Have the students strike the surface of the drum, listen to the sound and watch the grit carefully. They should see the grit jump on the surface when they hear the sound from the drum.

(E) [Possible extension with a real drum: In principle, if the drum is beat repeatedly and maintains its pitch, the grit should gather at the nodes of the vibration pattern of the drum skin. This would be a very nice demonstration but it's not clear if this is something that will be demonstrable in a real classroom under non-ideal circumstances!]

(2) Resonance

Aim: To illustrate the connection between pitch and wavelength, and to illustrate resonance.
Intro: The sound vibration travels through the air as a pressure wave. When this pressure wave hits something, the result is a pressure force on that object, which varies in strength in a periodic way, at the same frequency as the pressure wave. If the pressure wave hits something not normally inclined to vibrate at typical sonic frequencies, like (for example) the ground, the sound will be reflected. If, on the other hand, the pressure wave hits something that prefers to vibrate at or near the same frequency as the pressure wave (and thus usually the sound source), it will be driven into vibration by the pressure wave. This is resonance, and is demonstrated by this activity. Some singers have the ability to cause glass to break; they do this by singing a loud note at the natural frequency of the glass. The glass is driven to vibrate by the pressure wave that is transmitting the sound, but because glass is brittle in the transverse direction and resists vibration, the glass instead shatters!

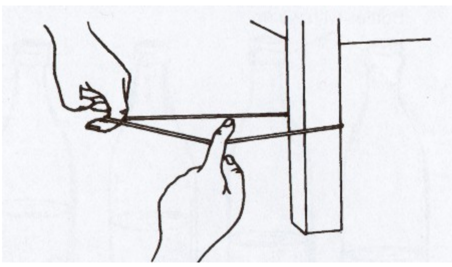
Materials: Guitar, *or*
Cardboard box, elastic band that is long enough to comfortably reach across the box, pencils to brace box if necessary, *or*
Elastic bands

Procedure:

(A) Introductory discussion: how does the ear work? Introduce the notion of a sound source undergoing physical vibration, then transmitting this vibration as pressure waves through the air. When these pressure waves reach the ear, the pressure vibrations drive the ear drum to vibrate, which simulates the surface of the sound source.

(B1) If you don't have a guitar at hand, create a 2-string version. Cut two parallel slits in the cardboard box, approx 1 cm apart, in one of the sides of the box. Repeat for the opposite side. Now loop the elastic band through the sets of slits so that it is stretched across the box. The tension may make the box collapse; use pencils or chalk to brace the insides against collapse.

(B2) Alternatively, hand an elastic band to the students. They can divide into pairs. One student will pull the elastic band taut while the other plucks the "strings." Or, finally, students can place the elastic band round an immovable object then pluck it (diagram on right).



(C) Whichever system you use, have the students pluck only one of the strings. If you are using the makeshift systems, both "strings" should already be tuned to more or less the same frequency. For the guitar you should press on the fifth fret of e.g. low E, then pluck that string.

(D) Get the students to describe what happens. If you are using the guitar, do all the strings vibrate? If not, which one does vibrate, and why is it this one only?

(3) Bottlephone:

Aim: To illustrate pitch as wavelength in pressure waves of the air
Intro: The frequency of a wave refers to how often the particles of the medium vibrate when a wave passes through the medium. The frequency of a wave is measured as the number of complete back-and-forth vibrations of a particle of the medium per unit of time. In the case of sound, hearing notes at different *pitch* is the ear / brain system's measurement of the frequency of the sound. High frequency notes correspond to high pitch, and vice versa.

The wavelength of sound is related to its frequency by the relation $\mathbf{f = c/\lambda}$, where f is the frequency of the wave, c its speed and λ its wavelength. All the sound waves the students hear in this experiment travel at the same speed – 330 m/s, the speed of sound in air. Thus longer wavelength vibrations produce lower pitch sounds. This can be easily demonstrated with an elastic band.

We illustrate the linkage between wavelength and frequency here by building a musical instrument. The part of the instrument that makes the notes is the confined airspaces in the bottle. The length of the air spaces in each bottle is the wavelength of the sound that bottle will produce. Thus, bottles with larger airspaces produce sound of lower frequency, thus lower pitch.

Materials:

Empty glass bottles, water, a striker of some sort (e.g. a pen)
(If no glass bottles are available, plastic ones will do)
Masking tape (to fasten the bottles together and make it harder for them to tip over)

Procedure:

(A) If necessary for the group, discuss the nature of sound propagation as pressure waves. Discuss with them the relationship between the dimensions of a container and the wavelength of sound it naturally produces if the container is made to vibrate and is not forced. Introduce the relationship between frequency and wavelength.

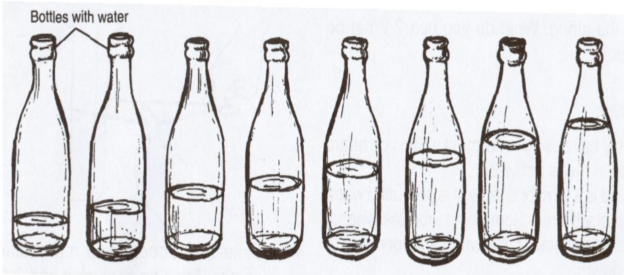
(B) Now the students will build an instrument that uses this concept directly. Depending on the availability of materials and supervisory capacity, either divide the students into groups and have each group build their own instrument, or you can have the entire group make one instrument.

(C) Making the instrument is simple; fill the bottles with water of different depths. If you like you can have the students add a colourant to the water to more dramatically illustrate the volumes of air left.

(D) Alternatively you can try to get them to make an octave. Assuming approximately 30 cm for the length of each bottle (2 litre bottles), the wavelength range for suitable notes will start at roughly 2 octaves above middle C.

Wavelengths in centimetres for musical notes, starting 2 octaves above middle C:

C	33	16.5
D	29.4	14.7
E	26.2	13.1
F	24.7	12.3
G	22	11
A	19.6	9.8
B	17.5	8.7
C	16.5	8.2



(E) Once the bottles have been filled to their respective depths, place them on a surface and confine them from moving too much with the masking tape. Now ask for a volunteer to play the instrument, or play it yourself. If the bottles are plastic you can blow over the rim, if they're glass you can tap them gently over the mouth. Discuss with the students what is going on and why.

4) Cup Telephone

Aim: To illustrate that sound can propagate through other media than air
Intro: All the examples described thus far have involved sound propagating through pressure waves in a gas (and by extension to liquid; both are fluids). In a solid, the atoms have much less freedom to move as the forces between them are much stronger. Sound still propagates through a solid, however, and in fact does so more quickly; the speed of sound in air is 330 m/s while in steel it is roughly 4 km/s! This is because the average distance between atoms is smaller in a solid than in a liquid or gas, which means that vibrations at one part of the solid are propagated through the solid by collisions much more quickly than in the case of a liquid or gas.

We illustrate that sound can indeed propagate through solids with the cup phone of this activity. The student speaks into the cup at one end of the phone. The cup vibrates, and sends this vibration down the string. The string in turn causes the second cup to vibrate. This causes the second cup to generate a good copy of the sound incident on the first cup, so the second student can hear what was said by the first student, even if it was too quiet to hear normally. This also acts as a good schematic for how telephones work; the difference being that rather than propagate the actual vibration down the wire, telephones convert the vibration of the mouthpiece into electrical signals which, when sent down the wire to Greenland or wherever the receiving person is, provide enough information for the earpiece of the receiving telephone to mimic the vibration of the first mouthpiece, creating a copy of the sound.

Materials: Two polystyrene cups or tins (see note below)

A few metres of string
Scissors, craft knife or other hole-punching implement
Tape to fasten string to cup (optional)
Two paper clips (optional)

N.B: only use tins if they can be opened with no jagged edges remaining on the rims!!!

(A) Use the scissors or craft knife to punch two small holes in the bases of the two polystyrene cups. The holes should be large enough to fit the string through, but small enough that it will stop a knot passing through.

(B) Fit the string through the holes in the two cups. Feed a few cm of the string through the holes in the cups. Now tie a paperclip to each end of the string. The paperclip will make it extremely difficult for the string to pass back through the holes in the cup!

(C) Have two students hold each end of the cup phone. Make them stand far enough apart to make the string taut. Now quieten the group and ask the student to whisper something to the other student. Ask the receiving student to repeat what the first student just said. Try to get the first student to say something innocuous and easily recognisable; if they say something embarrassing, you might want to give the receiving student the chance to exact revenge by picking their own statement to repeat!

OPTICS

Contents

(1) CD-Rom

Aim: To illustrate the breaking up of white light into colours
Intro: The colour of light is analogous to the pitch of sound, in that it is a measure of the wavelength of the light. Blue light is of shorter wavelength than red light. White light is a continuum of light signals at many wavelengths; the eye detects colour at all frequencies it is sensitive to. In this activity we unpack the continuum of white light into its component parts by dispersing it so that light of different wavelengths travel in slightly different directions. This is often described as being done with a prism, as it is what Newton used; the refractive index of the prism material depends strongly on the wavelength of the light. Here we disperse the light with something much more common - a CD.

The way this works is different from the case of the prism, and if the class is advanced you may want to discuss this with them. The CD records information in tiny grooves on its surface, similar in principle to a vinyl record. When light reflects off the surface of the CD, it does so through the pattern of grooves on the CD, making the CD a reflection diffraction grating. The light from each of the grooves spreads out more or less spherically, and is still a continuum of signals at various wavelengths. The signals from the grooves interfere with each other, leading to cancellation at some points and reinforcement at others. The location of these points is dependent on wavelength, which means that the colour which is most strongly reinforced (and thus what you see) is also dependent on wavelength. Hence the spectrum you see in the reflection.

Materials: A source of white light
some old CD's
optional – coloured cellophane to use as filters
optional – flashlight and cardboard with slit

Procedure:

(A) Discuss the concept of the spectrum with the students. Introduce the concept of white light as a mixture of colours of the spectrum

(B) Pass round the old CD's and get the students to play with reflected light. They will notice that the white light gets split into colours. This works best in a darkened space with a single, compact light source, but you will get spectra with almost any light source.

(C) Now pass round the filters. Get the students to hold the CD at an angle such that they can see the dispersed spectrum from the light source. Now ask them to hold the filter between the light source and the CD, without moving the CD (an activity for pairs of students). Get them to comment on the change they notice.

(D) Now a combination: get them to pass the rainbow spectrum through e.g. the green filter and show you what they see. Now have another student place e.g. the red filter between the light source and the CD. Have them describe what they see now.

(E) If the class is older, discuss diffraction with them from a physical optics point of view. This can lead into a thorough discussion of physical optics if you like!

(2) Mixing Disk

Aim: To illustrate how the brain has a "frame rate" akin to a tv screen; the colours move too quickly for the brain to register the change. Also reinforces the notion that colours mix into white.
Intro: The retina of the human eye contains two categories of sensor, the rods and cones. The rods are more light - sensitive and used to perceive contrast, while the cones are sensitive to colour. On a dark night, the contrast-sensitive rods are more sensitive than the colour-sensitive cones, which is why things appear less colourful at lower light levels. There are three types of cones. One is most sensitive to red light, one to green light, and one to blue light. Each type of cone has a different latency time, the time it takes to respond to a color, and a different persistence of response time, the time it keeps responding after the stimulus has been removed. Blue cones, for example, are the slowest to respond (have the longest latency time), and keep responding the longest (have the longest persistence time). This activity explores the repercussions of this effect, by showing the eye / brain visual system colour changes at a faster rate than the cones can respond.

This experiment is a modified form of "Benham's Disk," in which different areas of black and white are flashed in front of the eyes. The cones respond with different latency times, which leads to a colour excess in the signals sent to the brain. The result is that the brain perceives colours that are not really there.

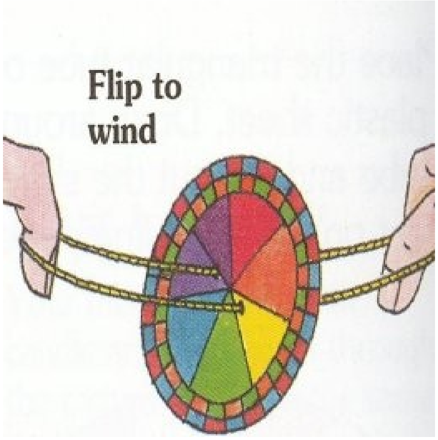
Materials:

thick paper or cardboard
felt-tip pens of as many colours of the rainbow as possible.
paintbrush
pencil
string
scissors

Procedure:

(A) Using the scissors, cut a disk at least 10cm in radius from the card.

(B) If assembling in the classroom, use the felt tip pens to create patterns of primary colour on the disk. The students can create their own designs if they wish. You can use paint if you're making this yourself and have time to let the paint dry.



(C) Punch two holes near the centre of the disk and thread the string through the holes. Tie the string at the ends to make a continuous loop.

(D) Now get the students to hold the disk as shown in the diagram on the right. Have them flip the disk along its axis many times to wind up the string.

(E) The students make the disk whirl along the axis by pulling the string out of the plane of the disk. Make the students rotate the disk as quickly as they can, and get them to watch it as its rotation slows down.

(F) Have them describe what they see. The colours will appear to blend into a near-white colour. This demonstrates two effects: (i) that the brain doesn't process visual information infinitely quickly, and (ii) this reinforces the notion that separate colours blend into white.

(3) Eclipses

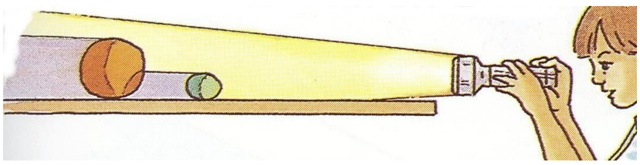
Aim: To demonstrate that light moves in a straight line through uniform medium
Intro: Light follows the path of least time when travelling from A to B. In this activity we introduce this concept by illustrating some of the more spectacular instances of this behaviour; eclipses

Materials:

flashlight or other bright light source (e.g. hole in roof) - Sun
orange - Earth
ruler
ball of plasticene or other object about quarter of size of the orange – Moon

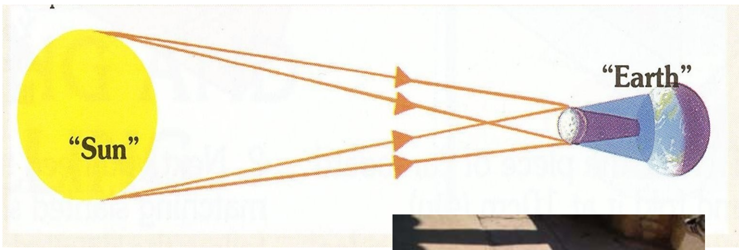
Procedure:

(A) Discuss eclipses with the students. This can start off very basic, for example shadows from regular objects, then build up to discussion of eclipses. Or you might want to go the other way, and begin by discussing eclipses and the various ideas students may have heard about them.



(B) Now generate eclipses with the students. You may want to point out that the moon is just the right distance from the sun to make its apparent diameter in the sky the same as the sun's – this is why the earth just covers the moon and makes for such a spectacular show as the corona becomes visible (contrast e.g. with the night side of the earth as viewed from the Shuttle, which is interesting in a different way…).

(C) If conditions are such that the primary and secondary shadow areas come out well, point this out to the students. Ask them to explain why there is a dark area and a not-so-dark area.



(D) If the kids are younger, you can have fun by challenging them to make shadows of with interesting shapes.

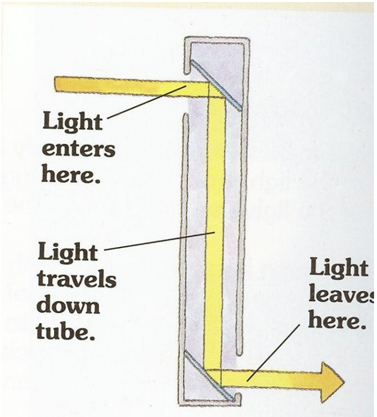
(4) Periscope

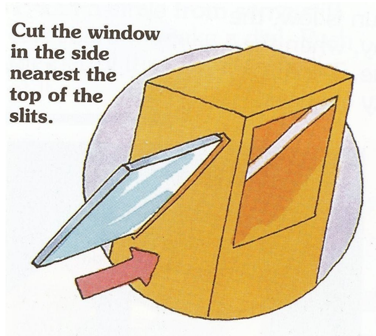
Aim: To demonstrate how we can use the straight-line travel of light to see rond corners
Intro:
Materials:

cardboard 60 x 45 cm
scissors
pencil
pen
adhesive tape
glue
mirror board 24x10 cm
or two mirrors 12x10cm
ruler

Procedure:

(A) Depending on the circumstances of the school, you may want to build the periscope beforehand and use it to augment discussion as a demonstration. Or if time and group size permits, you can choose to build the periscope as a project.





(B) If this unit is being done without any of the others, ask the students how light travels through air (straight line etc). Begin by getting the students to experiment with the pair of mirrors. An example challenge is to get them to look at ”infinity” – see who can get the most reflections in a pair of nearly plane-parallel mirrors.

(C) Build the periscope; this is best done by assembling a complete periscope by fixing two mirrors at roughly 45 degrees to a cardboard box (or tube; might be more easy to obtain)

(D) Allow the students to play with it to explore how it works. Discuss with them any possible variations or improvements to the design.

(5) Reflection and Refraction

Aim: This experiment uses a single bottle to demonstrate both reflection and refraction.

Intro: A good analogy to use in initial discussion is the lifeguard rescuing a swimmer; if you have a blackboard or other material which can be used as a demonstration surface, draw a line representing the beach, have the area to one side represent sand, the other water. The lifeguard sees a swimmer in trouble and has to reach the swimmer in the least time. The lifeguard can move faster on land than in the water, so what path is the quickest to the swimmer? This same principle describes light refraction. You can also use the analogy for reflection; for someone to run from point A to point B along the beach, but also touching the boundary between sea and sand, what path gives the shortest time?

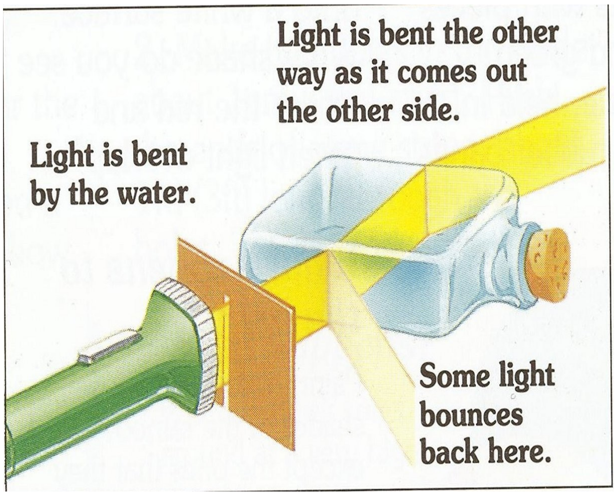
Materials:

flat bottle with lid that can be fastened to make it watertight
water
milk
flashlight
small piece of cardboard

Procedure:

(A) If the students are old enough, you can use the lifeguard analogy (for example) to explore the theory behind refraction and reflection. Otherwise discuss in a phenomenological way.

(B) Now set up the demonstration – ideally you need a darkened area and the flashlight to really bring out the light paths – if you don't have a flashlight but a hole in the roof or other light source, this will be harder to accomplish but should be possible.



(C) Take the piece of cardboard and cut a slit in it. This ensures the light will come out in a more or less collimated manner and trace a narrow ray path rather than spreading too much to make the path obvious. The cardboard must be large enough to cover the flashlight opening so that the only light let through is from the slit.

(D) Fill the bottle mostly with water, and top it up with milk, then shake the bottle. The milky water acts as a scattering medium for the light to make the path visible. We suggest that you experiment before demonstrating this unit with fractions of water and milk that are useful; the liquid should not scatter so much light that the path is totally smeared out.

(E) Now switch on the flashlight. The reflected and refracted light paths in the bottle will be obvious to the students and can be discussed. If you're lucky, ambient dust in the air will make the paths of light leaving the bottle, and the initial reflection off the first surface obvious.

ELECTRICITY AND MAGNETISM

NOTE: the static electricity demonstration is suitable for classroom use, as assembly is very easy. The second two units will take most of a session each to assemble and carry out. You may want to build the objects beforehand and bring them in if time is short. Otherwise you might assign at least one volunteer to each of activities (2) and (3), and running the two in parallel.

Contents

(1) Static Electricity
(2) Shocking Lemons
(3) Electromagnet
(4) Stripped-down Motor

(1) Static Electricity

Aim: To introduce students to charge movement and electric fields through static electricity.
Intro: Static charge build-up is caused by one of two processes: either by friction between two surfaces or by proximity to an electrostatic field. We focus on the former here. When substances become charged by friction, electrons migrate from the surface of one material to the surface of the other. This effect is most strongly felt by insulators – materials that conduct electricity badly.

Upon separation of the two surfaces, one surface loses electrons and becomes positively charged. The other surface gains electrons and becomes negatively charged. (This happens during the rubbing of the balloon in activities (i) to (iii) here). The result is that each surface now has a net charge, which sets up an electric field propagating from its surface. The activities (i) – (iii) here dramatically demonstrate this field through its effects on everyday objects.

Materials: **(i)** Balloon, plate, salt crystals
(ii) 2 balloons, 2 long pieces of string, a piece of paper
(iii) Balloon, stream of water – can be made from a tap or from a plastic bottle with a hole cut in the side of it.

Procedure:

Initial discussion: Charge, rubbing causes charge to be lost from the object, which sets up an e-field. Other objects will donate charge to the object causing them to move.

(i) Jumping Salt

Have the students do the following:

(A) Lay out a ceramic plate (not paper) and place some salt grains on the plate.

(B) Now rub the balloon on your hair or school sweatshirt, and hold it over the plate. Be careful not to touch the plate with the balloon

(C) What happens? Why?

(ii) Balloon Force Field

(A) Inflate the balloons, and tie one to each end of the string.

(B) Rub the balloons on your hair or sweatshirt

(C) Hold the string near the middle, so that the balloons hang near each other.

(D) Now place the piece of paper between the two balloons.

(E) What happens? Why?

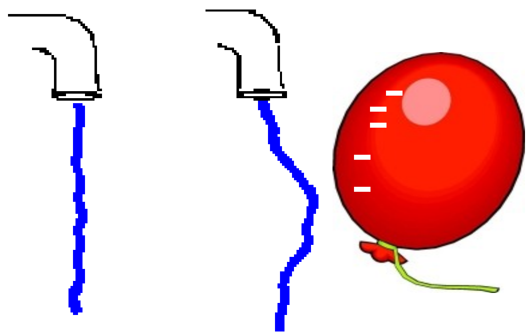
(iii) Bending Water

(A) Set up a thin, steady stream of water. If there is a tap in the room you can simply use the tap. Otherwise, take a plastic bottle and punch a hole a few millimetres wide in its side. Now fill the bottle with water above the hole and the water should come rushing out in a stream.

(B) Rub the balloon against your head or shirt to charge it.

(C) Slowly bring the balloon closer to the water stream, but don't touch it.

(D) What happens? Why?



(2) Shocking Lemons

Aim: Demonstrates the separation of charge and its mobility
Intro: The lemon battery is called a **voltaic battery**, which changes chemical energy into electrical energy. The battery is made up of two different metals (the steel paper clip and the copper wire). These are called **electrodes**, which are the parts of a battery where electric current enters or leaves the battery. The electrodes are placed in a liquid containing an **electrolyte**, which is a solution that can conduct electricity. In a solution of water and an electrolyte, like the acid in the lemon, an excess of electrons collects on one end of the electrodes. At the same time, electrons are lost from the other electrode.

Touching the electrodes to your tongue closes the circuit and allows a small electric current to flow. A single lemon produces about 7/10 of a volt of electricity. If you connected two lemons together, you can power an inexpensive digital watch (uses about 1.5 volts). (Use a length of thin, flexible wire to connect the silver wire of one lemon to the copper wire of the other lemon. Then attach thin wires from the other two wires in the lemons to where a battery's positive and negative poles connect to power the watch.) The tingle felt in your tongue and the metallic taste is due to the movement of electrons through the saliva on your tongue.

NB: although the potential difference set up by the orange battery is enough to light up a bulb (~1.5 V), the current it produces is too weak to provide enough power to visibly light it. During trials in UAS2002, partial success was reached with an LED. This unit is a variant of the lemon battery experiment using a different method to show the potential difference created.

Materials: 1 lemon
Copper wire, steel paperclip
sandpaper

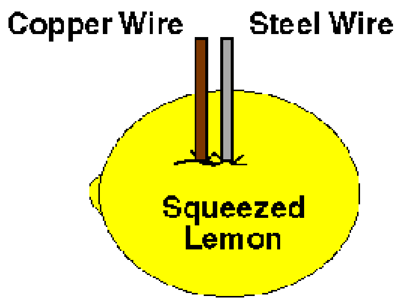
Procedure:

(A) Strip off a few cm of insulation from the end of the copper wire

(B) Straighten out the paper clip and strip off a few centimetres of any coating present.

(C) Use sandpaper to smooth any rough spots on the ends of the wire and paper clip.

(D) Now increase the mobility of the ions. Squeeze the lemon gently with your hands. But don't rupture the lemon's skin. Rolling it on a surface with a little pressure works great.



(E) Push the pieces of the paper clip and the wire into the orange so they are as close together as you can get them without touching.

(F) Ask for a volunteer. Get them to moisten their tongue with saliva. Get the volunteer to touch the tip of their wet tongue to the free ends of the two wires.

(G) They should feel a tingling sensation on their tongue.

(H) If you have one, an old digital watch makes a much better demonstration of the principles at work here, because everyone can see that the demonstration is working, rather than having to trust one student who says he or she felt a shock. This requires two lemons hooked up in series (so attach the copper wire from one lemon to the steel paperclip wire of the other). Now attach the remaining wires to where the battery's positive and negative terminals would power the watch.

(3) Electromagnet

Aim: To dramatically illustrate to the students the connection between electric currents and magnetic fields.
Intro: Any electric current produces a magnetic field, but the field near an ordinary straight conductor is rarely strong enough to be of practical use. A strong field can be

produced if an insulated wire is wrapped around a soft iron core and a current passed through the wire. The strength of the magnetic field produced by such an electromagnet depends on the number of coils of wire, the magnitude of the current, and the magnetic permeability of the core material; a strong field can be produced from a small current if a large number of turns of wire are used.

Materials: A battery
~3m copper wire,
a way to affix the wire to the battery terminals.
An iron nail and a ballpoint pen.
Some iron paperclips or other objects that will be attracted by a magnetic field.

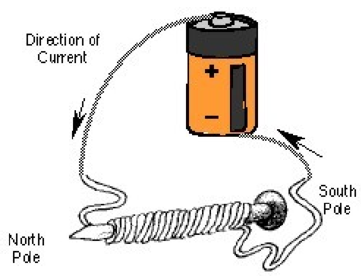
Procedure:

(A) Optional: use the toy magnets to pick up the iron paperclips. Encourage the students to play with the magnets, including orientation of the poles.

(B) Now introduce the concept of electric currents and magnetic fields being one and the same. Explain that we are going to build a magnet using just a wire and a battery.

(C) Take the biro and wrap the wire around it. Wrap the wire as closely as you can, but leave some space for the battery and optional bulb connection.

(D) Now strip off a few centimetres of insulation from the end of the wire. Connect **one** end of the wire to one of the terminals of the battery.



(E) If you like, connect the wire to a bulb first, then connect this to the battery terminal. This will act to illustrate that there is indeed current flowing through the wire later on.

(F) Now connect the second terminal of the battery to the other end of the wire. Use it to pick up the paperclips if you can.

CAUTION the wire in the electromagnet has very low resistance, which means the heat dissipation (V^2/R) will be high. Instruct the students only to turn on the electromagnets for periods of a few seconds.

(G) Remove the ballpoint pen and insert the iron nail. What has happened to the pulling power of the electromagnet? Why?

(4) Building a Motor

Aim: To dramatically illustrate the connection between magnetic fields and electric current by building a motor.
Introduction: If current flows through a wire, and the wire is situated in a magnetic field that has a component perpendicular to the direction of the current, the wire will

feel a force at 90 degrees to the perpendicular component and the current. This is illustrated by the "left hand rule," with which the students may already be familiar: point the thumb, first and second fingers at right angles to each other. The second finger shows the direction of the magnetic field, the thumb shows the direction of the force due to a magnetic field component in the direction of the first finger. This is the principle on which electric motors operate: a coil with electric current flowing through it is immersed in a magnetic field. The resulting force causes the coil to rotate. We illustrate this by building a simple motor in this unit.

Materials: 5 small disk or rectangular ceramic magnets
2 large paper clips.
A plastic, paper, or Styrofoam cup.
A solid (not stranded) enameled or insulated 20-gauge copper wire, about 2 feet (60 cm) long.
Masking tape.
A battery or power supply. This motor has been successfully run on one 1.5 volt D battery; additional batteries seem to make it easier to get the motor to run. You may want to try 6 volt lantern batteries.
2 electrical lead wires
Wire strippers (if you are using insulated wire).
Sandpaper (if you are using enamelled wire).
A black, waterproof marking pen.

Procedure:

A. Wind the copper wire into a coil about 1 inch (2.5 cm) in diameter. Make four or five loops. Wrap the ends of the wire around the coil a couple of times on opposite sides to hold the coil together. Leave 2 inches (5 cm) projecting from each side of the coil, and cut off any extra. (See diagram on right.)

B. If you are using insulated wire, strip the insulation off the ends of the wire projecting from the coil. If you are using enamelled wire, use the sandpaper to remove the enamel. Colour one side of one of the projecting ends black with the marking pen. (Note: It is very important that the orientation of the painted side corresponds to the orientation shown in the drawing below. If the coil is held in a vertical plane, paint the top half of one of the wires black.)

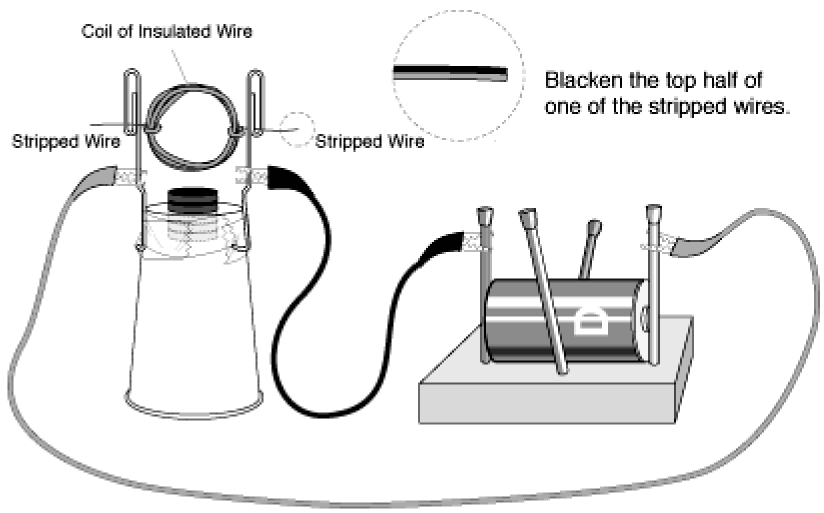
C. Turn the cup upside down and place two magnets on top in the centre. Attach three more magnets inside the cup, directly beneath the original two magnets. This will create a stronger magnetic field as well as hold the top magnets in place.

D. Unfold one end of each paper clip and tape them to opposite sides of the cup, with their unfolded ends down. (See diagram.) Rest the ends of the coil in the cradles formed by the paper clips. Adjust the height of the paper clips so that when the coil spins, it clears the magnets by about l/l6 inch (1.5 mm). Adjust the coil and the clips until the coil stays balanced and centred while spinning freely on the clips. Good balance is important in getting the motor to operate well.

E. Once you have determined how long the projecting ends of the coil must be to rest in the paper-clip cradles, you may trim off any excess wire. (The length of the projecting ends depends on the separation of the paper-clip cradles, which in turn depends on the width of the base of the cup you are using. See diagram.)

F. If you are using a battery, place it in a battery holder. You can make your own from a block of wood and four nails, as shown in the diagram. Use the clip leads to connect the battery or power supply to the paper clips, connecting one terminal of the battery to one paper clip and the other terminal to the other paper clip.

G. Give the coil a spin to start it turning. If it doesn't keep spinning on its own, check to make sure that the coil assembly is well balanced when spinning, that the enamel has been thoroughly scraped off if enamelled wire has been used, that the projecting end has been painted with black pen as noted, and that the coil and the magnet are close to each other but do not hit each other. You might also try adjusting the distance separating the cradles: This may affect the quality of the contact between the coil and the cradles.



H. Keep making adjustments until the motor works. Have patience! The success rate with this design has been quite good.

Chemistry

Contents

(1) Storing energy as starch

Aim: To illustrate the way in which plants store energy they produce from photosynthesis.
Intro: In green plants, chlorophyll is responsible for changing water and carbon dioxide into sugars and oxygen. This process is called "photosynthesis". The plants get water from the soil they are growing in, and carbon dioxide from the atmosphere. Light energy is required for this chemical reaction to take place. The sugars produced by photosynthesis are stored in the green plants in the form of starch. So the presence of starch in green plants indicates where photosynthesis has taken place.

To test for starch, iodine solution is used. If you put a drop of iodine solution on a white tile, you will see that it is brown in colour. Take a piece of bread or potato, which we know to contain starch. Add a few drops of iodine solution to the cut surface of the potato, or to the surface of a slice of white bread, and you will see that the iodine solution makes a blue-black colour instead of its original brown. This blue-black colour indicates the presence of starch.

Materials: Heat source to boil water
Saucepan
Water Source
Medicinal alcohol -- available from chemist
Iodine indicator – available from chemist

Procedure:

NOTE: This experiment requires boiling water. You should either do this yourself as a demonstration or make sure you can supervise the safety of the students who are doing it.

(A) In green plants, starch is only present where chlorophyll is available for photosynthesis to take place. Pick a green leaf from a plant.

(B) put leaf in boiling water – soften, make more permeable to chemicals

(C) put leaf in alcohol, heat indirectly by placing container with leaf and alcohol into boiling water – to remove green colour of leaf so any further colours can be easily observed

(D) rinse leaf in water to get rid of alcohol

(E) add iodine solution and observe blue-black colour only in areas that were originally green (e.g. in variegated leaves that have yellow spots, the yellow spots don't store starch).

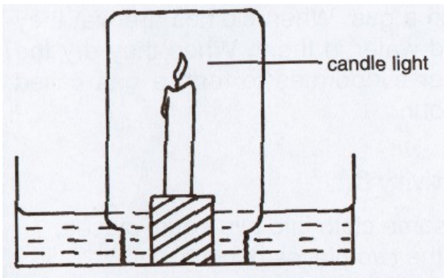
(2) Oxygen Consumption

Aim: To illustrate that chemical reactions can use oxygen as a reactant and that the amount in the air is finite.
Intro: Oxygen is what supports most of the current life on Earth – if humans do not have oxygen to breathe then we would die within minutes. Oxygen is used in a slow "burning" process within our bodies, to turn the food we eat into energy (e.g. for muscle movement). This process is similar to the combustion in flames, which also consume oxygen in the atmosphere, to produce heat and light energy. Since we know that the burning flame consumes oxygen, we can investigate the amount of oxygen in the atmosphere by this experiment:

Materials: Large bowl
Lump of plasticene
Candle, match or lighter
A glass

Procedure:

(A) Take a large bowl. Use a lump of plasticene to stand a candle in the middle of the bowl



(B) Half-fill the bowl with water (only covering the lower half of the candle) Light the candle.

(C) Take a glass, invert it and place it over the burning candle, such that the mouth of the glass is immersed in the water but not touching the bottom of the bowl.

(D) The candle will go out, and the water level inside the glass will rise to about a fifth of the entire height of the glass. The water in the glass is taking up the volume that was originally occupied by the oxygen in the air, which has now been consumed by the flame.

(E) A control experiment would be the bowl of water and an inverted glass held in it, the water level stays at the mouth of the glass and does not rise up the glass. In this case there was no burning candle to consume the oxygen in the air inside the glass.

(3) Chemical Reactions and Phases of Matter

Aim: This experiment demonstrates three phases of matter. A chemical reaction is used to produce one phase from the other two, illustrating a spectacular chemical reaction.

Intro: Everything around us is made up of different materials, with their own chemical make-up. Different materials sometimes REACT with each other, to produce a new kind of material. For example, iron will react with oxygen in the air – a chemical reaction called "oxidation" takes place, and we get rust on the iron. This usually takes some time to happen, but some other chemical reactions happen much faster. The reaction is as follows:

CH_3-COOH (vinegar) + $NaHCO_3$ (baking soda) -> CH_3-COO-Na + H_2O + CO_2

The gas that is filling up the balloon is therefore Carbon Dioxide (CO_2).

Materials:

1 Bottle (a soda bottle works well)
3 spoonfuls of baking soda
5 spoonfuls of vinegar
1 piece of string or rubber band
1 plastic bag (make sure there are no holes, it must be airtight), *or*
1 balloon and funnel

Procedure:

(A) Measure out the vinegar and the baking soda. Get the students to notice the relative volumes of the two materials, and compare them to the volume capacity of the balloon or bag.

(B) Using the funnel, pour the baking soda into the balloon or bag. Briefly discuss with the students the behaviour of the molecules in the substances; how fast do the students think they are moving in the soda and the vinegar. What about their packing and arrangement?

(C) Now use the string or rubber band to seal the mouth of the balloon or bag to the mouth of the bottle. Make sure none of the baking soda actually tips into the bottle while you are doing this. Get the students to notice that the balloon / bag is initially limp and deflated.

(D) Discuss with the students what they expect to happen. If they've not seen the experiment before, you can bring up some other examples of two substances mixing, e.g. coffee grounds in water – this will make the real behaviour of this experiment more dramatic! If the class has come across much chemistry before, you may want to show the chemical reaction for the reaction (see above), and identify the reactants and the products. You may want to ask the students to predict what will happen!

(E) Now tip the end of the balloon / bag up so that the baking soda falls into the bottle and mixes with the vinegar. The reaction that results will be spectacular; the mixture fizzes and bubbles, and the balloon / bag will inflate. While the reaction is in progress, ask the students what is causing the balloon to inflate. How are the molecules in this substance behaving? Why do they cause the balloon to inflate?

(F) Discuss with the students how this reaction differs from other examples of substances dissolving in water. Why is this different from mud granules dissolving in water, for example (alkali plus acid > precipitate + water + carbon dioxide).

Energy flow in Ecosystems

(Adapted by Kim Winges from a USDA Agriculture in the Classroom activity, available online at http://www.agclassroom.org)

Overview
Students construct food webs to learn how food chains are interconnected.

Suggested Grade Level
2 – 5

Estimated Time
30 – 40 minutes

Objectives
Students will be able to:
1. construct a food chain and explain how energy flows through the chain.
2. explain how all living things depend directly or indirectly on green plants for food.
3. use pictures and arrows to create a food web that includes the sun, green plants, herbivores, omnivores, and carnivores.

Materials
1. Ball of yarn
2. Activity Sheets 1- 8 (pictures of prairie plants and animals)
3. Tape to attach pictures to clothing
4. Space for the class to form a large circle

(1) Background

Living Things Need Energy From Food

Energy can be defined as the capacity for change. Living things need energy for everything they do. For example, a butterfly needs energy to change position when it flies, and a daffodil needs energy to change size as it grows and blooms. All living things get energy from food. Green plants use energy from the sun to make their food. Plants use the food they make for energy to grow. Animals get energy by eating plants or other animals.

The Sun is the Source

The energy in living things originates from the sun. Green plants are the only living organisms that can use the energy from the sun make food.

Although many children know that the sun keeps plants healthy, they may not know that plants rely on the sun's energy to make food, or that this food can be used by the plant itself or by animals that eat the plant. For example, a sugar maple tree uses the sun's energy to make sugar, a food, in its leaves. The tree uses the sugar for energy to grow and stay alive. If people eat maple syrup, they get energy from the sugar in the tree. But people cannot hold out their hands to the sun and make food in the same way that a maple tree can make food in its leaves.

Children may think that the sun is important because it keeps animals warm. The sun does provide warmth to the animals, but, more importantly, the sun provides the energy that green plants use to produce food. Animals get this energy when they eat the plants. To help students understand that animals depend on the sun for food energy, have them think about how long a deer could live if it only basked in the sun and did not eat green plants. The relationship between the sun's energy and the energy required by living things will become clearer as the children learn about food chains and webs.

Children may cling to the idea that plants draw in usable food from the soil through their roots. It is true that plants absorb water and essential minerals from the soil and that they need water to make food. Food contains energy, however, and the water and minerals in the soil do not contain energy. So plants use the energy from the sunlight plus water and minerals along with carbon dioxide from the air to produce food that contains energy.

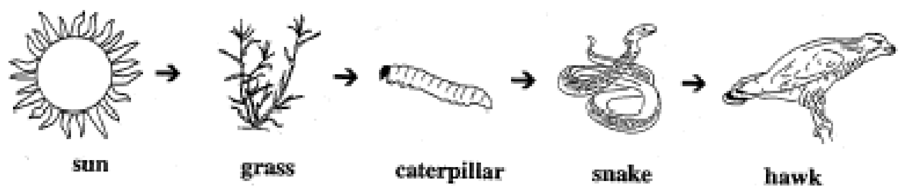
Food Chains

A food chains' energy is transferred in sequence. For example, energy comes from the sun, to green plants, to animals that eat plants, and to animals that eat other animals. Green plants use the sun's energy directly to make food. When animals eat green plants and other animals eat those animals, the energy moves from one living thing to another along the food chain. Animals that eat plants are called herbivores, animals that eat both plants and animals are called omnivores, and animals that eat *only* other animals are called carnivores. Ultimately, all members of a food chain depend on the energy from the sun that green plants transform into food energy. The sun provides energy for the grass, the grass for the caterpillars that eat the grass, and so on.

Students may want to use arrows to show animals moving toward their food. It may be necessary to help students recognize their thinking, as in the following example: "Does your arrow show that the frog hops toward the fly to get food? Now, can you draw the arrow to show which way the food energy is going? Does eating the fly give energy to the frog?" As they draw food chains in this unit, the students will better understand how the sun's energy passes through food chains.

Food Webs

Food webs are more complex than food chains. They consist of many food chains that are interconnected. The following example is a series of food chains, which together make a food web.



Vocabulary/Glossary

carnivore – an animal that eats only animals
community – all the plants and animals that live in one place, and that interact and depend on one another.
energy – the capacity for change: all living things need energy from food to live and grow.
food chain – transfer of energy in sequence, for example, from green plants, to animals that eat plants, to animals that eat other animals.
food web – a network of food chains that are interconnected within a particular community.
herbivore – an animal that eats only plants.
interact – to influence one another
omnivore – an animal that eats both plants and animals

Activity

(A) Have each student draw on a piece of paper a plant or animal from the local countryside. Ensure the class produces a wide spread of life forms (so you don't have an entire class of maize, for example). One should be the Sun.

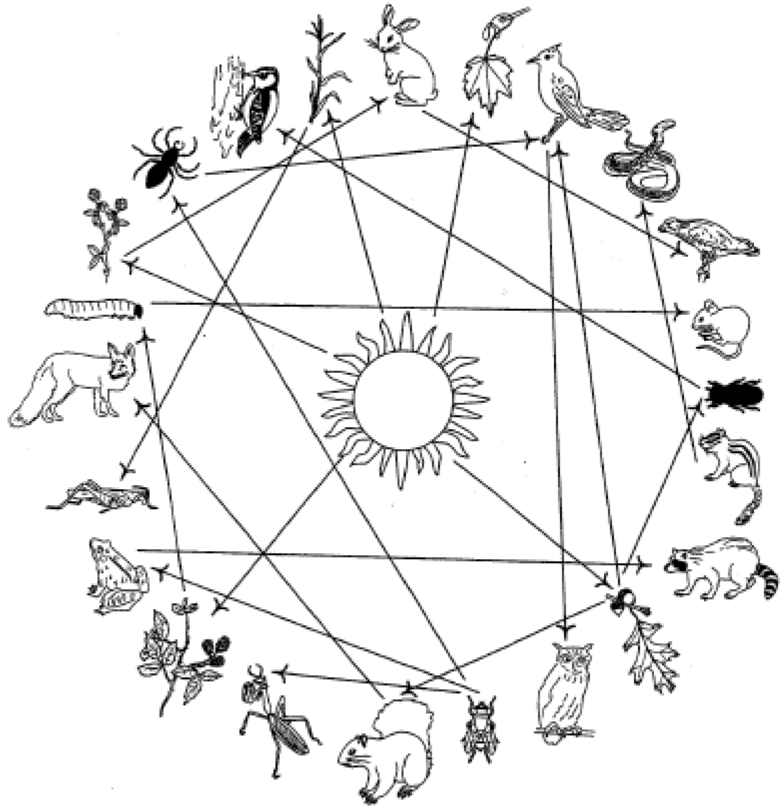
(B) Tell the students that they will make a food web. Have them stand in a circle and introduce themselves as the plant or animal they represent. The student with the sun picture should stand in the centre. They should look around and ask themselves:
Who in the circle could I give my energy to? (Who might eat me?)
Who in the circle could give me energy? (Whom could I eat?).

(C) Explain that the ball of yarn represents sunbeams, or energy from the sun.
Ask the student representing the sun to hold the end of the yarn tightly and toss the ball to someone who can use that energy (a green plant). When a student representing the green plant catches the ball of yarn, he or she should hold a piece of the yarn and throw the ball to someone else who could use the energy. For example, the sun might throw the yarn to the grass, the grass to the grasshopper, and the grasshopper to the meadowlark. After the yarn reaches a carnivore, break it off to represent one food chain. (Explain that humans, hyenas etc. are omnivores and can end a food chain, or they could be eaten by a carnivore.)

Ask: How can all these other plants and animals get the energy they need?
(Through different food chains)

(D) Return the yarn to the sun to start another chain. This time the sun might throw its energy to the grass, the grass to the field mouse, and the field mouse to a great horned owl. Again, break the yarn, throw it back to the sun, and have the sun start another chain. Continue making chains until every student holds at least one strand of yarn.

A view from above might look like this (animals from original example):



Ask:
Have we made food chains? (Yes, lots of them!)
What do all of our food chains together look like? (A food web.)
What is the difference between a food chain and food web? (A food web is made up of several food chains. A web is more complicated than a chain because it has connections among the chains.)
Who is holding the most pieces of yarn? (The sun.)
Why? (Because each food chain starts with the sun.)
Who else is part of many food chains? (Green plants).
What would happen if all the green plants died? (Nothing else in the food web could survive.)

Ask:
How could we show what could happen if one kind of plant, such as all the clover died? (The student representing clover could pull out his or her pieces of yarn and sit down.)
If all the clover is gone, who may have trouble getting enough food?
(Identify all the animals that were in food chains that included clover.
Whoever had yarn pulled out of their hands might have trouble getting enough food without the clover.)
What happened to our food web? (It is much thinner, less complex, and less strong.)
Why should we be concerned about each kind of plant or animal?
(Because other plants and animals in the food web may depend on it.)
Emphasize that each group is important and applaud each in turn.
Will the carnivores please show their teeth?
Will the omnivores please shake a leg?

Will the herbivores please wink an eye?
Will the only living things that can make food using the sun's energy – green plants – please take a bow?
Collect the "Who Eats Who" sheets to save for another activity.

Extensions

(E) Have students identify food chains from other ecosystems (forest, wetland, marine, etc.) and make pictures of the plants and animals from that ecosystem, using arrows to indicate the flow of energy.

(F) Students can learn about the plant or animal they represented in the food web activity and write a report, tell a story, or make an illustration about the plant or animal to share with the class.

Adapted from Project LEAP: Learning about Ecology, Animals, and Plants, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 14853.

HEALTH I - Activities

A major innovation of the Under African Skies 2002 venture was the inclusion of health education into the range of subjects taught. The modules for this unit are still very much in a state of flux, and the breadth of the field is such that it has not yet been possible to develop and test modules for the headings. We provide here two original units developed by Cosmos Education members, followed by discussion topics we have covered in the past. Finally there is some background information on topics that have proved an interesting challenge to discuss with the students.

Contents

(1) Disease Detective

Contributed by Rob Becker and Amy Vittor

Objectives:
1. Empowerment of youth to make a difference in their community by identifying problems and obtaining tools to solve them
2. Introducing the idea that addressing the root causes can be more effective than simply treating the symptoms
3. Introduce mechanisms of disease transmission
4. Illustrate the roles of various professionals (doctor, reporter, public health professional)

Overview

We are going to try to engage the students by ‘performing’ a play in which the students will take part. (this is just one idea – there are other ideas to brainstorm upon). There will be a large map of a village or town, depending on context, at the front of the class around which the play will be based. The students will be asked to take on the roles of a reporter, a doctor, health care worker (epidemiologists), and sick people. The rest of the class will function as the “private eye”; at regular intervals they will be asked to explain elements of the spread and nature of the disease. The health care worker will then enact these answers, reinforcing the concepts. Each of the characters will be wearing distinguishing articles of clothing (doctor’s coat, a hat for the reporter, and a tie for the health care worker), and we will feed them their lines on flash cards.

The Disease Play

The scenario will be introduced by presenting a person with diarrhoea consulting a doctor about his/her condition. This person represents the first case in a disease outbreak (Day 1). The doctor provides treatment, but cannot address the root cause. Through this first scenario on 'day 1', the concept of oral re-hydration therapy will be presented as a way of dealing with diarrhoea. On Day 2, three more people get sick. The location of the cases will be mapped as the play unfolds. On Day 3, ten people are sick. At this point, several questions are posed to the students (e.g. wait a minute, the doctor can't treat all these people…What's going on? What can we do about this?). The reporter presents the facts and answers to the questions as they arise. The students will be asked to identify the source of the problem by observing the map with the cases (which are geographically clustered). Day 4, the health worker then steps in to test the sources suggested by the students (e.g. wells, latrines, animals), and determines the culprit by examining the microbes. Eventually, we would like to make this a sort of "choose your own adventure" type of play where the next few days play out according to what the students decide to do.

At the end, the case will be summarized, and the message will be conveyed that the students can make a difference in the health of their communities by understanding the nature of the diseases. This will be a brief segue for introducing other modes of disease transmission. We will then use a few posters to demonstrate different mechanisms of disease transmission (e.g. HIV, malaria, tuberculosis). The content of the posters can be specific for the predominant health concerns in the areas we are visiting.

<u>Supplies</u>

2 Maps
Posters of pathogens
Red dots (to identify cases)
Flash cards with lines
Doctor's coat
Reporter's hat
Health care worker's tie
Salt
Sugar
Beakers/containers

(2) Water Filtration

Contributed by Eric Wanless

Aim: Look at the importance of water filtration and ways to accomplish it using simple means – examine effectiveness of these various methods

(i) Introductory Discussion

- Illicit input from students. Why do they think people get sick from drinking certain waters? Dirt? Faeces?… Pathogens?
  - All these things contribute to people getting sick. Faeces contains lots of pathogens (can talk about why if it comes up at this point).
  - Agricultural runoff leads to dirty looking water, this is increased bio-content and it makes things easy for the little buggers. The have lots of food to eat.

Lets take a quick closer look at the mechanisms for getting sick from bad water.

- Quickly run through concepts of microscopic organisms causing sickness.
  - Transmitted primarily through faecal oral route.
  - Emphasize size of organisms. You can't see them, but they still make you sick.
  - The little creatures eat your food from the inside, stealing it from your body even though you are still eating.
  - They attack your blood so they can use it to reproduce and make even more of them.

- Where do these little guys come from?
  - People and animals that are already sick go poop. Their faeces have the little organisms in them and they spread to the water, where they are ingested by healthy kids who later become ill.
  - What types of waters are more likely to have these little guys in them?
    - ⇨ Where people are dumping lots of trash and waste into rivers.
    - ⇨ Stagnant ponds where animals congregate for water and poop.
    - ⇨ Areas with concentrated agricultural runoff (field outlets)

- How do we get rid of these things?
  - Pass water through holes smaller than the organisms (possible demo with sifting sand through screen to take out larger rocks).

    - Make the water uninhabitable for organisms by adding chemicals or changing temperature (boiling facts), use UV rays from the sun to kill some organisms.

(ii) Problem Solving: Time to try and filter water!

Task: Filter out suspended solids from a bucket of water.

Materials:

- Two containers (one full of muddy water, the other empty)
- 2 liter coca cola bottle with bottom cut off
- wire screen
- sand and dirt
- ground up charcoal (maybe)
- brush
- cotton t-shirt (maybe)

Basic Concept: Students will apply what they just learned to create a minimal sand-bed filter.

This can be done in several ways. Ideally they will use the coca cola bottle to contain a filter made from leaves, sand, charcoal, and cotton t-shirt (if necessary). The wire screen serves as a base for the brush (leaves, small twigs). The brush serves as a base for the sand. The sand serves as a surface for the charcoal. This set-up can be prompted with a basic schematic (not showing much in the way of actually constructing the filtering layers).

After constructing the filter they then pour the water in the dirty bucket into the empty bucket through the filter. Done correctly this should remove most of the suspended solids. If the sand and charcoal is passing through the base layer of brush the cotton t-shirt could be used to remedy this.

Follow up: The students should see that most of the dirt in the water has been filtered through. If this is not the case the follow up is still valid in that the students just witnessed a filter not being small enough to filter out contaminates.

Discussion will be prompted with the following questions.

- Is the water that you just filtered safe to drink if there were originally small pathogens (little bad guys) in it?
    - This question leads to a discussion of scales. The dirt, even though it is still pretty small, is not nearly as small as all the little organisms living in the water that make you sick
- How small are these little bad guys?
    - 1,000,000,000 times smaller than a meter. If the dirt that you just filtered out were the size of your house, the little bad guys would be as small as the smallest grain of sand.
- How can you be safer in drinking water (keeping in mind what we talked about in the beginning)?
    - Stay away from drinking near livestock watering areas.

- Don't drink water with high organic content (really opaque)
- It is important to not let feces into a water supply (if possible)

Ideal Shared Knowledge in Conclusion

After going through this module the students have

- Gained some insight into the scale of pathogens in the environment
- Learned the basic concepts of filtering
- Learned about basic sources of pathogens
- Applied what they have learned to construct a working device, becoming engaged in experiential learning

(3) Discussion Topics

In previous Under African Skies ventures we have often engaged in discussion sessions with students about health and related issues. These units have tended to be quite freeform, with discussion covering some of the following topics:

(1) Personal Hygiene
: Definition of Personal Hygiene
: General Hygiene-How to stay healthy
: Illness associated with poor hygiene
: waste management

(2) Common water borne diseases i.e Cholera and Typhoid
Prevention
sanitation and safe water

(3) Sexuality and Gender(Reproductive Health)
definition of gender roles
some common myths about sexuality
responsible sex

(4) STDs and HIV/AIDS
STDs i.e herpes, syphilis, gonorrhea
HIV/AIDS: the basics
transmission
protection methods

(5) Drug abuse
Definition
Types of Drugs – palliative, narcotics, etc
Causes and Effects
How to avoid

Health II – Some Background Information

(1) Sexually Transmitted Diseases
(2) HIV/AIDS: the Basics
(3) The HIV/AIDS epidemic and young adults

(1) Sexually Transmitted Diseases

STDs are illnesses that are passed from one person to another by sexual intercourse or other intimate contact. As such, they are infectious diseases. That means they are caused by organisms that invade the body. Many common STDs such as syphilis, gonorrhea and chlamydia infections are caused by different types of bacteria. Viruses are responsible for several other types of STDs including genital herpes, genital warts and AIDS, which is caused by the human immunodeficiency virus (HIV).

STDs can permanently damage a person's health. Females who aren't treated and cured may never be able to have children. Certain STDs can be passed to the fetus during pregnancy and birth. Some STDs can cause a lifetime of health problems or even death.

Many STDs can be cured, but others cannot. Antibiotics are very effective against STDs caused by bacteria. A few others caused by fungi and parasites also respond well to treatment. On the other hand, STDs caused by viruses can't be cured. Current treatments can only help control symptoms or prevent recurrences.

Know and Look For Symptoms

If there's even the slightest chance you could have been exposed to a sexually transmitted disease, you need to be aware of and look for the symptoms. Symptoms of some of the most common types of STDs are listed in the chart below. Some of the most common symptoms are sores and blisters on or near the sex organs or mouth; unusual discharges from the penis or vagina; itches, rashes and bumps on the sex organs and other parts of the body; and burning pain during urination. But symptoms of some STDs are mild and may go unnoticed.

If you Suspect You Have an STD

If you have the slightest suspicion that you or your partner have an STD, seek medical attention immediately. When diagnosed early and dealt with promptly, most STDs can be treated. Contact your doctor or other health worker. Don't let embarrassment prevent you from seeking prompt treatment.

If you are diagnosed with a STD, you'll need to do the following:

- Tell your sexual partner(s) to get tested immediately.
- If you don't want to do it yourself, ask your health-care professional to contact him or her.
- Abstain from all sexual activity until your health-care provider says it's safe.
- Follow instructions and prescriptions exactly. Be sure to have a follow-up examination to see if the treatment is working.

Common STDs

STD	Symptoms
Chlamydia	No symptoms; or pain and burning when urinating, discharge
Crabs	Severe itching
Cytomegalovirus (CMV)	No symptoms; or fever, fatigue; or damaged immune systems
Genital herpes	Pain and burning when urinating, red bumps/blisters in genital area
Genital warts	Bumpy warts on/near genitals
Gonorrhea	Pain or burning when urinating, yellow discharge
Hepatitis B	Nausea, vomiting, stomach pain, yellow skin
HIV/AIDS	Recurrent fever, unexplained and rapid weight loss, swollen lymph glands, fatigue, diarrhoea, appetite loss, white spots or unusual blemishes in mouth
Syphilis	Chancre sore, rash, genital ulcers
Trichomoniasis	Itching in/around vagina, strawberry-coloored rash

Protection from STDs

The following are the three best methods to prevent infection from HIV and other sexually transmitted diseases:

(1) Restrict sexual relations to one uninfected partner who in turn only has sexual relations with you.
(2) Use a condom during sexual intercourse
(3) Abstain from sex altogether.

While abstinence is highly recommended for adolescents, it is highly likely that at some point in their adulthood (or earlier), the pupils will feel a strong desire not to continue abstaining from sex. It is thus essential that pupils know about condoms, as the chances are high they will need to use them at some point.

Several studies have demonstrated that latex condoms are highly effective in preventing HIV transmission when used correctly and consistently. These studies looked at uninfected people considered to be at very high risk of infection because they were involved in sexual relationships with HIV-infected persons. The studies found that even with repeated sexual contact, 98-100% of those people who used latex condoms consistently and correctly remained uninfected.

(2) HIV/AIDS: the basics

During Under African Skies summer 2002, we encountered an enormous range of preconceptions about HIV and AIDS. To prepare you for questions you may get asked in the course of the journey, here follows a summary factsheet of the medical issues of HIV and AIDS. (Source: *Centers for Disease Control – CDC*, *San Francisco AIDS Foundation* and *AIDS.ORG*)

(1) HIV and AIDS

HIV is the virus that causes AIDS. Over time, infection with HIV (Human Immunodeficiency Virus) can weaken the immune system to the point that the system has difficulty fighting off certain infections. These types of infections are known as opportunistic infections. Many of the infections that cause problems or that can be life-threatening for people with AIDS are usually controlled by a healthy immune system. The immune system of a person with AIDS has weakened to the point that medical intervention may be necessary to prevent or treat serious illness.

Currently, the average time between HIV infection and the appearance of signs that could lead to an AIDS diagnosis is 8-11 years. This time varies greatly from person to person and can depend on many factors including a person's health status and behaviours.

H - Human: because this virus can only infect human beings.
I - Immuno-deficiency: because the effect of the virus is to create a deficiency, a failure to work properly, within the body's immune system.
V - Virus: because this organism is a virus, which means one of its characteristics is that it is incapable of reproducing by itself. It reproduces by taking over the machinery of the human cell.

A - Acquired: because it's a condition one must acquire or get infected with; not something transmitted through the genes
I - Immune: because it affects the body's immune system, the part of the body which usually works to fight off germs such as bacteria and viruses
D - Deficiency: because it makes the immune system deficient (makes it not work properly)
S - Syndrome: because someone with AIDS may experience a wide range of different diseases and opportunistic infections.

(2) Transmission

HIV can be transferred through the following bodily fluids: Blood (including menstrual blood) , Semen ,Vaginal secretions Breast milk

The following "bodily fluids" are NOT infectious: Saliva, Tears, Sweat, Faeces, Urine

The following activities allow HIV transmission:

- Unprotected sexual contact.
- Direct blood contact, including injection drug needles, blood transfusions, accidents in health care settings or certain blood products
- Mother to baby (before or during birth, or through breast milk)

Sexual intercourse (vaginal and anal): In the genitals and the rectum, HIV may infect the mucous membranes directly or enter through cuts and sores caused during intercourse (many of which would be unnoticed). *Vaginal and anal intercourse is a high-risk practice.*

Oral sex (mouth-penis, mouth-vagina): The mouth is an inhospitable environment for HIV (in semen, vaginal fluid or blood), meaning the risk of HIV transmission through the throat, gums, and oral membranes is lower than through vaginal or anal membranes. There are however, documented cases where HIV was transmitted orally, so we can't say that getting HIV-infected semen, vaginal fluid or blood in the mouth is without risk. *However, oral sex is considered a low risk practice.*

Sharing injection needles: An injection needle can pass blood directly from one person's bloodstream to another. It is a very efficient way to transmit a blood-borne virus. *Sharing needles is considered a high-risk practice.*

Mother to Child: It is possible for an HIV-infected mother to pass the virus directly before or during birth, or through breast milk. Breast milk contains HIV, and while small amounts of breast milk do not pose significant threat of infection to adults, it is a viable means of transmission to infants.

HIV and Kissing: Casual contact through closed-mouth or "social" kissing is not a risk for transmission of HIV. Because of the potential for contact with blood during "French" or open-mouth, wet kissing, CDC recommends against engaging in this activity with a person known to be infected. However, the risk of acquiring HIV during open-mouth kissing is believed to be very low. CDC has investigated only one case of HIV infection that may be attributed to contact with blood during open-mouth kissing. In this case both partners had extensive dental problems including gingivitis (inflammation of the gums). It is likely that there was blood present in both partners' mouths making direct blood to blood contact a possibility.

You can NOT get HIV from the following kinds of contact: shaking hands, hugging, using a toilet, drinking from the same glass, or the sneezing and coughing of an infected person.

HIV is a fragile virus that does not live long outside the body. HIV is not an airborne or food borne virus. HIV is present in the blood, semen or vaginal secretions of an infected person and can be transmitted through unprotected vaginal, oral or anal sex or through sharing injection drug needles.

(3) Prevention

The following are the three best methods to prevent infection from HIV and other sexually transmitted diseases:

(1) Restrict sexual relations to one uninfected partner who in turn only has sexual relations with you.
(2) Use a condom during sexual intercourse
(3) Abstain from sex altogether.

(These methods are also stated in the STD section above, but we see no harm in reiterating them for quick reference!) While abstinence is highly recommended for adolescents, it is highly likely that at some point in their adulthood (or earlier), the pupils will feel a strong desire not to continue abstaining from sex. It is thus essential that pupils know about condoms, as the chances are high they will need to use them at some point.

Several studies have demonstrated that latex condoms are highly effective in preventing HIV transmission when used correctly and consistently. These studies looked at uninfected people considered to be at very high risk of infection because they were involved in sexual relationships with HIV-infected persons. The studies found that even with repeated sexual contact, 98-100% of those people who used latex condoms consistently and correctly remained uninfected.

(4) HIV Tests

Types of HIV test: The combination of an Eliza/Western Blot **HIV Antibody Test** is the accepted testing method for HIV infection. This combination test is looking for the **antibodies** that develop to fight the HIV virus. There are two ways to conduct this test. Either through a **blood draw** or through the "**Orasure**" method (a sample of oral mucus obtained with a specially treated cotton pad that is placed between the cheek and lower gum for two minutes). Both forms, by blood draw or orally, have the same accuracy with their results.

Other tests that you will hear about are **Viral Load** tests. These tests are used by physicians to monitor their patients who have already tested positive for HIV antibodies. Viral Load tests are very costly and should not be used to determine if one is HIV positive.

A positive result means: You are HIV-positive (carrying the virus that causes AIDS). You can infect others and should try to implement precautions to prevent doing so.

A negative result means: No antibodies were found in your blood at this time.

A negative result does NOT mean:

- You are not infected with HIV (if you are still in the window period).
- You are immune to AIDS.
- You have a resistance to infection.
- You will never get AIDS.

If you test positive:

Testing positive for HIV means that you now carry the virus that causes AIDS. It does not mean that you have AIDS, nor does it mean that you will die. Although there is no cure for AIDS, many opportunistic infections that make people sick can be controlled, prevented or eliminated. This has substantially increased the longevity and quality of life for people living with AIDS.

If you test positive, the sooner you take steps to protect your health, the better. Early medical treatment, a healthy lifestyle and a positive attitude can help you stay well. Prompt medical care may delay the onset of AIDS and prevent some life-threatening conditions. It is important to know that a positive HIV test should always be confirmed, to be sure that it is a true positive. If your test result is positive, there are a number of important steps you can take immediately to protect your health:

- See a doctor, even if you don't feel sick. Try to find a doctor who has experience treating HIV. There are now many new drugs to treat HIV infection. There are important tests, immunizations and drug treatments that can help you maintain good health. It is never too early to start thinking about treatment possibilities.
- Have a tuberculosis (TB) test done. You may be infected with TB and not know it. Undetected TB can cause serious illness. TB can be treated successfully if detected early.
- Recreational drugs, alcoholic beverages and smoking can weaken your immune system. There are programs available to help you stop.
- Consider joining a support group for people with HIV infection or finding out about other resources available in your area, such as HIV/AIDS-knowledgeable counsellors for one-on-one therapy. There are also many newsletters available for people living with HIV and AIDS.

(5) HIV and other Sexually Transmitted Diseases

Having a sexually transmitted disease (STD) can increase a person's risk of becoming infected with HIV, whether or not that STD causes lesions or breaks in the skin. If the STD infection causes irritation of the skin, breaks or sores may make it easier for HIV to enter the body during sexual contact. Even an STD that causes no breaks or sores can stimulate an immune response in the genital area that can make HIV transmission more likely. See the previous unit for more information on STD’s.

(3) The HIV/AIDS Epidemic and Young Adults in Sub-Saharan Africa

This section is a quick-look guide to the HIV/AIDS epidemic, to support our efforts to cover sexual health with the students. Information from this section is taken from the World Health Organisation and UNICEF publications "Young People and HIV/AIDS" [YP] and "AIDS epidemic update," [AU] published June and December 2002 respectively. Both can be downloaded for free from the following websites:
http://www.who.int/hiv/pub/epidemiology/epi2002/en/
http://www.unicef.org/pubsgen/youngpeople-hivaids/

The scale of the epidemic

According to World Health Organisation figures collected at the end of 2002, some 42 million people worldwide were infected with AIDS/HIV, of which over half lived in Sub Saharan Africa.

Number of adults and Children estimated to be infected with HIV/AIDS, end of 2002 [YP].

Global Totals for 2002:

	Living with HIV/ AIDS	Newly infected	Deaths from AIDS
Total	**42 million**	**5 million**	**3.1 million**
adult men	19.4 million	2.2 million	1.3 million
adult women	19.2 million	2 million	1.2 million
Children under 15	3.2 million	800,000	610,000

The scale of the epidemic in Sub-Saharan Africa

Below is a chart of the percentage of the population infected with HIV/AIDS. Young people (age 10-24) make up approximately 35-40% of the total population of these countries [YP].

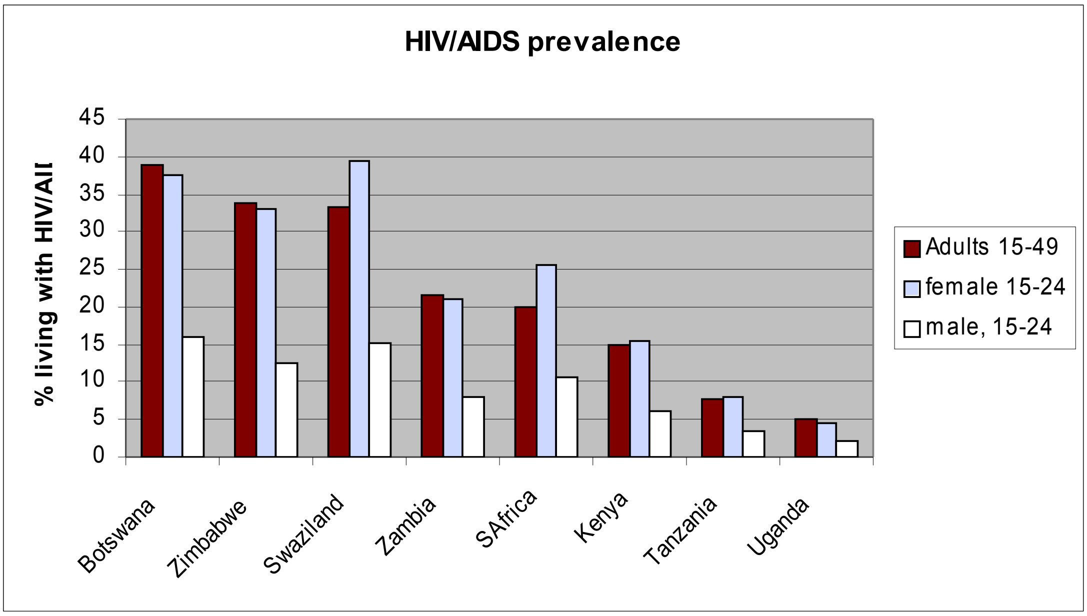


Chart 1: HIV/AIDS prevalence amongst adults (15-49) and the young. [YP].

Sexual activity amongst young adults

One aspect of the sexual health issue that is vital to get across to the students is its relevance to them from an early age. Roughly 8-35% of boys and 5-20% of girls will have their first sexual experience before age 15 (see chart below).

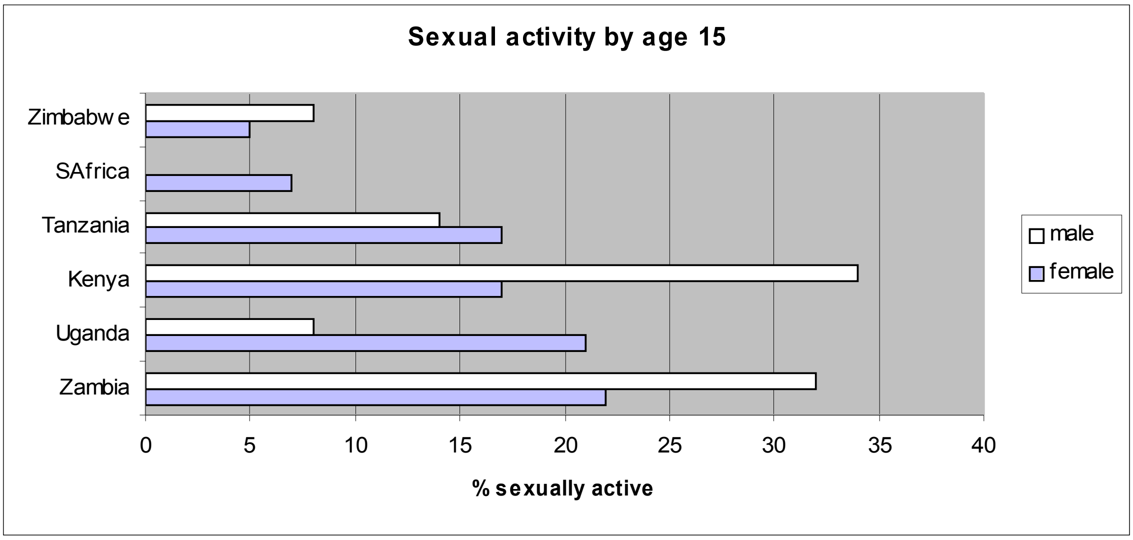


Chart 2: Percentage of children who have their first sexual experience at or before age 15 [YP].

Knowledge of prevention methods

A substantial number of young adults have some awareness of methods to prevent becoming infected with HIV, but there is still some distance to go. Roughly speaking, about two thirds of young women (age 15-24) know the three primary methods of protection against HIV: (1) having sex with one faithful, uninfected partner, (2) consistent condom use, and (3) abstaining from sex. The actual figures are shown beneath.

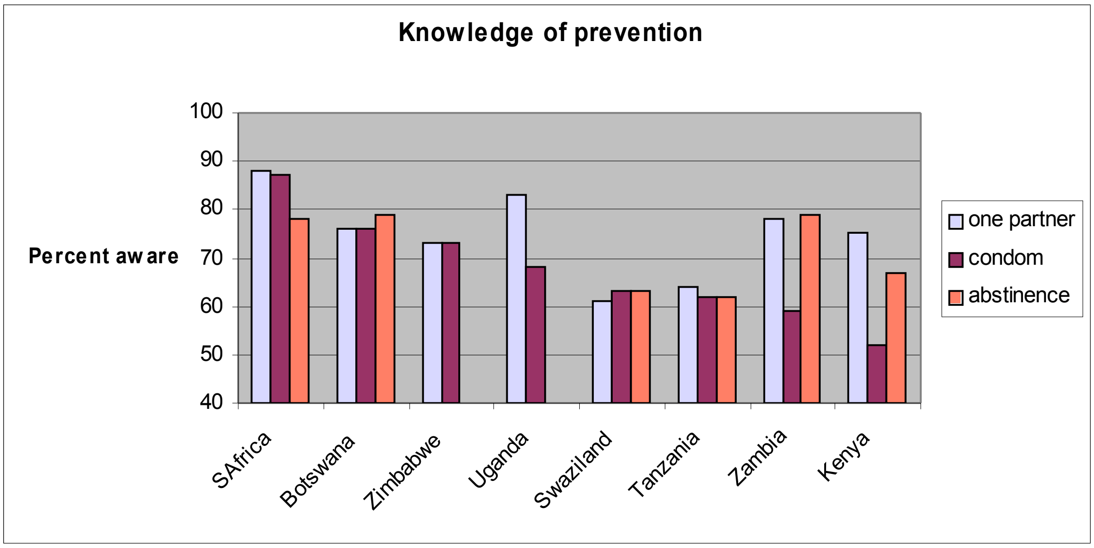


Chart 3: Percentage of young women (15-24 years) aware of the primary methods of protection against HIV/AIDS. Note: figures for "abstinence" are for age group 15-19, as the majority of 20-24 year olds are sexually active [YP].

Theory and Practice

In all the countries visited by Cosmos Education, there is a substantial gap between the proportion of young adults who know how to take preventative action, and those who actually do so. The same is true for getting tested for HIV/AIDS; although most know where to get tested, few actually do so.

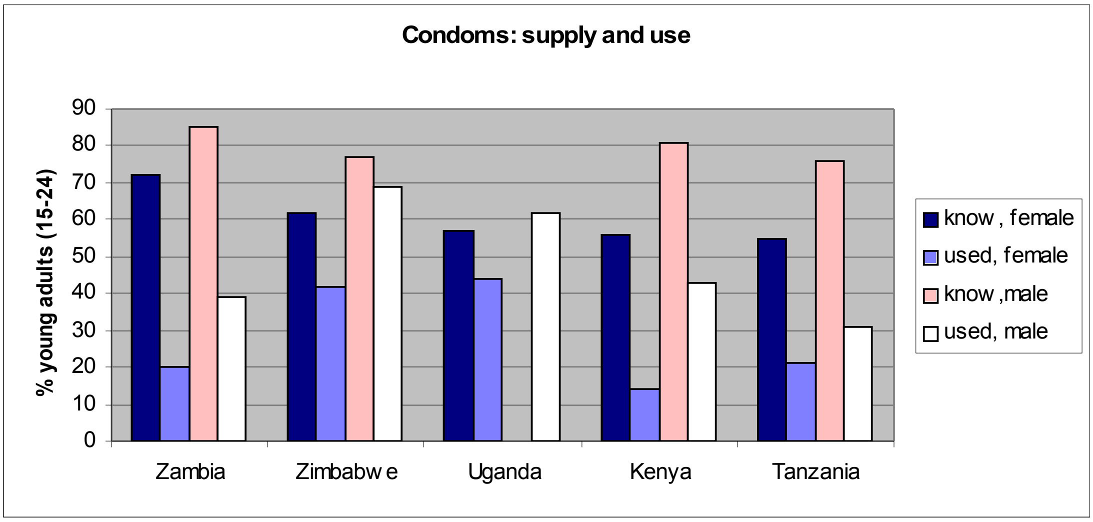


Chart 4: Percentage of young adults (15-24) who know where to find condoms, with the percentage who used a condom during sex with a non-marital, non-co-habiting partner in the last 12 months [YP].

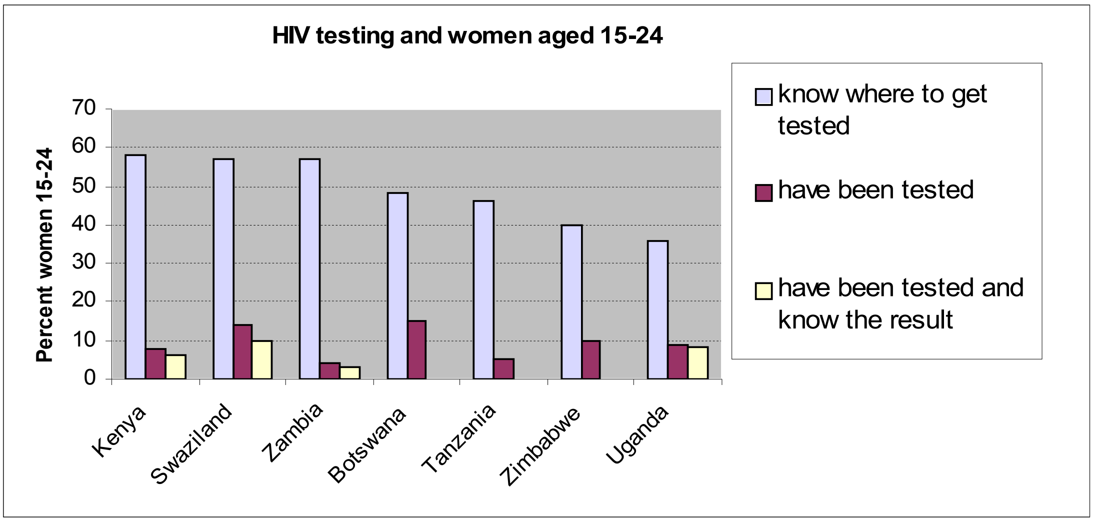


Chart 5: Percentage of young women who know where to get tested fore HIV, along with the proportion who have actually been tested. Of those women who are tested, 10-30% are not informed of the result of their tests.

<u>Why do young African women appear more prone to HIV infection?</u>

Unlike other regions undergoing the HIV/AIDS epidemic, in Sub Saharan Africa, the prevalence is particularly high amongst young women. This appears to be due to a combination of factors. The following is quoted from the WHO Aids Epidemic Update, 2002:

"Women and girls are commonly discriminated against in terms of access to education, employment, credit, health care, land and inheritance. With the downward trend of many African economies increasing the ranks of people in poverty, relationships with men (casual or formalized through marriage) can serve as vital opportunities for financial and social security, or for satisfying material aspirations. Generally, older men are more likely to be able to offer such security. But, in areas where HIV/AIDS is widespread, they are also more likely to have become infected with HIV. The combination of dependence and subordination can make it very difficult for girls and women to demand safer sex (even from their husbands) or to end relationships that carry the threat of infection.

Studies have shown that young women tend to marry men several years older, and that their risk of infection increases if a husband is three or more years older than they are. Meanwhile, ignorance about sexual and reproductive health and HIV/AIDS is widespread. In countries with generalized epidemics in Africa, up to 80% of women aged 15–24 have been shown to lack sufficient knowledge about HIV/AIDS. This, combined with the fact that young women and girls are more biologically prone to infection (the cervix being susceptible to lesions), helps explain the large differences in HIV prevalence between girls and boys aged 15–19." [AU]

Positive Signs

Recent anecdotal evidence suggests that awareness campaigns and prevention programs are starting to make a difference in the fight against the epidemic. For example, in South Africa the prevalence rate of HIV amongst pregnant women under 20 showed a net fall, from 21% in 1998 to 15.4 % in 2001. In Uganda the prevalence among pregnant women aged 15-19 has fallen steadily between 1995 and 2001. Condom use by single women aged 15-24 almost doubled during this period, and more women in this age group delayed sexual intercourse or abstained completely. To quote the World Health Organisation again:

"Notwithstanding such progress, a lot of ground still needs to be made up. The vast majority of Africans—more than 90%—have not acquired HIV. Enabling them to remain HIV-free is a massive challenge, with the protection of young people a priority." [AU]

The Cosmos Education Resource Network

In order to serve as a continuing resource for the teachers and students in the school we visit, Cosmos Education is constantly working to collect educational materials that canned be shipped off to schools in our network. At the moment, this network consists of more than 60 schools.

As part of our work with teachers and students, we try to identify the needs of the schools so we can better serve them as a resource. Several schools gave us specific lists of materials that could help them with their science programs. We have generated a master list and ask that if you have any thoughts, suggestions or means of getting donations that might be of help, please contact us.

The following list of items was generated during our Under African Skies 2001 Education Expedition. The items below were contained in lists gathered from the schools we visited. Many of the lists were generated by science teachers and thus this list is by no means all inclusive of the general needs in the schools. The list is organized into sections: a general list of equipment we observed to be lacking in schools and a specific list of requests from science teachers. Subjects such as history, writing, languages, etc. would greatly benefit from book donations and other items in the general list. Computers and computer equipment are listed at the bottom in a separate list. For many of the schools computer donations would be beneficial, however for a significant portion of the schools in our network, access to a reliable source of electricity presents a more fundament problem. For this reason, included in the third list are items such as solar panels and other alternative sources of energy.

General Equipment

Books for libraries
Pens, pencils, chalk
Posters for classrooms (maps, tables, pictures)
Paper

Technical Equipment

Computers
Solar Panels
Radios
Phones

More Science Equipment

Tripod stand
Test tubes, beakers, flasks, and various chemistry bottles and containers
Litmus paper
Test tube holders
Burette
Pipette
Glass blocks and prisms
Gyroscope
Telescope
Chemicals: copper, sulphate, carbonate, sodium, chlorine, calcium, potassium, iodine
Scalpel

Science Equipment

Charts
Globe
Lenses
Meter stick
Stop watch
Rain gauge
Weighing scale
thermometers
Bulbs
Bulbs holders
Paper clips
Magnifying glass
Switches
Batteries
Magnets
Electrical plugs
Electrical wires
Microscope
Voltmeter
Galvanometer
Ammeter
Variable Resistors
Soldering gun/iron
Callipers
Chemical balance
Platinum wire
Wire gauze
Litmus paper

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The Australian Academy of Sciences	http://www.science.org.au/
Centre for Disease Control	http://www.cdc.gov/
Dirtmeister's Science Lab:	http://teacher.scholastic.com/dirt/
The Earth from the Space Shuttle	http://earth.jsc.nasa.gov
Explorescience.com	http://explorescience.com/
The Exploratorium	http://www.exploratorium.edu/
The Hunger Project Africa Prize	http://www.thp.org/prize/
Schoolnet Canada	http://www.schoolnet.ca/
UNICEF	http://www.unicef.org/
The US Department of Agriculture	http://www.usda.gov/
The World Health Organisation	http://www.who.int/en/

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Age Range of Pupils: ________________________________

Head Teacher: ____________________________________

Contact Name: ____________________________________

School Address: ____________________________________
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Telephone / Fax (if applicable): ______________________________

Comments: If you have any comments about our work, please feel free to write them below. If there are any resources you think we could help with through the resource network, please write them here.

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Thank you!