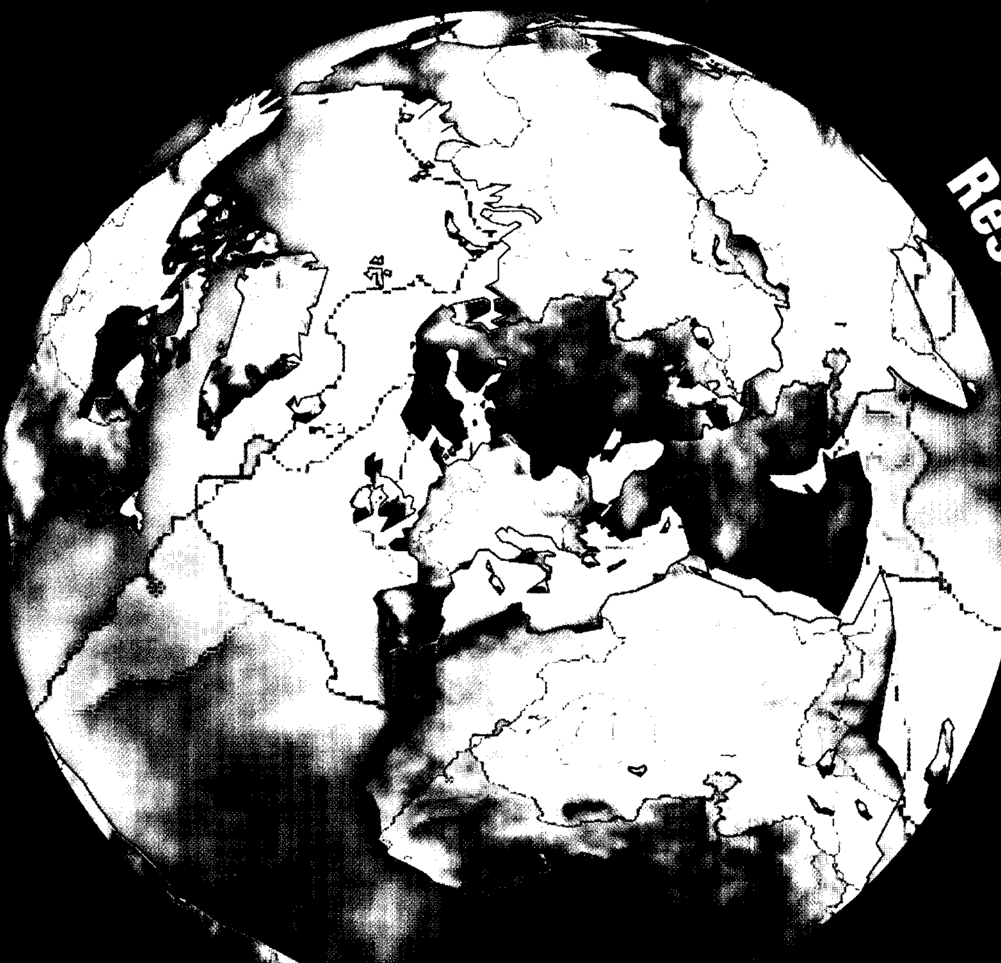
UNESCO Resource Kit

Science & Technology Education



Resources for the 21st

UNESCO Resource Kit

Science & Technology Education

Science for the 21st

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In a world increasingly shaped by science and technology, *scientific and technological literacy* (STL) is a universal requirement if people are not to be alienated in some degree from the society in which they live. It is vital to improve scientific and technological literacy .

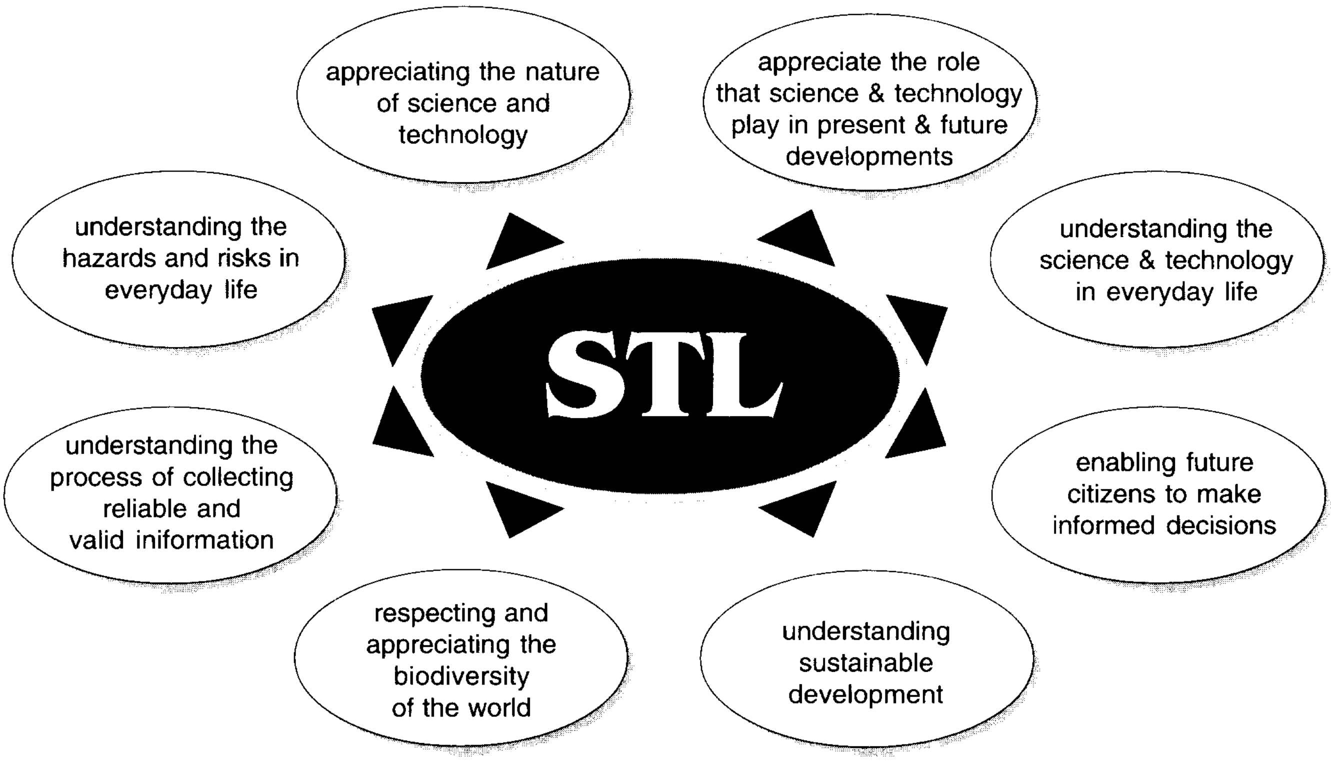
We need, through educational means of all kinds, formal and non-formal, to bring about a much more thorough infusion of scientific and technological culture into society. Only in this way shall we succeed in creating the continuum, the virtuous circle encompassing the establishment of a broad educational base in science and technology, enhanced capacity to cope with change and to pursue development goals, scientifically informed decision making, and finally - completing the circle - expanding investment in human development.

Federico Mayor, Director-General, UNESCO.

Scientific & Technological Literacy (STL)

What is STL?

Scientific and technological literacy is about understanding and applying concepts, process skills, attitudes and values which enable a person to relate science and technology to the life and culture of their own society.



Why teach Scientific & Technological Literacy?

For the teacher, the modules are designed to:

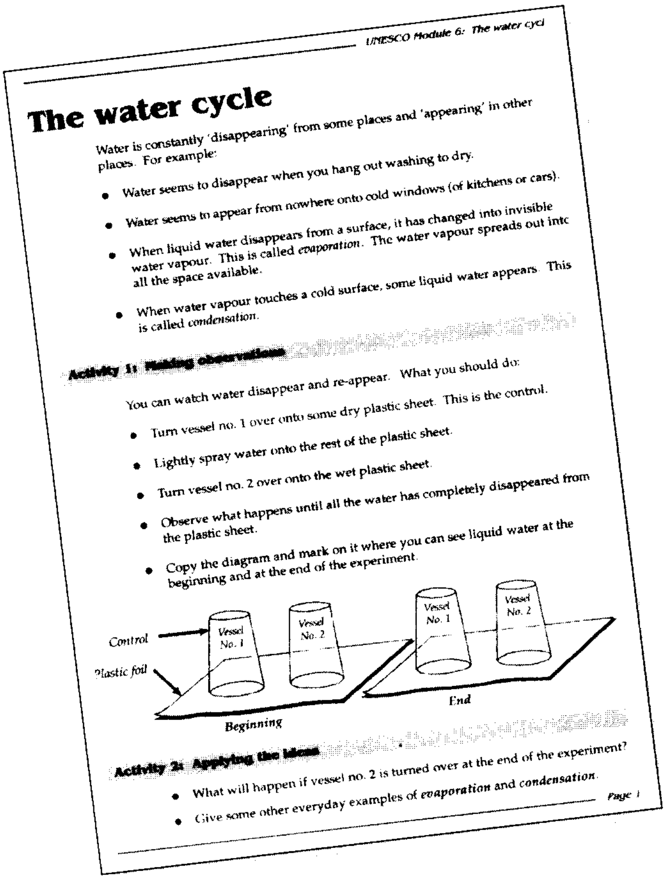
- look at real issues in real situations;
- provide inspirational resource material that is challenging, thought provoking and stimulating;
- supplement regular science and technology teaching;
- provide opportunities for formative and summative assessment;

For the student the modules are designed to:

- involve students in active learning;
- involve students in making informed judgements.

Contents

There are two parts to each module



UNESCO Module 6: The water cycl

The water cycle

Water is constantly 'disappearing' from some places and 'appearing' in other places. For example:

- Water seems to disappear when you hang out washing to dry.
- Water seems to appear from nowhere onto cold windows (of kitchens or cars).
- When liquid water disappears from a surface, it has changed into invisible water vapour. This is called *evaporation*. The water vapour spreads out intc all the space available.
- When water vapour touches a cold surface, some liquid water appears. This is called *condensation*.

Activity 1: Making observations

You can watch water disappear and re-appear. What you should do:

- Turn vessel no. 1 over onto some dry plastic sheet. This is the control.
- Lightly spray water onto the rest of the plastic sheet.
- Turn vessel no. 2 over onto the wet plastic sheet.
- Observe what happens until all the water has completely disappeared from the plastic sheet.
- Copy the diagram and mark on it where you can see liquid water at the beginning and at the end of the experiment.

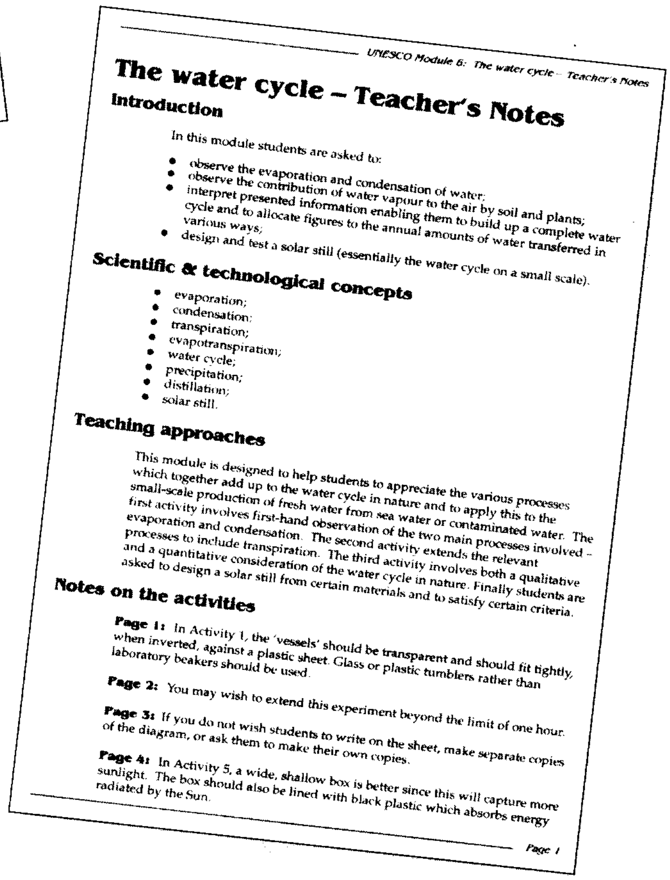
Activity 2: Applying the ideas

- What will happen if vessel no. 2 is turned over at the end of the experiment?
- Give some other everyday examples of *evaporation* and *condensation*.

Page 1

Student's Notes

Pages are designed individually so that teachers can select those which are appropriate to their class, in terms of conceptual demand, previous experience and curriculum requirements. There is a progression in the degree of difficulty of the activities.



UNESCO Module 6: The water cycle - Teacher's Notes

The water cycle – Teacher's Notes

Introduction

In this module students are asked to:

- observe the evaporation and condensation of water;
- observe the contribution of water vapour to the air by soil and plants;
- interpret presented information enabling them to build up a complete water cycle and to allocate figures to the annual amounts of water transferred in various ways;
- design and test a solar still (essentially the water cycle on a small scale).

Scientific & technological concepts

- evaporation;
- condensation;
- transpiration;
- evapotranspiration;
- water cycle;
- precipitation;
- distillation;
- solar still.

Teaching approaches

This module is designed to help students to appreciate the various processes which together add up to the water cycle in nature and to apply this to the small-scale production of fresh water from sea water or contaminated water. The first activity involves first-hand observation of the two main processes involved – evaporation and condensation. The second activity extends the relevant processes to include transpiration. The third activity involves both a qualitative and a quantitative consideration of the water cycle in nature. Finally students are asked to design a solar still from certain materials and to satisfy certain criteria.

Notes on the activities

Page 1: In Activity 1, the 'vessels' should be transparent and should fit tightly, when inverted, against a plastic sheet. Glass or plastic tumblers rather than laboratory beakers should be used.

Page 2: You may wish to extend this experiment beyond the limit of one hour.

Page 3: If you do not wish students to write on the sheet, make separate copies of the diagram, or ask them to make their own copies.

Page 4: In Activity 5, a wide, shallow box is better since this will capture more sunlight. The box should also be lined with black plastic which absorbs energy radiated by the Sun.

Page 1

Teacher's Notes

The heading 'Scientific & technological concepts' is used to indicate where the unit might fit in the curriculum.

Notes on all activities are included, together with suggested answers to all questions.

The design of a module

Each module contains detailed Teacher's Notes as well as information and activity pages for students. Select a module on a topic of interest, and one which matches an appropriate topic on the science curriculum.

Teacher's Notes

UNESCO Module 6: The water cycle – Teacher's Notes

The water cycle – Teacher's Notes

Introduction

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Page 1

◀ Summaries the contents.

◀ Key scientific & technological concepts covered within the unit.

◀ Each activity can be used as an individual unit or as a whole unit.

◀ There are usually three to four activities in a unit and they can be carried out without specific scientific apparatus.

◀ Detailed notes with helpful hints on how to manage the unit.

◀ Any factual information needed by the teacher will be found here.

Information & Activity Papers

All the modules contain a number of activities. Each activity can be used as a stand alone unit or as one of a number of activities on the topic.

Acknowledgements

Module	Name of Unit	Acknowledgements
1	Cars and energy	Pages 1 and 2 are based on extracts from *Cars and the Environment,* a publication of the Science with Technology project, organised by The Association for Science Education and the Design and Technology Association of the UK. Page 3 is based on Unit 41 of *The World of Science,* produced by the Association for Science Education (UK) and published by John Murray.
2	Getting to school	This module was written by Patrick Whittle. It is based on data provided by Kabinet van de Burgemeester, Groenplein 1, B-3500 Hasselt, Belgium. Pages 2 and 3 are based on *Cars and the environment,* a publication of the Science with Technology project, organised by The Association for Science Education and the Design and Technology Association of the UK.
3	Fuels for the future	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
4	Problems with fossil fuels	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
5	Oremulsion	This module is based on a unit edited for UNESCO by Jack Holbrook (ICASE).
6	The water cycle	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
7	Sources of fresh water	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
8	Managing water resources	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
9	Forests for the future	This module was written by Mervi Skyttä, Finland. It draws on materials developed as part of a collaboration between two Finnish organisations: the Science Teachers' Association (BMOL) and the Forest Association (SMY).
10	Tropical rain forests	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
11	Wood as a fuel	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
12	Wood as a structural material	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.
13	Materials made from wood	This module is based on material developed for UNESCO workshops in Argentina, Estonia and Pakistan.

Acknowledgements (continued)

module	name of unit	acknowledgements
14	Understanding biodiversity	This module is based on a module on biodiversity developed for UNESCO by Jean-Paul Orsini, environmental and community consultant, of Swanbourne, Western Australia.
15	Cloning sheep	This module was written by Patrick Reygel (Belgium).
16	Investigating pollution	This module is based on a series of activities developed by Dr Neelima Jerath and colleagues of the Punjab State Council for Science and Technology, India.
17	Sorting out waste	This module is based on Pineapple-Shaped Waste Bins, developed by four Nepalese teachers: Mrs Ishwari Dhungana, Mr Rudra Kafle, Mr Nanda Lal Tripathi and Mr Shanker Man Shrestha. It is Unit 4 in the UNESCO sponsored publication 'Promoting Students' Scientific and Technological Thinking'.
18	Noise pollution	This module is based on a series of activities developed by Dr Neelima Jerath and colleagues of the Punjab State Council for Science and Technology, India.
19	Combined heat and power	This module is based on Unit 37 of The World of Science, produced by the Association for Science Education (UK) and published by John Murray. The information in the module is based on the Gärstad CHP Plant, Linköping, Sweden. Data was supplied by Tekniska Verken i Linköping AB.
20	Solar heating	This module is based on Making use of Renewable Energy, a publication of the Science with Technology project run jointly by the Association for Science Education and the Design and Technology Association (UK). Assistance in developing Making use of Renewable Energy was provided by The Body Shop International.
21	Photovoltaics	This module is based on a unit on photovoltaic systems developed by Paul Rowley for Science Across the World, a project run by the Association for Science Education (UK). For more about Science Across the World, see their website (http://www.bp.com/saw/). The technical data on photovoltaic systems around the world (pages 7-12) were generously provided by BP.
22	Wind power	This module is based on Making use of Renewable Energy, a publication of the Science with Technology project run jointly by the Association for Science Education and the Design and Technology Association (UK). Assistance in developing Making use of Renewable Energy was provided by Longley Farm, West Yorkshire, UK.
23	Alcohol in your body	This module is based on ideas and information from *Organic Chemicals in Everyday Life*, published by the Irish Science Teachers' Association.
24	Testing the quality of food	This module is based on a module developed for UNESCO at a workshop in Nepal, and edited by Dr Sharada D Maharjan and Professor Patrick A Whittle.

Acknowledgements (continued)

Module	Name of Unit	Acknowledgements
25	Understanding eclipses of the sun	This module was written by David Sang, ASE (UK), and is based on material from *Total Eclipse of the Sun: Activities for Secondary Schools* (ASE).
26	Working with numbers	This module is based on a unit devised by Prof. Alan Bishop of Monash University, Australia.

Outline of the modules

1 Cars and energy

In this module, students are asked to:

- consider the energy content of a car, in terms of its construction;
- determine the total fuel and energy consumption of a car during its lifetime;
- develop their understanding of energy transfers in a car;
- understand aspects of the technology of electric cars;
- draw up a comparison of petrol-fuelled and electric cars.

Cars are among the major consumers of energy in developed societies. They also make a major contribution to urban pollution, and to global warming. This module asks pupils to look at the question of energy consumption by cars in quantitative terms. At first sight, electric cars may seem attractive because they do not pollute their local environment. The last part of this module will help pupils to think critically about this idea.

2 Getting to school

In this module, students are asked to:

- Consider how traffic congestion affects their journey to school;
- find out about atmospheric pollution caused by car exhaust emissions;
- identify environmental problems arising from increases in traffic flow;
- study traffic management measures in Hasselt, Belgium;
- suggest possible traffic management measures for their own locality.

The module can be tackled in two ways:
Start either with the consideration of students' own experience of travelling to school (page 1). Then go on to study the problem of exhaust pollution, its effects and control (pages 2 - 4), or to a detailed consideration of the Hasselt traffic management scheme (pages 5 - 8). (These two sections can be used in either order.) Use the discussion of local traffic management on page 9 to tie these different aspects together.

In areas where most pupils walk to school, an alternative approach would be to consider how family members make other regular journeys, eg, to work or to market.

Alternatively, you may wish to build the module into a more extended piece of work involving (for example) speed measurements, traffic monitoring, interviews with local planners and police officers, and surveys of public attitudes.

3 Fuels for the future

In this module, students are asked to:

- extract and apply data about a range of fuels presented in tabular form;
- devise and carry out tests to compare the energy transferred when the same mass of each of a range of fuels is burned;
- suggest why simple methods of **comparing** the energy transferred when different fuels burn are not very accurate ways of **measuring** the energy transferred;
- evaluate more accurate ways of obtaining energy measurements.

In this module students begin by comparing a range of properties of a number of fuels in order to evaluate the suitability of those fuels for a range of different uses. They then devise an experiment to compare the energy transferred when 1 gram of a fuel burns and carry out the experiment on at least two different fuels. Students are shown how to use the results of their experiments to calculate the amount of energy transferred and asked to suggest why their results give much lower figures than the accepted values. Finally students are given details of more accurate ways of measuring the energy transferred when fuels burn and asked to explain why these methods are more accurate.

Outline of the modules (continued)

4 Problems with fossil fuels

In this module, students are asked to:

- interpret information presented in diagram form;
- evaluate the pros and cons of a renewable fuel from a variety of viewpoints and reach a balanced judgement;
- relate differences between fuels to (simple) differences between their molecules;
- follow a detailed set of instructions for preparing a sample of bio-diesel;
- devise and carry out tests to compare various properties of different fuels.

Students begin by interpreting visually presented information about the formation of fossil fuels, some of the effects of burning them and their non-renewable nature. They are then given information about renewable fuels (derived from plants) and asked to identify some advantages and disadvantages of these fuels. Either, or both, of two specific bio-fuels are then explored in more detail:

- the actual and potential uses of ethanol as a replacement for petrol are considered from a number of perspectives;
- students consider what needs to be done to vegetable oils to make a replacement for diesel fuel, actually make a sample of bio-diesel and finally devise and carry out tests to compare their bio-diesel with the original vegetable oil and with normal diesel fuel.

5 Oremulsion

In this module, students are asked to:

- extract and present scientific information from a map;
- compare technical data on two fuels;
- identify criteria for assessing fuels;
- find out about the impact of fuel combustion;
- present ideas about a technological change from a variety of points of view;
- contribute to the production of a balanced report.

The module is designed to help students extend their knowledge of combustion and electricity generation and their impact on the environment. It starts with an exercise which, for many students, may be a revision of ideas about fuel-burning power stations. This part might be set as an introductory homework. In the next part, analysis of data is used as an introduction to the idea that many factors determine the choice of fuel for a power station. Finally, students adopt different roles to consider particular aspects in detail. Some of the necessary information is available within the unit; other information will need to be researched.

6 The water cycle

In this module students are asked to:

- observe the evaporation and condensation of water;
- observe the contribution of water vapour to the air by soil and plants;
- interpret presented information enabling them to build up a complete water cycle and to allocate figures to the annual amounts of water transferred in various ways;
- design and test a solar still (essentially the water cycle on a small scale).

This module is designed to help students to appreciate the various processes which together add up to the water cycle in nature and to apply this to the small-scale production of fresh water from sea water or contaminated water. The first activity involves first-hand observation of the two main processes involved – evaporation and condensation. The second activity extends the relevant processes to include transpiration. The third activity involves both a qualitative and a quantitative consideration of the water cycle in nature. Finally students are asked to design a solar still from certain materials and to satisfy certain criteria.

Outline of the modules (continued)

7 Sources of fresh water

In this module students are asked to:

- interpret data, presented in tabular form, on the distribution of water on Earth and on daily inputs and outputs in humans and transpose these into visual form;
- find out from first-hand practical activity the percentage of water in various fruits and vegetables;
- interpret visually presented information on the various sources of fresh water;
- treat a sample of "raw" water in the same ways that it would be treated by a water company and to understand the purpose of each step in the treatment process;
- undertake tasting tests of various samples of drinking water and relate the tastes to some standard reference solutions.

This module is designed to help students to appreciate the importance of fresh water to humans (and other living things), where this fresh water comes from, how it can be made safe to drink and the effects that the source and any subsequent treatment of the water can have on its taste. All of the activities except tasting water can be done individually or in groups. Tasting should be done individually though judgements about how best to describe the taste are best discussed.

8 Managing water resources

In this module, students are asked to:

- estimate how much water they use each day;
- suggest ways that they could reduce the amount they use;
- compare the savings they could make with the estimated losses from leaking pipes;
- consider competing claims on water resources, present the case for a particular point of view and participate in reaching a balanced judgement;
- compare the amounts of water used by people in different parts of the world;
- consider likely problems in meeting the demand for water during the next quarter century.

This module is designed to help students to appreciate just how much water they personally use and the problems there might be in meeting this demand in different parts of the world or in the future. The first activity involves two different exercises in estimation and the second activity involves adopting the roles firstly of a particular user of water resources and secondly of an impartial decision maker. Presented data is then used both to make comparisons and to anticipate possible future problems.

9 Forests for the future

In this module, students are asked to:

- assess the economic importance of wood products;
- consider where wood products come from;
- survey various aspects of a forest environment;
- investigate the interaction between water and soil;
- estimate the economic value of a forest;
- assess the health of coniferous trees.

The module provides an opportunity for students to consider, in the context of a practical situation, the broad environmental concepts of biodiversity, sustainability, regenerating capacity, productivity etc. These general ideas can be drawn out of the particular context of forestry. Finland is bound by the principles defined at the Rio Conference on Environment and Development (1992) and at the subsequent Helsinki Conference on the Protection of Forests in Europe (1993), and these govern the development of its forestry policies.

About one third of the Earth's land surface is covered by forests. Finland is situated in the boreal coniferous zone and the corresponding figure is two thirds.

Outline of the modules (continued)

9 Forests for the future (continued)

Finnish laws governing forestry are aimed at achieving sustainable management and use of the forests. This involves the stewardship and use of the forests which will maintain their biodiversity, vitality and productivity into the future. This module is designed to help students to gain an appreciation of these ideas and some of the problems associated with achieving them.

The first page sets the scene; after this, you may wish to select particular pages from the module to make up your own sequence of activities relating to the study of a local forest. Groups of students could be set different tasks: investigating the forest's biodiversity, microclimates, soil types, tree density and so on. Then each group could report back to the class and a joint report produced.

10 Tropical rain forests

In this module, students are asked to:

- become familiar with key features of tropical rain forests through interpreting data presented in the form of a map, an illustration and bar-graphs;
- select and use information about the rate, causes and some effects of the destruction of tropical rain forests;
- interpret information about the impact of tropical rainforests (and of their destruction) on the Earth's atmosphere and to relate the likely effect of this to a simple "greenhouse" experiment;
- reconcile differing points of view to reach a balanced judgement regarding an appropriate policy for the remaining tropical rain forest.

The module begins by providing students with an opportunity – via the interpretation of visually presented information – to acquire an appreciation of what tropical rain forests are like and where they are found. They then study written information about why these forests are under threat and the effect of their destruction on soil erosion and bio-diversity. The effects of tropical rain forests (and of their destruction) on atmospheric carbon dioxide levels are then explored and a simple experiment undertaken to show the likely effect of this. Finally, students use information from all the earlier sections of the module, together with additional information and points of view to decide – individually or via group discussion/debate – an appropriate policy regarding tropical rain forests.

11 Wood as a fuel

In this module, students are asked to:

- interpret textual information about the reasons for the fire-wood crisis in many countries despite wood being a renewable fuel;
- suggest possible solutions to the firewood crisis;
- interpret and evaluate data about ways of making cheap, efficient and acceptable alternatives to the traditional fires used for cooking;
- make a simple stove and compare its efficiency with that of a traditional fire.

The module begins with information about the importance of wood as a fuel for billions of people and about why this energy source, though renewable, is not at present sustainable. After brain-storming and then discussing possible solutions to the problem, students are provided with information, via text and diagrams, about a partial solution to the problem – replacing inefficient 3-stone fires with more efficient stoves – and asked to interpret and evaluate this information. Finally, students are given guidelines for making a stove – full-scale or, more probably as a working scale model – and for finding out how much less fuel it needs than an "open" fire to do the same job.

Outline of the modules (continued)

12 Wood as a structural material

In this module, students are asked to:

- interpret visually presented data about the structure and growth of wood;
- plan and carry out comparisons of stiffness and strength using the simple apparatus with which they are provided;
- interpret data on the stiffness and strength of wood and steel and relate this to their densities;
- apply information about why the moisture content of wood varies and how this affects wood to practical situations;
- compare the swelling/shrinking of different types of wood due to changes in humidity.

The module begins by providing students with the opportunity to relate the fact that wood has a grain to its microscopic structure. Details of the microscopic structure are also related to the growth pattern of wood. Students then plan and carry out tests: firstly to compare the stiffness of wood and plastic; secondly, to compare the strength of wood along and across the grain and to relate this to the structure of wood. Data is also provided to enable students to compare the strength and stiffness of wood compared to steel in relation to their densities. Finally, students are given information about the seasoning of wood and data about how seasoned wood swells and shrinks with changes in humidity. These ideas are then applied to practical contexts and students are also asked to compare the amount of swelling/shrinking in different types of wood.

13 Materials made from wood

In this module, students are asked to:

- interpret information (presented in various forms) about how a number of materials are made from wood and about what these materials are used for;
- make some of the materials by a simple small-scale method.

Students are introduced to any – or all – of the following wood products: paper, plywood and chipboard, charcoal. Information about how paper is made and about the amounts we use is presented for interpretation. Step-by-step instructions are then provided for students to make some paper of their own. The internal structure of both plywood and chipboard is examined and related to their consistent strength and stiffness in different directions (unlike wood itself). These properties are then tested on samples of plywood made by students themselves. Data comparing wood and charcoal as fuels and information about how charcoal is made are presented for interpretation. Students then make some charcoal for themselves.

14 Biodiversity

In this module, students are asked to:

- develop their ideas about biodiversity and the interdependence of living creatures;
- identify areas of greater or lesser biodiversity, and the pressures which tend to reduce biodiversity;
- understand the value of biodiversity;
- design and establish a garden which takes account of biodiversity;
- make a mural to celebrate biodiversity and to remind their community of its importance.

Biodiversity is a broad concept. To grasp the scientific idea, pupils need to have some understanding of many ideas from biology: food webs and chains, genetic diversity, ecosystems and so on. This module cannot hope to teach all of these things. Instead, it sets out to convey a general idea of biodiversity and its importance to humans, and to suggest two extended activities (creating a garden and making a mural) which will help to reinforce these ideas.

Outline of the modules (continued)

15 Cloning sheep

In this module, students are asked to:

- discuss the nature of twins;
- develop an understanding of genetic inheritance;
- understand the meaning of the term 'cloning';
- learn about two cloning techniques;
- take part in a debate about the acceptability of cloning.

The module is designed to help students to understand a little about cloning technology and its implications, so that they can better understand items in newspapers and other media on current developments in this field.

A good starting point would be to find a selection of current items about recent developments in this field, ask students to scan them, and then discuss what their current understanding of this field is. (Developments are so rapid, and widely reported, that it would be inappropriate to reproduce any such items here.) Students should feel free to express any fears they may have, make jokes about armies of cloned zombies, and so on. The teacher's role at this stage is to listen, summarise, and point to the need for informed debate on the subject.

This discussion can then lead into the module itself. This provides information about clones and cloning techniques and finishes with some points for debate.

Note that cloning is not the same as genetic engineering, in which the genetic information in a cell is altered, usually by importing genes from another organism. The two technologies often come together, since the techniques for growing individuals from single cells are common to both.

16 Investigating pollution

In this module, students are asked to:

- think about local sources of pollution (air, water and soil);
- learn how to measure air and water pollution;
- survey air and water pollution locally;
- identify sources of air pollution in their own homes;
- establish priorities in the reduction of local pollution, with reference to economic development and a variety of interest groups.

Pollution is a very broad topic, with many aspects - local, national and international; chemical, physical and biological. This module focuses on local sources of air, soil and water pollution and their effects. It only touches on more global aspects of pollution, such as the enhanced greenhouse effect and damage to the ozone layer; also,it does not consider in depth ways of reducing pollution.

17 Sorting out waste

In this module, students are asked to:

- think about the way in which their own waste materials are dealt with;
- learn about different ways of disposing of waste materials, and suggest when these are appropriate;
- investigate how different waste materials behave in different environments;
- put into operation at least one method of encouraging better handling of waste materials.

This module encourages pupils to think about waste materials and their impact on the environment. It helps them to develop their scientific understanding of how waste materials can be dealt with.

The module leads from an assessment of the current situation, through a scientific investigation, to a practical application of what pupils have learned.

Outline of the modules (continued)

18 Noise pollution

In this module, students are asked to:

- identify sources of noise pollution;
- consider the problems caused by noise pollution;
- use the decibel scale;
- suggest ways of reducing noise pollution.

Noise pollution has increased in recent decades. This module asks students to consider the many sources of noise and how they may be controlled.

19 Combined heat and power

In this module, students are asked to:

- consider the benefits and disadvantages of a district heating scheme;
- find out about environmental control measures used at power stations;
- calculate and compare the efficiencies of different types of power station;
- suggest how better use might be made of waste water from power stations;
- design a storage tank for hot water;
- explain the desirability of multiple electricity supply systems.

The module gives pupils an opportunity to consider authentic data concerning a CHP plant and district heating system at Linköping in Sweden. Pupils should have a simple understanding of how a thermal power station works. The module is most appropriate for pupils who live in an area where winters are cold; in other areas, they could be asked to explain why a CHP scheme would be less viable.

Another issue which could be raised by this unit is that of recycling versus burning of waste. It is difficult, without detailed data, to decide whether waste paper should be recycled or burned for its energy content. The module is self-contained, and it could be used as an extended homework activity.

20 Solar heating

In this module, students are asked to:

- find out about active and passive solar design; evaluate a commercial company's environmental policy;
- make energy estimates and calculations;
- evaluate a design for a thermal energy store;
- interpret a design for a solar energy heating system.

The need to reduce fuel consumption worldwide has led to an increase in the importance of solar design, both passive and active. In less developed countries, passive solar design has been an established technology for thousands of years. More developed countries have gone in for 'energy-guzzling', and efforts are now being made to reduce this.

This module could be used as part of a study of renewable energy resources. Alternatively, it could be used when students are studying thermal properties of matter (thermal energy transfer and heat capacity).

21 Photovoltaics

In this module, students are asked to:

- consider the uses of photovoltaic systems;
- find out about the worldwide availability of solar radiation;
- monitor the position and brightness of the Sun;
- study and interpret information about photo voltaic projects from around the world;
- calculate the cost of electricity supplied by photovoltaic systems.

Photovoltaic (PV) cells are finding increasing uses. As the technology develops, their cost decreases. At the same time, pressure for cuts in polluting methods of electricity generation has enhanced the desirability of PV systems. This module is intended to help students to understand the technology and its applications. The module could be used when students are studying energy technologies. A group of students might study this module, while others were studying other technologies. Then each group could prepare a report on their findings, for presentation to the rest of the class.

Outline of the modules (continued)

22 Wind power

In this module, students are asked to:

- find out about wind turbines and where they are best sited;
- make power estimates and calculations;
- make cost effectiveness calculations;
- make measurements of wind speeds;
- suggest a suitable site for a wind turbine;
- evaluate the envirnomental impact of a proposed wind turbine.

Wind power is a renewable resource, and is readily available in many parts of the world. Traditionally, it has been used for operating mills and pumps; today, it is finding new applications in electricity generation.

This module could be used as part of a study of renewable energy resources. It provides opportunities for students to consider the appropriateness of wind power in their local situation.

23 Alcohol in your body

In this module, students are asked to:

- consider the social context of alcohol consumption;
- calculate the alcohol content of a variety of drinks;
- analyse data relating to the metabolism of alcohol in the body;
- apply their knowledge to devise publicity in favour of responsible alcohol use.

The consumption of alcohol is a sensitive topic. Some students may already be users of alcohol; others may come from backgrounds where alcohol is not used; some may have cases of abuse in their families. Some caution will be needed in opening up this topic.

The module shows how some basic ideas from chemistry can be applied in a Health Education topic. You might start by having a brief discussion of the effects of alcohol on the body, as shown in the table on page 1. It is likely that students will take the opportunity to tell of their own experiences (first or second-hand). This can cause amusement; however, it is advisable to let this run its course before making the point that alcohol use and abuse is a serious topic. All societies where adults use alcohol as a social drug have rules about alcohol consumption, and ways of inducting children into sensible use. This is the focus of the discussion on page 1. Thereafter, the unit deals with various aspects in a fairly straightforward way.

24 Testing the quality of food

In this module, students are asked to:

- interpret information about food adulteration;
- carry out simple tests on samples of adulterated foods;
- find out about the work of food inspectors;
- explain the importance of the work of food inspectors.

This module encourages pupils to think about food quality, why it may be poor, and how it may be checked. Although the module was developed for use in schools in Nepal, the same issues arise in every culture. For most people, the state provides some protection via a food inspection service.

The module starts by presenting the problem of food adulteration. Pupils can then carry out some simple tests on samples of adulterated foods. Then they are asked to find out about the Food Inspection service. Finally they can present what they have learned through a short piece of drama.

Outline of the modules (continued)

25 Understanding eclipses of the Sun

In this module, students are asked to:

- understand the origins of solar and lunar eclipses;
- appreciate the excitement of a total solar eclipse;
- make a model to illustrate why eclipses happen;
- collect memories of eclipses;
- interpret historical ideas, reports and other evidence.

Eclipses have been understood for over 2000 years. However, this knowledge was built up gradually, and was questioned in the same way that any scientific knowledge is debated. This module provides an opportunity for students to consider some of this debate.

It is often suggested that scientific knowledge and understanding destroy any romantic or emotional response one may have to natural events. Scientists' responses to eclipses tend to give the lie to this idea, although the responses of educated scientists and members of the public are clearly not the same as those of a medieval peasant.

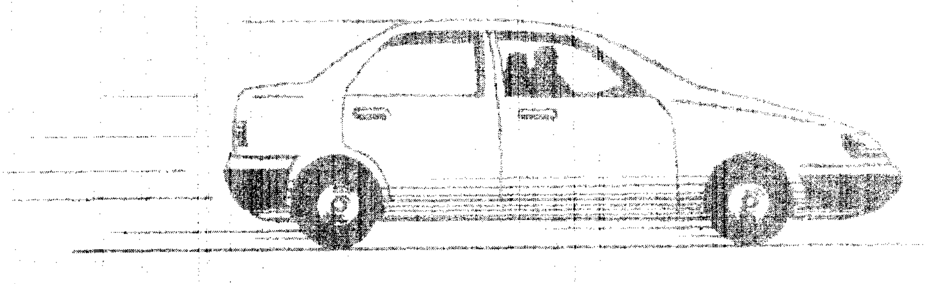
26 Working with numbers

In this module, students are asked to:

- learn to compare large numbers;
- develop their understanding of large numbers, particularly one million;
- consider ways of estimating large numbers;
- learn how to produce maps and plans using simple surveying techniques;
- find out how to represent the population of the world by scaling down.

As with other modules in this pack, you may wish to make a selection from the activities offered in this module, depending on the experience and numeracy skills of members of your class.

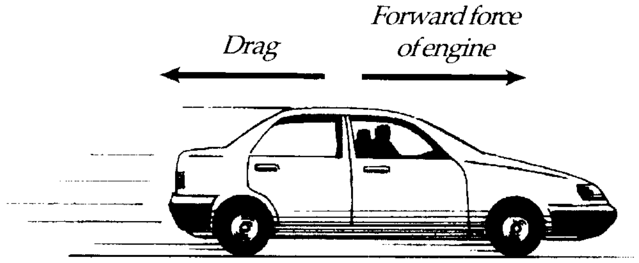
Transport

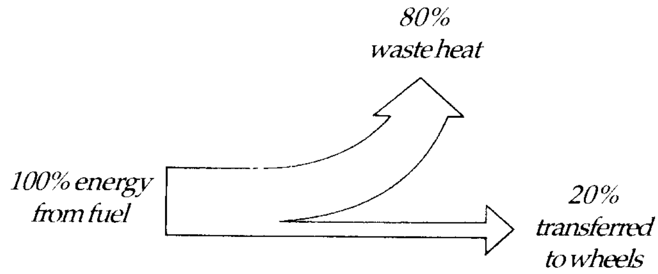


Cars and energy

It takes energy to make a car, and it takes energy to run it. Energy is expensive, and in short supply. Using energy causes pollution and contributes to global warming. In this module, you can find out just how much energy is needed to make and run a car, and how to use less energy.

Running a car





The energy needed by the car's engine comes from burning its fuel (petrol, diesel or LPG). Car engines are not very efficient. Only about 20% of the energy from the fuel is used to keep the car moving. The rest escapes as waste heat, or is used for the car's lights, heater etc.

When a car is moving at a steady speed, the engine provides the force needed to overcome the drag of air resistance. Air resistance is greater when the car is moving fast, so the driver must press on the accelerator to provide a bigger force. That uses more fuel.

When the driver brakes, the car loses kinetic energy. The brakes get hot. That energy came from the fuel, and now it is wasted.

Data: for cars in the UK; the situation may be different in your country.

life of typical car	10 years
average distance covered each year	16 000 km
energy content of petrol	40 million joules per litre (40 MJ/l)
average fuel consumption	1 litre per 10 km

Activity 1: Interpreting information

Use the ideas above to answer these questions:

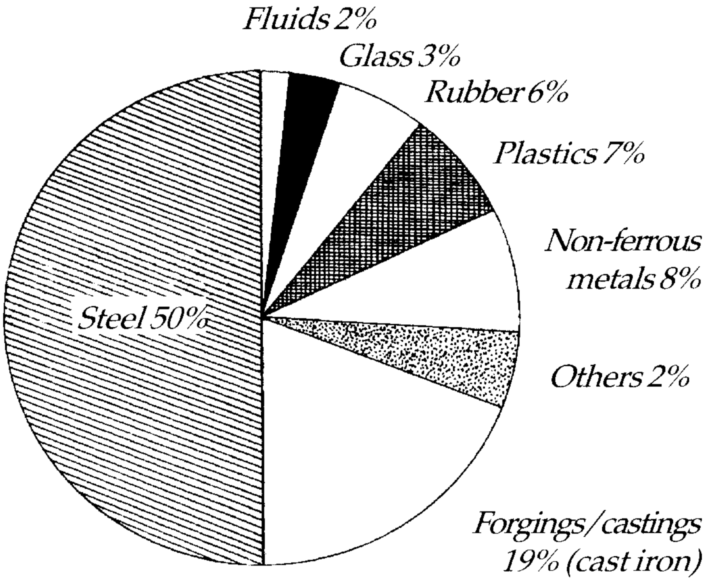
1 A car can be designed to make it more streamlined. Then it uses less fuel. Use scientific ideas to explain why a streamlined car uses less fuel. Sketch a car with a streamlined shape.

2 A driver can save fuel by avoiding driving at high speeds. Explain why.

3 Some drivers speed up and slow down a lot as they drive along. Explain why they would use less fuel if they drove at a steadier speed.

4 Calculate how much fuel a typical car uses in its lifetime. How much energy is supplied by this amount of fuel?

Making a car



About 80% of a car is metal - mostly steel with smaller amounts of cast iron, aluminium and copper. Much of the rest is made from plastics. Rubber is used for the tyres and some hoses.

It takes energy to make a car:

- Energy is needed to make the materials from which the car is built.
- Energy is used in building the car.

mass of an average car	1 tonne	1000 kg
energy to make 1kg of steel	30 million joules	30 MJ/kg
energy to make 1kg of plastic	160 million joules	160 MJ/kg
energy to make and assemble car	20 000 million joules	20 000 MJ

Activity 2: Interpreting information

Use the ideas above to answer these questions:

5 Which takes most energy to make, 1 kg of steel or 1 kg of plastic?

6 What material accounts for 50% of a car?

7 Estimate the energy needed to produce the materials needed to make a car. Explain why your answer is only an estimate - what assumption have you made?

8 Estimate the total amount of energy needed to make a complete car.

9 How does this compare with the energy supplied by the fuel which a car uses during its lifetime? (Look back to the answer to question 4.)

10 Draw a suitable diagram to show the different contributions to the energy consumption of a car during its lifetime.

Activity 3: Brainstorm

List as many ways as you can of reducing energy consumption by cars.

Electric vehicles

Electric cars are clean, quiet and smooth-running. So why don't we see more of them on our streets? Many car manufacturers are working on proposals to build electric vehicles or EVs. Large amounts of money have been invested in developing the cars and the systems that will be needed to keep them running.

City streets are the same the world over, with motor engines idling in traffic jams, which sometimes last nearly the whole day. When petrol and diesel engines are idling, they are at their most polluting and least efficient. What a waste of energy! EVs cause very little pollution. When stationary, they do not use energy. They are ready to go as soon as the accelerator pedal is pressed, and they are almost silent.

EVs run on batteries which power the electric motor. When the driver presses down on the accelerator pedal, electric current flows from the batteries to the motor, which turns the wheels. Cleverly, when the driver's foot comes off the accelerator, the process is reversed. Now the motor is turned by the wheels and acts as a generator. Current is sent back to the batteries to recharge them. In this way, the car brakes, and its kinetic energy is not wasted as it slows down.

	lead/acid battery	NiCad battery
current supplied	33 A	30 A
for how long?	2 h	3 h
voltage	120 V	120 V
mass	390 kg	280 kg
range of car	50 km	75 km

Activity 4: Interpreting information

Use the ideas above to answer these questions:

11 NiCad batteries are replacing the older lead/acid batteries in EVs. What advantages do they have?

12 Draw a diagram to show how energy flows (a) when an EV is accelerating, and (b) when it is braking.

13 EVs seem very clean, but people say that they 'transfer pollution from the city to the countryside'. What do you think they mean by this? (Think about where the electricity comes from to charge the car's batteries.)

Activity 5: Summing up

Draw up a chart to compare electric cars with petrol-fuelled cars. Think about energy consumption, pollution, range, refuelling and any other points you feel are important.

Cars and energy – Teacher's Notes

Acknowledgements

Pages 1 and 2 are based on extracts from *Cars and the Environment*, a publication of the Science with Technology project, organised by The Association for Science Education and the Design and Technology Association of the UK. Page 3 is based on Unit 41 of *The World of Science*, produced by the Association for Science Education (UK) and published by John Murray.

Introduction

In this module, students are asked to:

- consider the energy content of a car, in terms of its construction;
- determine the total fuel and energy consumption of a car during its lifetime;
- develop their understanding of energy transfers in a car;
- understand aspects of the technology of electric cars;
- draw up a comparison of petrol-fuelled and electric cars.

Scientific & technological concepts

- forces;
- air resistance;
- energy transfers;
- energy efficiency;
- fuels;
- kinetic energy;
- energy content of materials;
- regenerative braking;
- pollution.

Teaching approaches

Cars are among the major consumers of energy in developed societies. They also make a major contribution to urban pollution, and to global warming. This module asks students to look at the question of energy consumption by cars in quantitative terms. At first sight, electric cars may seem attractive because they do not pollute their local environment. The last part of this module will help students to think critically about this idea.

Notes on the activities

Pages 1, 2: These pages provide detailed information about energy transfers in cars, together with quantitative data about energy consumption. Students will find that the energy consumed in making a car is small compared to the energy it uses from fuel during its lifetime. Energy savings in the manufacturing process are less significant than any which might be made by improving the car's efficiency.

Page 3: Here we take a quick look at electric vehicles. Students will find that, although they have some advantages over petrol cars, their range is limited. Batteries are bulky and heavy, and this makes it difficult to have an electric vehicle with a long range. Recharging times are long, too.

Students could be asked to devise a demonstration (using a rechargeable battery, an electric motor etc) to show the principles of regenerative braking.

Students could research manufacturers' data about hybrid cars, which use electric motors in towns, but have a petrol or diesel engine for long-distance rural travel.

Answers to questions

1 Streamlined shapes give less air resistance, so the engine does not have to work so hard to overcome drag.

2 More air resistance at higher speeds. (Drag is proportional to speed squared.)

3 Accelerating and braking both waste energy. During braking, kinetic energy is transformed to heat.

4 16 000 l; 640 000 MJ.

5 1 kg of plastic (but note that plastic is much less dense; energy per unit volume is comparable for plastic and steel).

6 Steel.

7 Assuming 80% steel, 20% plastic: 2400 MJ + 3200 MJ = 5600 MJ.

8 25 600 MJ.

9 Much less – only a few per cent.

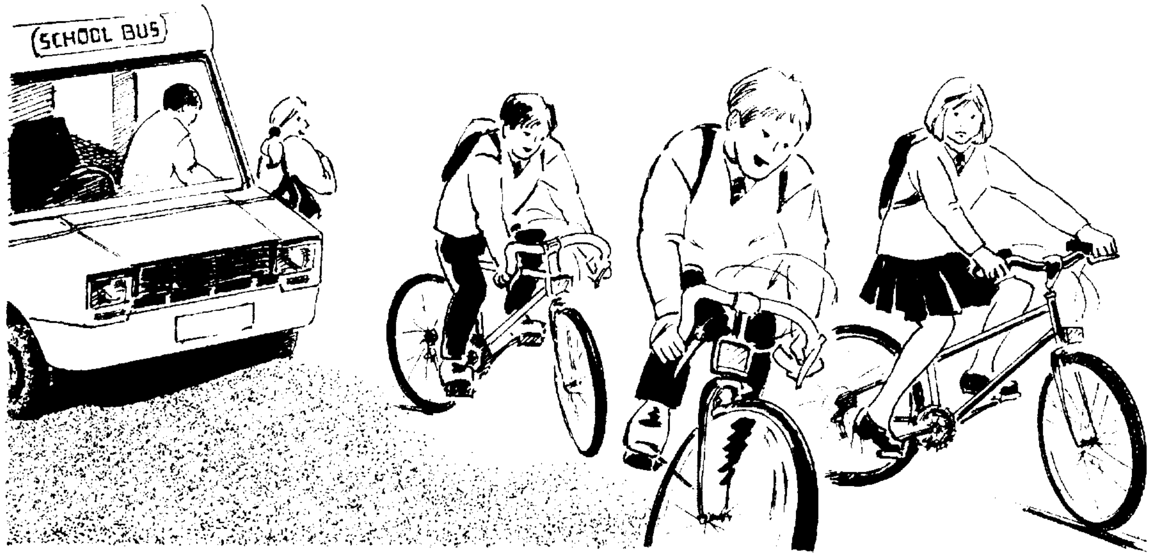
10 Pie chart or bar chart.

11 Lighter (less mass); longer range, because they provide current for longer.

12 (a) Energy from battery to motor to KE; (b) energy from KE of car to motor to battery.

13 The electricity used for recharging must come from somewhere – usually from a fossil-fuelled power station which is causing pollution elsewhere.

Getting to school



There are many ways of getting to school - walking, cycling, by car, bus or train. Your journey may be very easy, or you may suffer from problems caused by traffic congestion. As the amount of traffic on our roads increases, congestion gets worse.

Traffic congestion causes problems: delays, accidents, road rage, noise, air pollution and more. How can we reduce congestion? Here are some examples from around the world – you probably know of other solutions from your own area.

- In Lagos, Nigeria, the number of cars on the roads was halved by only allowing vehicles with odd-number-plates to use the roads on Mondays, Wednesdays and Fridays, and even-number-plates on Tuesdays, Thursdays and Saturdays.
- In Kathmandu, Nepal, delivery lorries are only allowed to drive into the city along the road at night (between 7.00 pm and 7.00 am). City centre parking is strictly limited.
- In Hasselt, Belgium, the city council banned all cars from the old city centre. They provided free buses, and car parks on the edge of the town.

Activity 1: Survey and data analysis

- How long did it take you today, to travel from home to school?
- How far did you travel?
- What means of transport did you use?

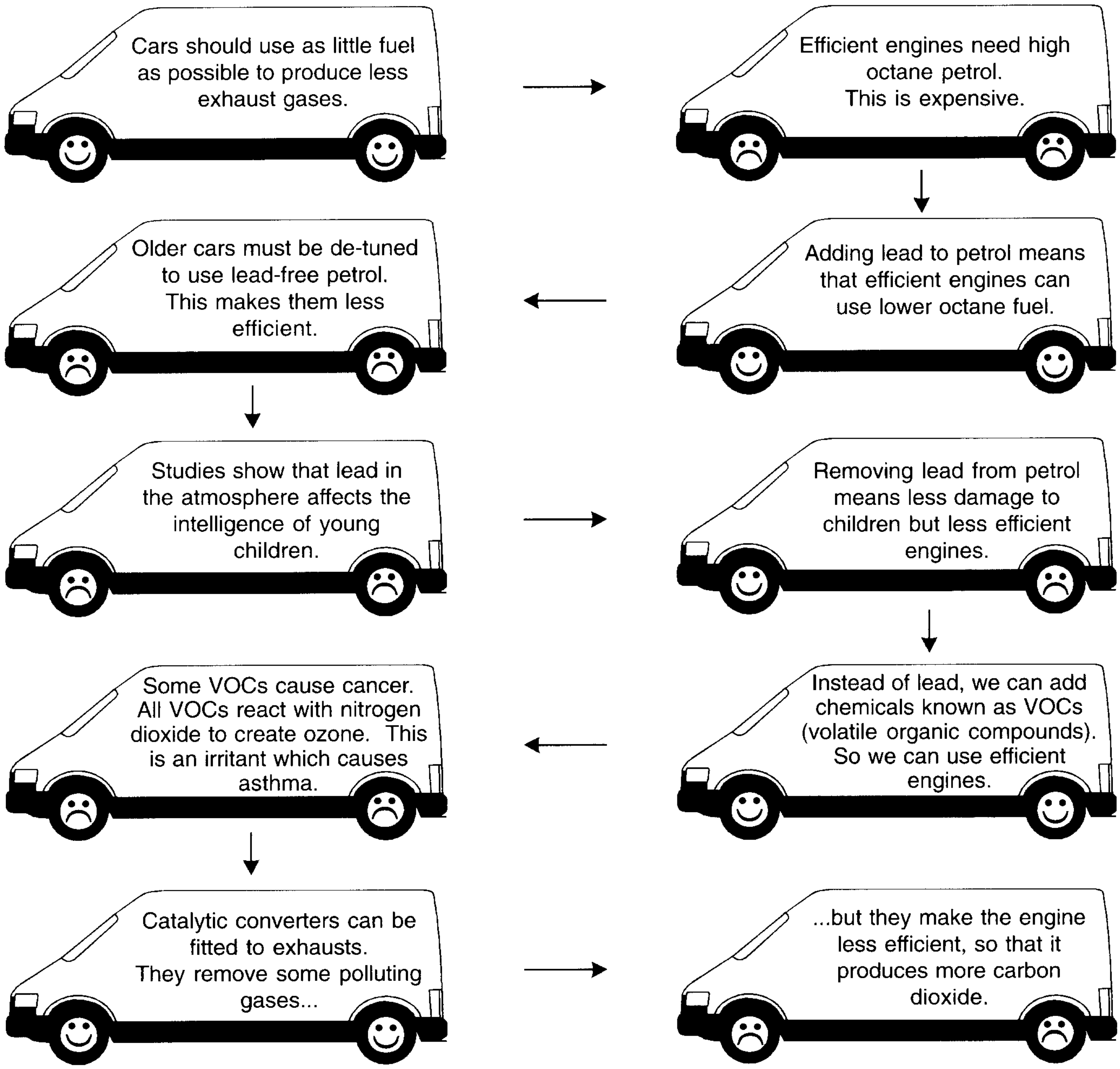
Collect this data from everyone in the class. Work out the average speed for each person: average speed = distance travelled/time taken. (A spreadsheet would be a good way to record this data, and to calculate the speeds.) Think of a way of displaying the data. How could you compare the speeds of people who use different forms of transport?

Car exhaust emissions - Information sheet 1

Burning petrol or diesel fuel produces carbon dioxide. Carbon dioxide is one of the gases that cause global warming. In this way, cars contribute to pollution on a global scale. It would be a good idea to reduce the amount of fuel used by a car in order to reduce the amount of carbon dioxide it produces.

Adding lead to petrol produces lead in the atmosphere. This is thought to damage the brains of young children and affect their intelligence.

Catalytic converters can be fitted to car exhausts. They remove some pollutants from exhaust gases (but not carbon dioxide). They can only be used with lead-free petrol. Perhaps all cars should be fitted with catalytic converters and use lead-free petrol. However, the issue is more complicated than this...



Car exhaust emissions - Information sheet 2

When fuel is burnt the following reactions take place:

*This reaction is **exhothermic**; this means that it produces heat.*

FUEL petrol + AIR oxygen nitrogen ⟶ carbon dioxide + water + some unburned and partly burnt fuel – hydrocarbons + oxides of nitrogen + carbon monoxide + heat

+ If lead fuel is used, compounds of lead are formed.

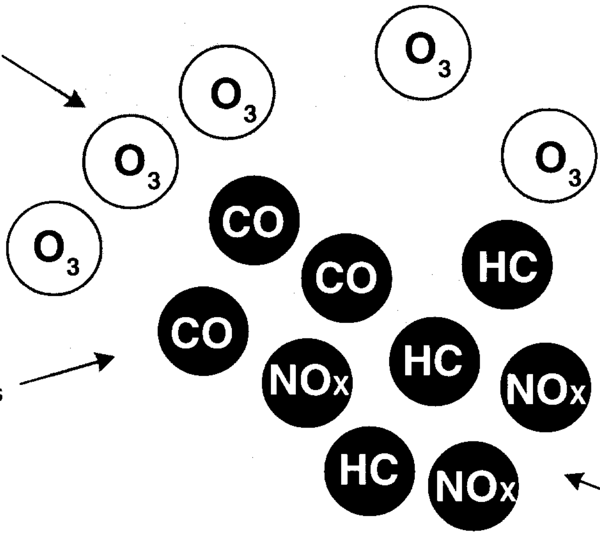
Nitrogen *is normally unreactive.*
Car engines produce very high temperatures; at these temperatures oxides of nitrogen can be formed.

Under strong sunlight the emissions from the car exhaust (especially oxides of nitrogen, and hydrocarbons which act as catalysts) can produce ozone. **photochemical reaction**

SUNLIGHT

Chemistry of exhaust gases

ozone
a toxic gas which is an irritant; it causes asthma and can damage vegetation.



hydrocarbons
unburned or partly burnt fuel;
can cause smog.

carbon monoxide
colourless and poisonous gas; contributes to the formation of ozone.

oxides of nitrogen
contribute to acid rain;
can cause respiratory diseases such as asthma;
contribute to smog.

Recent surveys have shown that 10% of motorists are responsible for more than half of the carbon monoxide emissions. One badly polluting car can produce four or five times as much pollution as a 'clean' car.

Monitoring equipment has been developed to catch these motorists.

These are causes of
local air pollution

Activity 2: Questions

Study *Car exhaust emissions – Information sheet 1* and answer these questions:

1 An efficient car engine uses less fuel. Why is it a good idea for cars to use as little fuel as possible? Give at least two reasons.

2 Adding lead to petrol is both good and bad for the environment – there are costs and benefits. In what way is it good – the benefit? In what way is it bad - the cost?

3 What substances can be added to petrol, instead of lead, to make engines more efficient? What are the problems with these substances?

4 Catalytic converters can be fitted to car exhausts. What are the benefits to the environment, and what are the costs?

Activity 3: Preparing a leaflet

Everyone has seen cars or lorries with hazardous fumes belching out of their exhausts. We all know the smell of these fumes.

- In many countries, vehicles are tested each year. As part of the test, their exhaust emissions are checked. If they are producing too much pollution their engines must be adjusted before they can go back on the road.
- In some countries, roadside checks are also used to catch offending motorists.
- There may be a telephone 'hotline' you can ring to report an offending vehicle.

Drivers may not be aware of the danger they are causing to other people if their car engine is producing a lot of hazardous fumes. Your task is to design a leaflet which drivers could be given to read while their car or lorry is being tested. (You will find some useful information on *Car exhaust emissions – Information sheet 2*.) The leaflet should explain:

- the different kinds of pollution produced by a badly adjusted engine;
- the effects of each kind of pollution on people who breathe them in;
- why regular testing is important.

The Green Boulevard Project

Making Hasselt a pleasant, accessible city

Hasselt is a city in Belgium. Its population is about 70 000, and there are about 800 000 people in the region it serves. The centre of Hasselt has many old, narrow streets. Every day, more than 130 000 people come into the city for work, shopping or recreation. The result is a poor quality of life due to noise and air pollution.

The first solution

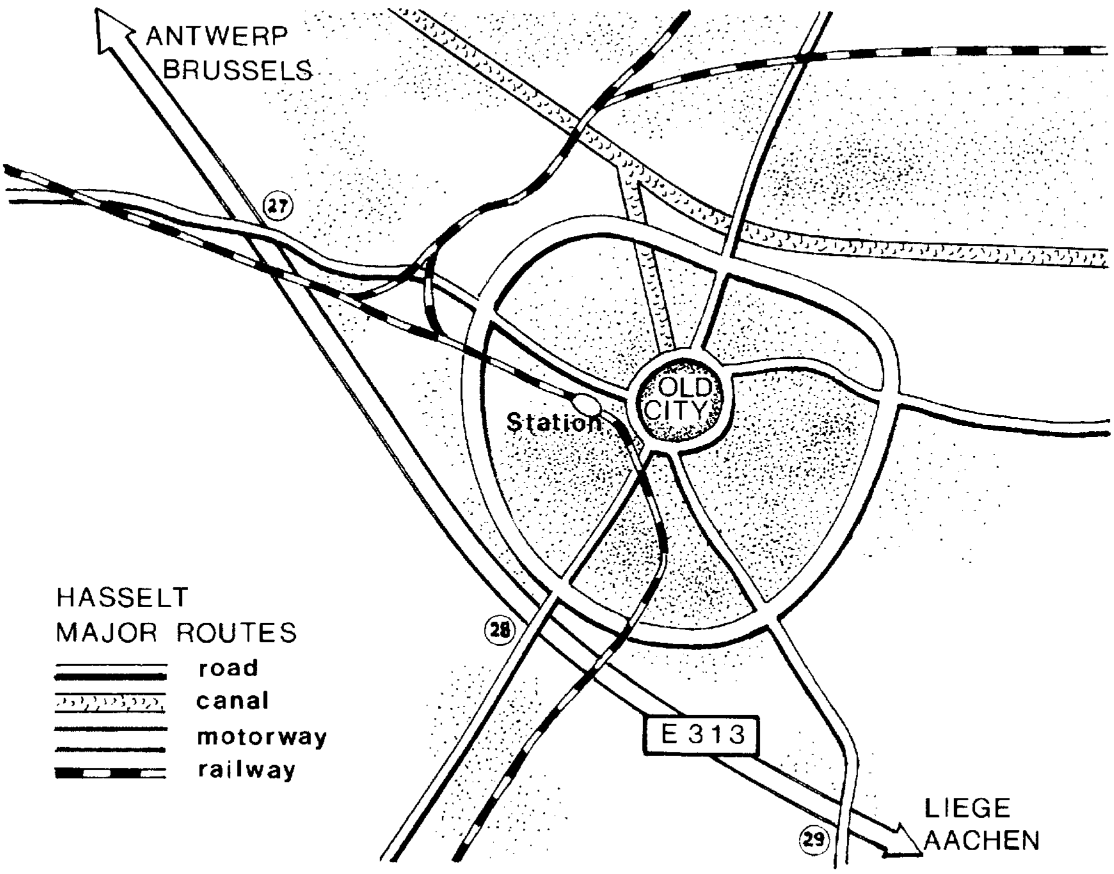
As the amount of traffic increased, the roads were expanded to cope. The city's approach roads were expanded, three motorway exits were constructed, and two circular roads were built – the Small Ring and the Big Ring.

The result was even more traffic, more noise and more pollution.

Activity 2: Questions for discussion

Study the map of Hasselt. Look for the following:

- The old city centre.
- The Small Ring and the Big Ring.
- The Albertkanaal and the E313 motorway.
- The railway and the station.



1 What reasons do people have for coming into the Hasselt city centre?
2 What problems are caused by traffic in the city centre?
3 When a new road is built, who benefits? Who loses out? List as many winners and losers as you can. Explain how they benefit or lose out.

The Green Boulevard solution

By 1996, traffic congestion was very bad. Hasselt city council came up with a new solution to the problem:

- All traffic (except buses) was banned from the city centre.
- All through traffic was diverted to the Big Ring.
- All city buses became free to everyone.
- All regional buses became free to people who lived in Hasselt.
- Car parks were built outside the city centre.
- Wide cycle tracks were built, with ten conveniently-located cycle sheds.
- The Small Ring was dug up to make room for trees, footpaths and cycle tracks. This is the "Green Boulevard", with a pedestrian promenade and wide footpaths on either side.

The free bus service

The city bus services are the Green Lines. Anyone can travel free on these buses. The regional bus services are the Red Lines. You have to pay if you do not have an identity card to prove you live in Hasselt.

The table shows how many people use the new bus services, compared with the old ones. The cost of running the free buses is 25 million Belgian francs each year. The city council gets much of this back from car park charges.

bus passengers/month	old bus network (before 1996)	new city lines (after 1996)
city buses	30 134 (paying)	266 420 (free - Green)
regional buses	34 255 (paying)	57 989 (free - Red)

Activity 3: Data analysis

- Do more people use the buses today, now that they are free?
- Draw a chart to show how the numbers of bus passengers have changed.

Hasselt people

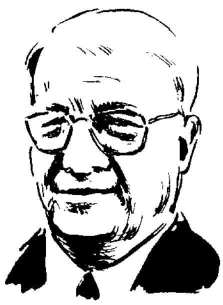
Patrick, age 12
"I live in the old city centre. I like to visit my friends after school. We go to the library, or play by the canal."

Angela, age 18
"I work in an office in the city centre, but my home is about 5 km from there. I can't drive to work any more. At the weekends, I meet up with my friends in a city bar; we often go to one of the nightclubs."

Mrs Langveld, age 30
"My house overlooks the Small Ring – we call it the Green Boulevard now. My boy Leopold suffers from asthma, but I think it's better since they changed the traffic system."

Mr Ruckert, age 47
"I have been a bus driver in Hasselt for nearly twenty years. We've seen some big changes. The Green Lines are very busy – there's a bus every five minutes from the station to the city centre. My daughter has just gained her bus-driver's licence and starts work next week."

Ms Macke, age 55
"I am a commercial traveller. Twice a week, I travel from Brussels to Hasselt. I have to visit the shops in the city centre, and in the suburbs. I carry a large case of samples to show the shopkeepers. I am concerned that the car parks may get very full."



Mr Martin, age 78
"I have lived in Hasselt city centre all my life. I'm not very fit now – the doctor says my lungs are packing up. I can walk about 100 metres with the help of my stick. I'm worried that they'll put up my taxes to pay for all these free buses."

Activity 4: Writing a letter

Choose one of the characters above. Think of all the different ways in which they might have benefited from the Green Boulevard scheme, and how they might have lost out.

Imagine that the city council is thinking about changing back to the old traffic system. Write a letter to the Burgemeester (the mayor), putting the point of view of your character.

Easing local congestion

Now you have thought a little about your own journey to school. You have also studied the Green Boulevard solution to traffic congestion in Hasselt. Here are some more points to think about:

Your journey to school:

- Does your journey time vary from day to day? What causes any variation?
- Have you ever come this way during the holidays, or at a different time of day? What difference did you notice?

Local traffic problems:

What steps has your local council taken to manage traffic? Think about

- Car parks, parking restrictions, park-and-ride schemes.
- Cycle tracks, footpaths, pedestrian areas.
- Restrictions on lorries or other large vehicles.
- Bus and train services.

Activity 5: Making recommendations

- Discuss any local traffic problems which affect pupils' journeys to school.
- Make some suggestions about how these problems could be reduced.
- Decide on a suitable way to present your ideas – perhaps as a poster, a letter to the local newspaper, or a presentation to the class.

Getting to school – Teacher's Notes

Acknowledgement

This module was written by Patrick Whittle. It is based on data provided by Kabinet van de Burgemeester, Groenplein 1, B-3500 Hasselt, Belgium.

Pages 2 and 3 are based on *Cars and the environment*, a publication of the Science with Technology project, organised by The Association for Science Education and the Design and Technology Association of the UK.

Introduction

In this module, students are asked to:

- consider how traffic congestion affects their journey to school;
- find out about atmospheric pollution caused by car exhaust emissions;
- identify environmental problems arising from increases in traffic flow;
- study traffic management measures in Hasselt, Belgium;
- suggest possible traffic management measures for their own locality.

Scientific & technological concepts

- average speed;
- noise;
- atmospheric pollution.

Teaching approaches

The module can be tackled in two ways: Start either with the consideration of students' own experience of travelling to school (page 1). Then go on to study the problem of exhaust pollution, its effects and control (pages 2 – 4), or to a detailed consideration of the Hasselt traffic management scheme (pages 5 – 8). (These two sections can be used in either order.) Use the discussion of local traffic management on page 9 to tie these different aspects together.

In areas where most students walk to school, an alternative approach would be to consider how family members make other regular journeys, eg, to work or to market.

Alternatively, you may wish to build the module into a more extended piece of work involving (for example) speed measurements, traffic monitoring, interviews with local planners and police officers, and surveys of public attitudes.

Notes on the activities, answers to questions

Page 1: This page introduces the idea of traffic congestion and asks students to collate information about their fellow students' journeys to school. Only approximate data is required. They need to be able to calculate average speed from figures for distance and time. A spreadsheet would be an excellent way of collating and handling this data. Column headings might be as shown:

student	method of travel	home area	distance travelled/km	time taken/h	average speed/km/h

Page 2, 3: These are information sheets which outline (Sheet 1) the costs and benefits associated with different methods for reducing exhaust gases, and (Sheet 2) the chemistry of exhaust gases.

Page 4: Activity 2 consists of questions based on Information sheet 1:

1 Using less fuel means less environmental pollution is produced, and it is cheaper.

2 The benefit is that less fuel is used, so less carbon dioxide and other exhaust gases are produced. The cost is that lead enters the environment, and can cause brain damage to children.

3 Volatile organic compounds (VOCs); some are carcinogenic, and all can lead to the production of ozone, which causes asthma.

4 Benefit: less polluting exhaust gases; cost: less efficient engines, so more fuel burned, releasing more carbon dioxide.

Page 5: Students are introduced to the city of Hasselt and its traffic problems. They need to establish the environmental problems caused by traffic.

1 Work, shopping, recreation etc.

2 Noise, air pollution.

3 Winners include motorists who can get about more quickly; people from out of town can get to and through the city more easily. Losers include those who suffer from noise and other pollution; people who have to move to make way for the new road.

Page 6: Map of Hasselt.

Page 7: This page outlines the 1996 solution to the problem. Students are asked to look at some data which shows the great increase in use of buses. This data could be shown in the form of a bar chart.

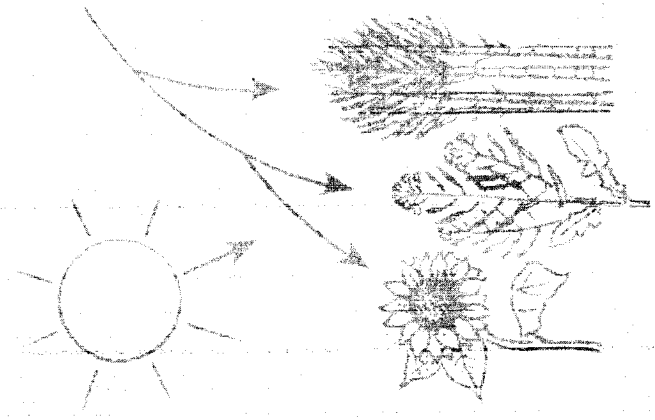
Page 8: The characters shown on this page are imaginary. They will stimulate students to identify the various benefits and problems arising from the new scheme.

Students are encouraged to adopt one of the characters and write a letter from him or her to the Burgemeester. An alternative approach would be for students to interview one another in role, and present the results as a newspaper article, or as a TV news item.

Page 9: To sum up, students are asked to think about traffic management measures which might be helpful in their own area. The table shows some factors which may contribute to local traffic congestion and consequent pollution.

contributory factor	effect	possible solution
road width, junctions	slow traffic	widen, by-pass, one-way system
accidents, traffic lights	slow traffic	more police, tidal flow system
one/two persons per car	more traffic	share cars, ban or tax single drivers
convergence on institutions	more traffic	stagger school and office hours
unreliable public transport	more traffic	more school and other bus services
lack of level footpaths, cycle ways	more traffic	convert some roads for cyclists
old, smoky, noisy vehicles	increased pollution	compulsory vehicle testing

Fuels



Fuels for the future

Which fuel is best? – Comparing fuels

Fuels are substances that we burn so that they transfer thermal energy (heat). When fuels burn they react with oxygen. This oxygen usually comes from the air.

fuels + oxygen → combustion products* + energy

(* The combustion products are usually carbon dioxide and/or water plus smaller amounts of other oxides. 'Combustion' is another word for 'burning'.)

We can use the energy that is transferred when fuels burn to cook food to heat water or to keep the insides of buildings warm. We can also use the energy from burning fuels to produce movement, e.g. in vehicle engines or to produce the steam for the turbines which drive the generators in power stations.

The table below gives some information about some commonly used fuels. Which of these fuels is best depends on what we want to use the fuel for. In vehicle engines, for example, the fuel is burned inside the engine itself, so they need fuels that are gases (or liquids that can easily be turned into gases) and that produce only gases when they burn. It should be easy to carry quite a lot of fuel on a vehicle so that it can travel a long way without re-fuelling and when the vehicle needs to be re-fuelled this should also be easy.

fuel	solid, liquid or gas (at 20°C)	combustion products	how the fuel is stored	cost	energy/gram (kilojoules)
coal	solid	gases + ash	in a heap	low	33
diesel	liquid	gases	in a tank	low	46
ethanol	liquid	gases	in a tank	moderate	143
hydrogen	gas	gas	in cylinders at very high pressure or as a liquid at -253°C.	low	56
methane (natural gas)	gas	gases	in cylinders at very high pressure (but can be supplied to users, as they use it, through pipes.)	high	48
petrol	liquid	gases	in tanks	low	50
propane (liquid petroleum gas)	gas	gases	in cylinders as a liquid (under moderate pressure)	low	16
wood	solid	gases + ash	in a heap	very low	30

Activity 1: Interpreting data

1 Draw a bar graph of the energy transferred when 1 gram of each fuel is burnt. Arrange the fuels in order on your bar graph, starting with the fuel that transfers most energy per gram.

2 **(a)** How does the energy transferred by burning 1g of hydrogen compare with the energy transferred by burning 1g of petrol?

(b) How does the energy transferred by burning 1g of coal compare with the energy transferred by burning 1g of wood?

3 Decide each of the following, giving your reasons in each case:

(a) Which two fuels are most appropriate for vehicle engines?
Which other fuels could be used?

(b) Which fuel is most appropriate for space rockets. (Space rockets cost a very large amount of money to build and it is important to keep the mass as low as possible).

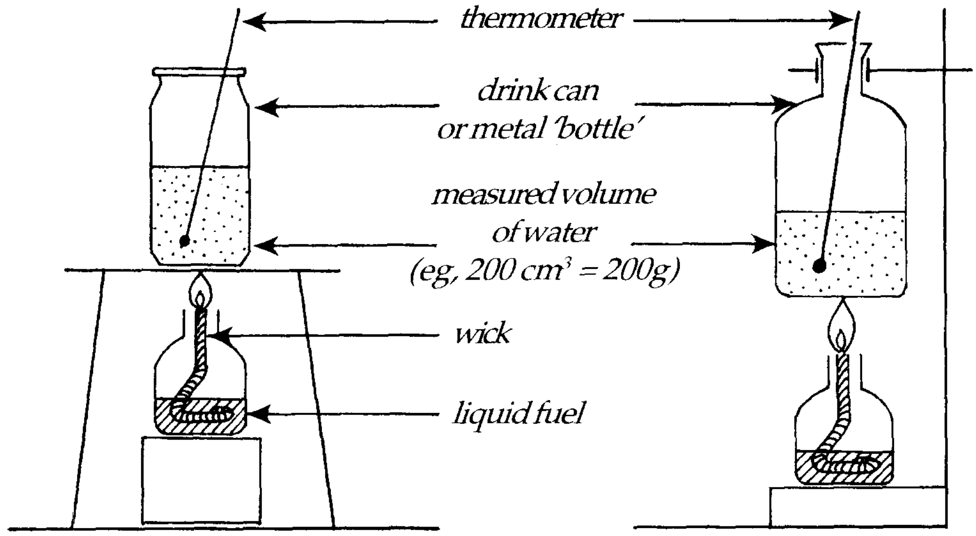
(c) Why natural gas, if it is available, is a popular fuel for heating and cooking in homes.

(d) Why coal is a suitable fuel for power stations.

4 What other factors, besides those shown in the table, do you think are important when choosing a fuel?

Comparing the energy transferred when fuels burn

To compare the energy transferred when different liquid fuels burn, you can burn them in the **same** burner and use them to heat up the **same** volume of cold water in the **same** container by the **same** number of °C.



Activity 2: Making measurements

- Measure out the cold water and pour it into the can.
- Note the temperature of the water.
- Fill the burner half full with fuel and weigh it.
- Place the burner under the can and light it.
- Stir the water gently with the thermometer and check the temperature every 30 seconds or so.
- When the temperature of the water is about 50°C blow out the burner flame.
- Continue to stir the water until the temperature stops rising. Note the highest temperature.
- Weigh the burner + the remaining fuel.

how to work out your results	
mass of burner + fuel X at start	41.67g
mass of burner + fuel X at end	40.52g
mass of fuel X burned	1.15g
temperature of water at end	51°C
temperature of water at start	18°C
rise in temperature of water	33°C

Burning 1.15g of fuel X increased the temperature of the water by 33°C
So burning 1g of fuel X would raise the temperature by 33 ÷ 1.15 = 29°C.
Which fuel gives the biggest temperature rise when 1g is burned?

Measuring the energy transferred when fuels burn

You compared the energy released by burning 1 gram of different fuels by comparing the rise in temperature of the same amount of water.

Scientists know that it takes 4.2 joules of energy to raise the temperature of 1g of water by 1°C. You can use this to measure the actual amount of energy transferred to the water when fuels burn.

For example, burning 1g of fuel X raised the temperature of the water in the can by 29°C. There were 150 cm^3 (= 150 g) of water in the can. The energy transferred to the water by burning 1g of fuel X is:

4.2 x 150 x 29 = 18270 joules (J) In round figures this is 18 kilojoules (kJ)

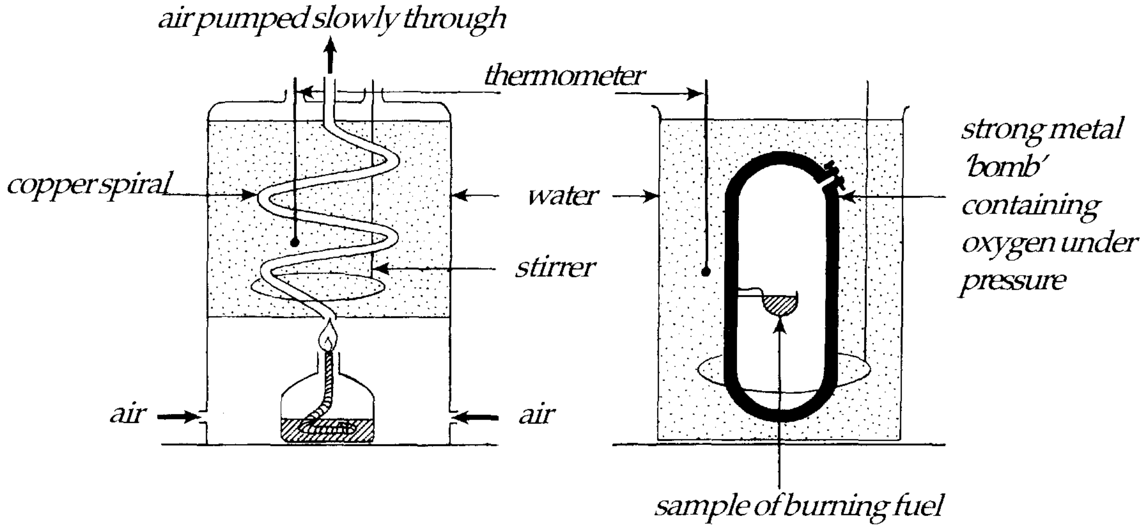
Activity 3: Evaluating measurements

- Calculate the amounts of energy transferred to the water for each gram of the fuels you burned in the previous section of this module.
- How do your figures compare with the correct figures? (For ethanol this is 30 kJ/g. Figures for other fuels are given in the table in the first section of this module.)
- Suggest reasons for the (probably quite large) differences between your measurements for the energy transferred when fuels burn and the correct figures.
- Why didn't the errors in your figures matter very much when you were **comparing** the energy transferred by burning different fuels rather than **measuring** them?

Activity 4: Interpreting diagrams

The diagrams below show more accurate methods of measuring the energy transferred when fuels burn.

- Explain why these method are more accurate.
- Why do you need to know the heat capacity of the apparatus?



Fuels for the Future – Teacher's Notes

Introduction

In this module, students are asked to:

- extract and apply data about a range of fuels presented in tabular form;
- devise and carry out tests to compare the energy transferred when the same mass of each of a range of fuels is burned;
- suggest why simple methods of **comparing** the energy transferred when different fuels burn are not very accurate ways of **measuring** the energy transferred;
- evaluate more accurate ways of obtaining energy measurements.

Scientific & technological concepts

- fuels;
- combustion products;
- solids/liquids/gases;
- energy transfers;
- joules;
- kilojoules.

Teaching approaches

In this module students begin by comparing a range of properties of a number of fuels in order to evaluate the suitability of those fuels for a range of different uses. They then devise an experiment to compare the energy transferred when 1 gram of a fuel burns and carry out the experiment on at least two different fuels. Students are shown how to use the results of their experiments to calculate the amount of energy transferred and asked to suggest why their results give much lower figures than the accepted values. Finally students are given details of more accurate ways of measuring the energy transferred when fuels burn and asked to explain why these methods are more accurate.

Notes on the activities

Pages 1, 2: Which fuel is best. This activity can be done as an individual activity (e.g. for homework) but is better done as a small group activity so that students can discuss – and defend – their judgements.

Though petrol and diesel are the most convenient fuels for vehicles, any of the gases can be (and have been) used. LPG is the most convenient of these since it can be liquefied by moderate pressure at ordinary temperatures.

'Other' relevant factors include cost and the extent to which the combustion products pollute the atmosphere. With fuels for vehicles, the number of miles per gallon, how easily the engine starts and the safety of the stored fuel in case of accident are all relevant factors.

Page 3: Comparing the energy transferred when fuels burn. Students should discuss, in small groups and/or as a whole class:

- the details of how they intend to carry out their tests;
- how they intend to record their measurements and work out their results;

before they are given the relevant worksheet.

This experiment is very much more satisfactory with liquid fuels (or with butane which is supplied as a liquid in small pressurised canisters). Solid fuels are generally difficult to ignite and/or to keep alight in small quantities, though a candle could be used if desired.

The most suitable liquid fuels to use are diesel fuel (or paraffin/kerosene, which is very similar) and ethanol (or methylated spirit, which is mostly ethanol). Petrol is too flammable to be safe. Ethanol and butane are deliberately not included in the table in the first section of this module so that students do not have prior knowledge of the expected outcome of their investigations. (Butane transfers very nearly the same amount of energy per gram of fuel burnt as propane does.)

Page 4: Measuring the energy transferred when fuels burn. Typically, only 25%-50% of the energy transferred when a fuel burns is transferred to water using the simple apparatus likely to be suggested by students (and shown on the worksheet). The higher figure is most likely to be obtained using a metal container (rather than a glass container) for the water, suspending or clamping the container over the flame (rather than using a tripod and gauze) and in draught-free conditions (possibly using a wind-shield).

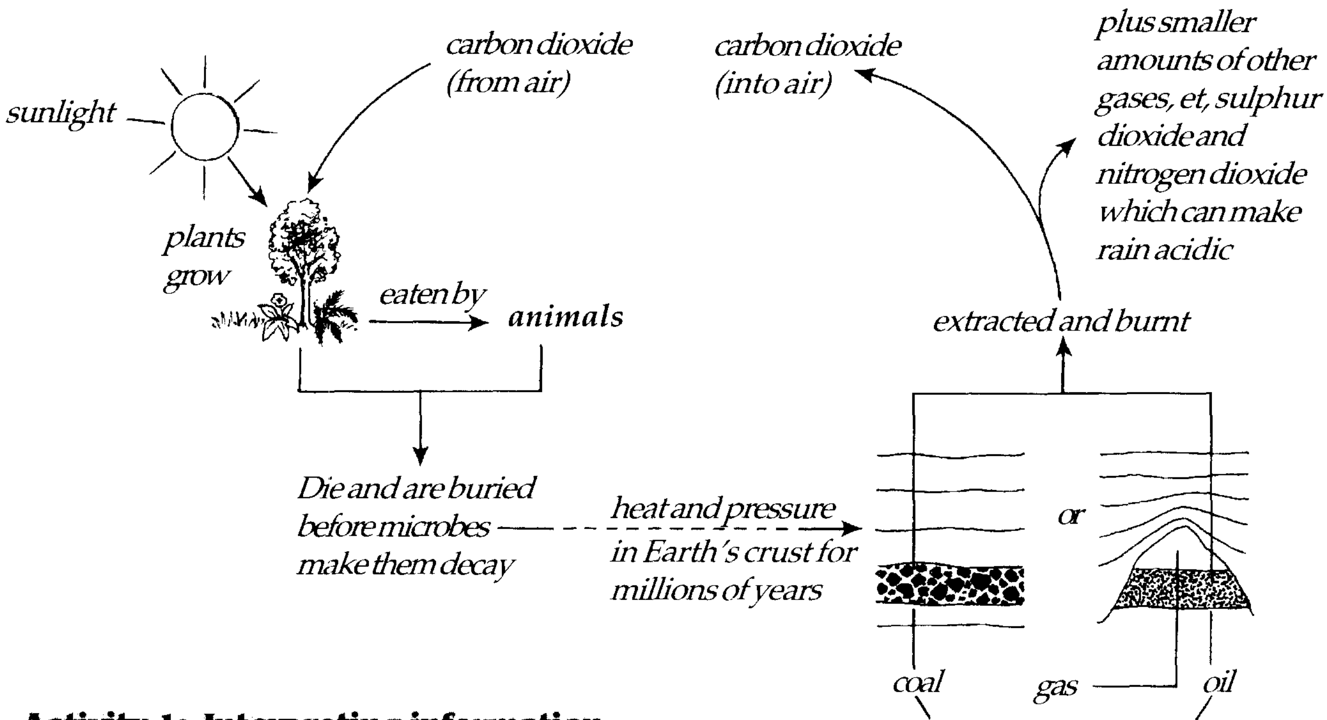
Energy is 'lost' because the container itself (and the tripod + gauze, if used) are also heated and because much of the energy from the burning fuel is transferred to the surrounding air (mainly because the hot gases from the flame rise due to convection). Furthermore, less flammable fuels such as diesel do not burn completely using a burner with a wick (the very smoky flame, for example, being due to unburnt carbon).

These various losses don't matter so much when **comparing** fuels, because they will be more or less the same for all fuels tested under the same conditions. If, however, one fuel is a lot smokier than another or takes a lot longer to heat up the water then proportionally more energy will be 'lost'.

The two more accurate methods shown in Activity 4 give better results because very little energy is 'lost' to the surrounding air. Quite a lot of energy is, however, transferred to the apparatus as well as to the water so it is important to know how much energy it takes to heat up the apparatus by 1°C. Using oxygen under pressure in the 'bomb' calorimeter ensures that the fuel burns completely.

Problems with fossil fuels

About 90% of the energy that people use in the world today comes from burning **fossil fuels**. The diagrams show how these fuels are formed and some of the unwanted effects of burning them.



Fossil fuels buried in the Earth's crust. These 'lock-up' a lot of carbon.

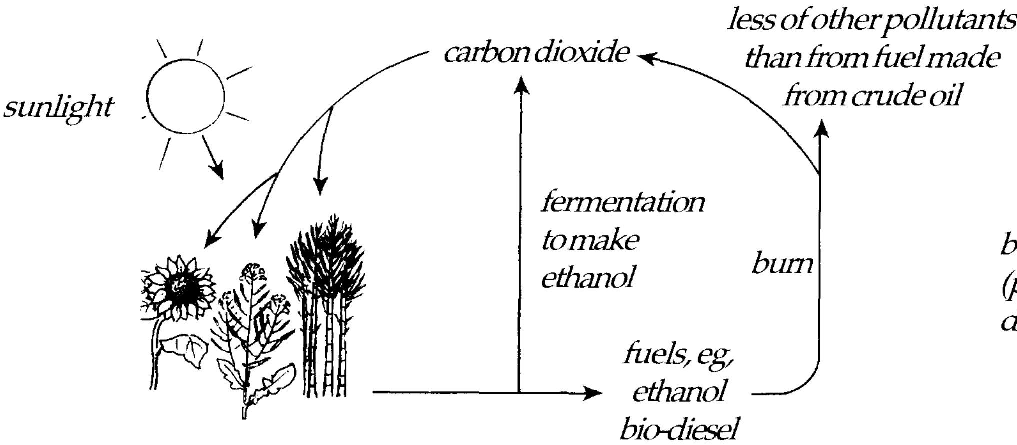
Activity 1: Interpreting information

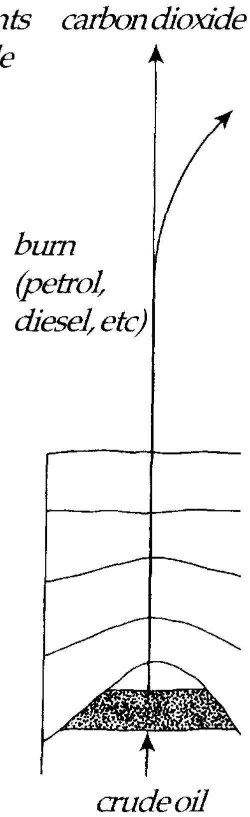
- Write down the names of the main fossil fuels that people burn. Why are these fuels called **fossil** fuels?
- Write a few sentences telling the story of how the fossil fuels that people burn today were formed.
- All the dead plants and animals that eventually became fossil fuels kept on being buried for millions of years. What effect would this have on the Earth's atmosphere?
- Large amounts of fossil fuels are being brought to the Earth's surface all the time and then burned as fuels. How does this affect the Earth's atmosphere? How does it affect Earth's climate?
- From about 1870 to 1970, humans extracted about 10% of the crude oil that we know is in the Earth's crust. Since 1970, about another 10% has been extracted every 10 years. About how long are the reserves of crude oil in the Earth's crust likely to last if we keep using them at the present rate?
- We say that fossil fuels are **non-renewable**. Explain why.

Fuels from plants

When **non-renewable** fossil fuels such as crude oil are used up, we will need to find **renewable** fuels to use instead. These renewable fuels can be made from plants.

Many people think that we should use a lot more renewable fuels even though the crude oil in the Earth's crust has not yet been all used up. The diagrams show some of the reasons why they think this.





Plants do not produce ethanol directly. They produce carbohydrates such as sugars and starch. We have to make this into ethanol. This can then be used in petrol engines. These engines work better if they are slightly modified.

Oil from plants (vegetable oils) must be converted into simpler substances to produce a fuel called bio-diesel. Then they can be used in diesel engines.

Ethanol and bio-diesel are more expensive than petrol and diesel fuel made from crude oil.

Activity 2: Interpreting information

Copy the following table and complete it using the information above.

substance from plants	what we make it into	fuel it can replace
	bio-diesel	
		petrol

- What are the advantages of using ethanol and bio-diesel instead of petrol and diesel fuel made from crude oil.
- Why, across the world as a whole, do we only a very small amount of fuel made from plants.

Only Brazil uses a lot of ethanol as a replacement for petrol. Suggest some possible reasons why Brazil uses much more ethanol than other countries.

The ethanol debate

Activity 3: Evaluating ideas

Running cars on ethanol (mainly in Brazil)

- In Brazil, about ¼ of the fuel used for transport is ethanol.
- About 4 million cars use 'straight' ethanol (actually a mixture of 95% ethanol and 5% water) in modified petrol engines.
- About a further 1 million cars use a mixture of petrol (80%) and ethanol (20%) in unmodified petrol engines.
- In cooler countries, one problem with ethanol is starting the engine in cold weather. This problem can be solved:
  - by starting the engine with petrol and then switching over to ethanol;
  - by pre-heating the engine as we already do with diesel engines.

  Both of these solutions make petrol engines more expensive.
- At present, ethanol is more expensive than petrol but this wasn't so in 1975 when the Brazilian government started a big changeover to ethanol.

Producing ethanol

- Fermenting sugar with yeast will produce a solution that is about 12% ethanol. The yeast then dies in its own waste product.
- The weak ethanol solution produced by fermentation is distilled to produce a mixture of 95% ethanol and 5% water. Energy is needed for the distillation process.
- Energy is also needed to grow the sugar cane that is used to produce the ethanol (for example to make fertilisers and in the fuel for tractors).
- Unless all the processes are done very efficiently, producing each litre of ethanol can use more energy than you get from burning it.
- You could make ethanol production more efficient and cheaper:
  - by developing better strains of yeast to produce a stronger solution of ethanol;
  - by reducing the pressure and distiling the temperature.

Environmental aspects

- Each ethanol molecule contains an oxygen atom so it burns more cleanly than petrol:
  - less carbon monoxide (a toxic gas) is produced than with petrol;
  - less unburnt hydrocarbon molecules (which help to produce smog) are released into the air than with petrol;
  - slightly less nitrogen oxides are produced than with petrol (but petrol+ethanol mixtures actually produce <u>more</u> nitrogen oxides)
- Sao Paulo, a city in Brazil with 20 million people, has much cleaner air than most smaller cities in other countries.
- Burning a fuel made from plants has no overall effect on carbon dioxide in the atmosphere. The carbon dioxide taken from the air as plants grow is put back into the air when the ethanol is produced and then burned.

Social aspects

- In Brazil, ethanol is made from sugar cane. Growing the sugar cane uses about 7.5% of the agricultural land.
- If all the cars in Brazil used 'straight' ethanol, *either* 25% of the agricultural land would be needed for sugar cane *or* large areas of the remaining tropical rain forest would need to be cleared.
- You could feed a small family quite well by growing food crops on the land needed to produce the ethanol used by an average small car.
- In Brazil, only the richer 20% of families have cars.
- In countries where sugar cane won't grow you can make ethanol from sugar beet or corn instead.

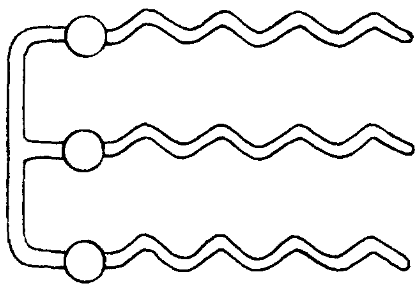
About Bio-diesel

Some plants such as sunflowers, which grow well in warm, dry climates, and oil-seed rape, which grows well in cooler, wetter climates, produce seeds which contain a lot of oil. A tonne (100 kg) of crushed rapeseed, for example, produces over 300 kg of rapeseed oil.

Sunflower oil and rapeseed oil will burn but they are not suitable for use in diesel engines. This is because:

- they are **more viscous** than normal diesel fuel (they are not 'runny' enough);
- they are **less flammable** than normal diesel fuel (they don't burn easily enough);
- they are **less volatile** than normal diesel (they don't evaporate easily enough).

Activity 4: Interpreting diagrams



molecule of vegetable oil

molecule of diesel fuel

The reason that vegetable oils are less suitable in all the above ways is that their **molecules** (the tiniest possible bit of each vegetable oil) are different from the molecules in diesel fuel.

- Describe the differences between a vegetable oil molecule and a molecule of diesel fuel.

- What would you need to do to vegetable oil molecules to make them more like the molecules in diesel fuel? *Hints:* A good way to answer this question is to draw diagrams to *show* what needs to be done. You do not need to use all of the vegetable oil molecule.

Fuel from rapeseed oil

Rapeseed oil is changed into a fuel that is suitable for diesel engines by reacting it with methanol. This produces a bio-diesel called RME (rape methyl ester).

RME costs more than twice as much as normal diesel but is a cleaner burning fuel:

- RME releases fewer hydrocarbons into the air (these help to cause smog).

- RME releases fewer small particles of soot (carbon) into the air (these affect people with breathing problems such as asthma).

- RME produces no sulphur dioxide [sulphur dioxide causes rain to be acidic].

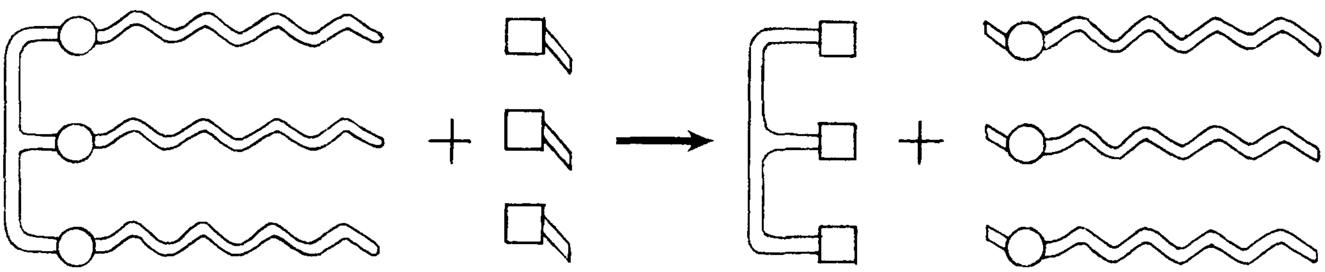
Activity 5: Questions

1 Why would people in cities prefer buses and lorries to use RME rather than normal diesel?

2 Suggest why very little RME is actually used at the present time.

Making Bio-diesel

Bio-diesel is made from vegetable oils by reacting them with methanol.



vegetable oil *methanol* *glycerine* *bio-diesel (RME)*

However, methanol fumes are toxic and can cause headaches, dizziness, sore eyes and nausea. So it is safer, in school, to make bio-diesel using ethanol or methylated spirit (which is ethanol with a small amount of methanol added).

Activity 6: Laboratory synthesis

How to make bio-diesel

- Pour 100 cm^3 of vegetable oil and 15 cm^3 of ethanol (95%) or methylated spirit into a 250 cm^3 beaker.
- Add 1 cm^3 of potassium hydroxide solution from a plastic syringe, one drop at a time and stirring gently all the time, over about 1 minute.
- Stir continuously, but not too vigorously, for a further 2 - 3 minutes.
- Then stir every 2 - 3 minutes for 5 - 10 seconds until two layers form on settling. (This normally takes 2-3 hours so you will need to have a system for making sure that the stirring gets done whilst you get on with something else.)
- Pour into a separating funnel and allow to settle for 1 hour.
- Run off the lower layer and pour it away down the sink. This contains the glycerol which is released during the reaction.
- Wash by adding 10 cm^3 of distilled water and stirring well (but do not shake or it will take a very long time for the layers to separate. Leave to stand for 1 hour.
- Run off the lower layer and pour it away down the sink.
- Dry by adding 0.5 g of anhydrous sodium sulphate and stirring for 15 minutes.
- Let the sodium sulphate settle.
- Pour off the bio-diesel in to a clean dry bottle.
- How could you test your sample?

Problems with fossil fuels – Teacher's Notes

Introduction

In this module, students are asked to:

- interpret information presented in diagram form;
- evaluate the pros and cons of a renewable fuel from a variety of viewpoints and reach a balanced judgement;
- relate differences between fuels to (simple) differences between their molecules;
- follow a detailed set of instructions for preparing a sample of bio-diesel;
- devise and carry out tests to compare various properties of different fuels.

Scientific & technological concepts

- fossil fuels;
- renewable/non-renewable;
- ethanol;
- fermentation;
- distillation;
- viscous;
- flammable;
- volatile;
- molecule.

Teaching approaches

Students begin by interpreting visually presented information about the formation of fossil fuels, some of the effects of burning them and their non-renewable nature. They are then given information about renewable fuels (derived from plants) and asked to identify some advantages and disadvantages of these fuels. Either, or both, of two specific bio-fuels are then explored in more detail:

- the actual and potential uses of ethanol as a replacement for petrol are considered from a number of perspectives;
- students consider what needs to be done to vegetable oils to make a replacement for diesel fuel, actually make a sample of bio-diesel and finally devise and carry out tests to compare their bio-diesel with the original vegetable oil and with normal diesel fuel.

Notes on the activities

Page 1: Since fossil fuels 'lock up' a lot of carbon, the amount of carbon dioxide in the Earth's atmosphere would have been reduced by their formation. Extracting and burning fossil fuels, on the other hand, increases the amount of carbon dioxide in the atmosphere (by about 50% over the past century). This is likely to make the Earth warmer (global warming, the 'greenhouse effect') and change the weather patterns (climate) in many parts of the Earth.

Page 2: The advantages of using ethanol and bio-diesel are:

- they are renewable fuels;
- they don't add to the carbon dioxide in the atmosphere; (they just keep on re-cycling the same carbon dioxide)
- they pollute the atmosphere less with other gases.

The main disadvantage of bio-fuels is their greater cost compared to fuels made from crude oil.

This is the main reason that they are not more widely used. (Producing them also requires a lot of agricultural land though this point isn't raised until the next section of the module.)

The question about Brazil is intended as a 'trailer' for the next section of the module. Brazil is not a particularly wealth country and its *government* wanted to reduce the cost of imported fuels the price of which increased greatly during the second half of the 1970s.

Page 3: The ethanol debate. The information is given on the students' sheet in four blocks and can be used in a number of different ways. Each student could, for example, be given access to all four blocks of information and asked to use it, individually, in small groups or in a whole class situation, to reach a considered judgement:

- about whether the Brazilian policy was a good one and whether it should be developed further;
- about whether another country, actual or fictitious, should adopt a similar policy.

Alternatively, the above topics could be debated, within small groups or on a whole class basis, with individual students each being provided with only one of the four blocks of information and therefore having different points of view.

Notes

- The processes of fermentation and distillation are well-established topics on most science curricula and have, therefore, *not* been included in this module. Teachers may, however, wish to include them, as student practicals or as demonstrations, prior to embarking on the ethanol debate.
- Students could be asked to look at the labels on wine bottles to ascertain the maximum alcohol (ethanol) concentration. Spirits have, of course been distilled and drinks such as sherry and port have been fortified with distilled spirit.
- Ethanol transfers far less energy than petrol when it burns per gram but very nearly the same amount of energy per litre.

Page 4: About bio-diesel. From the information provided, students should realise that vegetable oil molecules are bigger than the molecules in diesel fuel and also that each molecule of vegetable oil contains three parts very similar to the molecules in diesel fuel all of which are joined to an E-shaped part of the molecule. [**Note:** Unless students are older and at a reasonably advanced stage it is more confusing than helpful to show all of the atoms and bonds in the molecular structure of tri-glyceride and hydrocarbon molecules, or to use these terms. A schematic, non-technical appreciation is more appropriate.]

At this point students should be able to say that to make diesel fuel from vegetable oil you need to be able to 'chop off' the three parts of the vegetable oil molecule that are similar to a diesel fuel molecule. They'll see later that the actual reaction used is similar to, though not quite the same as, this suggestion.

Despite the advantages, especially to people with respiratory problems (e.g. asthmatics), of less polluted air in towns and cities, the main reason for RME not being more widely used is that it is about twice as expensive as normal diesel fuel.

Page 5: Making bio-diesel. The full preparation as outlined on the student sheet is a lengthy process and also involves a large quantity of reactants for each group of students. Teachers could, therefore, reduce the quantities by up to a factor of ten and also omit the washing and drying stages for students' own preparation of bio-diesel. The single settling process that is then needed could take place between one science lesson and the next (e.g. overnight, or if necessary over a few days). Different groups of students could prepare bio-diesel from different types of vegetable oil.

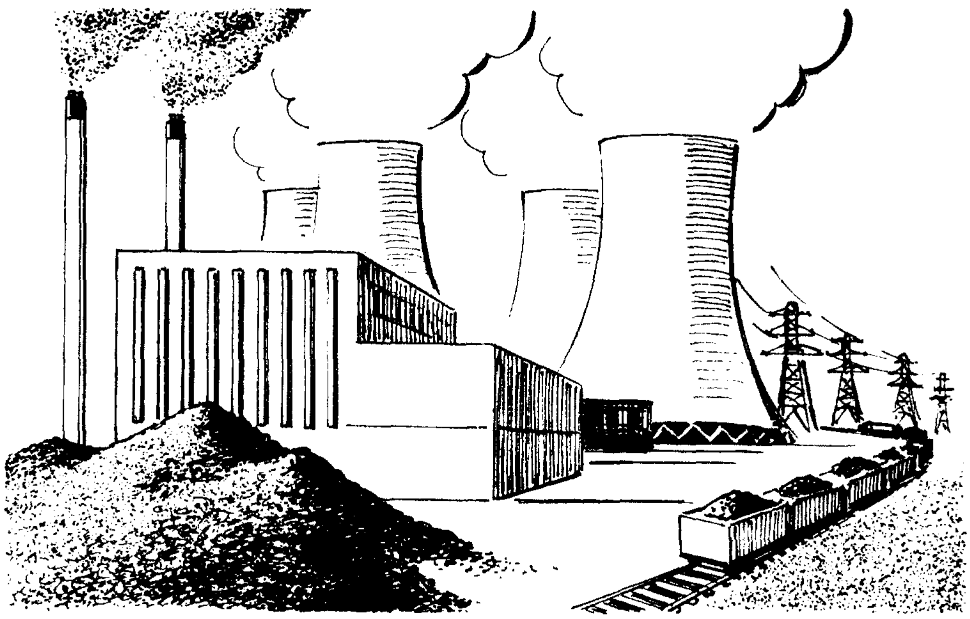
If the preparations are carried out on a smaller scale, students may not have enough bio-diesel for a viscosity test but teachers could solve this problem by having prepared a larger quantity of bio-diesel beforehand.

Students could go on to test their samples.

Testing bio-diesel. Ideas for the tests should be elicited from students:

- **flammability** can be tested by applying a lighted match or splint to a few drops of fuel in a metal bottle cap or on a watch glass. Using a cotton wool wick will make the samples easier to ignite;
- **smokiness** is also best compared as the fuel is burned using a wick;
- **viscosity** can be compared very simply by almost completely filling a narrow tube with the fuel, sealing with a stopper (or finger), inverting and comparing the times taken for the air bubble to rise to the top of the tube. The times taken for a small ball bearing to fall through a tube of the fuels could also be compared, though this needs a reasonable depth and width of tube and hence more of each fuel. Another way of comparing viscosity is to compare the rate of flow through a glass jet, a short length of capillary tubing or a burette with an almost closed tap. Care needs to be taken that the head/ pressure of fuel is the same in each case. This last method is most akin to the way that diesel fuel is actually used in a diesel engine: it is injected through a fine nozzle into the cylinders of the engine after the air in the cylinder has been rapidly compressed and become hot enough to ignite the fuel.

Oremulsion – an alternative fuel?



Power stations are an important part of a nation's economy. They supply the energy needed for all sorts of things - homes, industry, farming and so on. The electricity they generate is a convenient way of distributing energy around the country. Without energy, there would be no economic development.

Power stations generate electricity. Most power stations do this by burning fuel. Here are some examples of fuels burned in power stations:

- coal
- oil
- gas
- wood
- peat
- rubbish

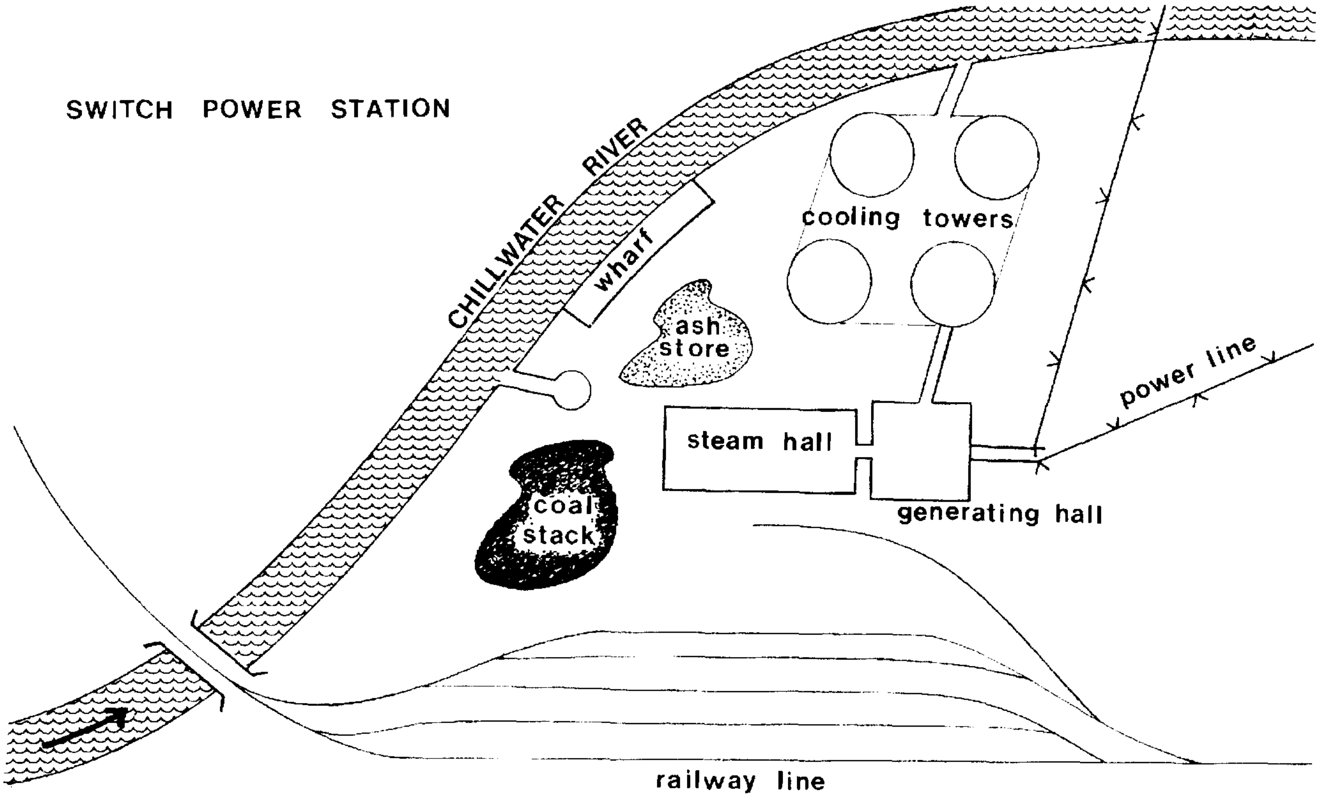
A big power station occupies a lot of land. The combustion products which come from the burning fuel pollute the atmosphere and the land round about.

Activity 1: Interpreting and presenting information

Study the power station map on the next page. You will also find some information about the substances produced when fuels are burned.
Now answer these questions:

1 What fuel does this power station use? How does the fuel get there?
2 How is the electricity carried away from the power station?
3 Why does the power station need water from the river?
Where does the water end up?
4 What happens to the ash from the burned fuel?
What else does the power station produce?

Now, summarise your findings by drawing a diagram to show all the things that go into the power station, and all the things that come out. You could use a colour code to show the flow of materials and the flow of energy.



Information about "products of combustion"

Most fuels are hydrocarbons. Their molecules are made of hydrogen and carbon atoms. When they burn, these elements combine with oxygen:

hydrogen + oxygen → water $2H_2 + O_2 \rightarrow 2H_2O$ carbon + oxygen → carbon dioxide $C + O_2 \rightarrow CO_2$

Fuels often contain impurities, including sulphur and nitrogen. When these burn, they produce harmful substances in the air: sulphur dioxide, nitrogen dioxide and nitrogen trioxide.

Fuels may also contain 'heavy metals' such as vanadium as impurities. When they burn, these poisonous substances escape in the smoke and ash.

Information about oremulsion

Oremulsion is a fuel sometimes used in power stations. It is a thick, black liquid. It is an emulsion (mixture) of natural bitumen and water.

Bitumen is a black tarry substance, sometimes used for making roads. One place where large underground desposits of bitumen are found is the Orinoco river basin in Venezuela, South America.

To extract the bitumen, hot steam is pumped down into a well. The steam and bitumen mix together to make a runny emulsion which can be easily pumped out of the well.

Oremulsion can be used in power stations instead of fuel oil. The data tables below compare these two fuels.

	energy content joules per gram	sulphur content	ash content	vanadium content
oremulsion	27,000 J/g	27%	0.25%	0.03%
fuel oil	40,000 J/g	27%	0.1%	0.01%

In producing equal amounts of energy, we also produce these pollutants; some can be reduced using filters:

	sulphur dioxide	nitrogen oxides	carbon monoxide	vanadium
oremulsion	114 units	140 units	100 units	444 units
fuel oil	100 units	100 units	100 units	100 units

Prices on the Rotterdam goods exchange, including delivery:

oremulsion	$4.5 US per tonne, stable
fuel oil	up to $8 US per tonne, varies

(Comparative data for combustion products of fuel oil and oremulsion based on data from Dalhaus power plant, Canada.)

Activity 2: Data interpretation

The information about fuel oil and oremulsion will help you to think about this question:

What makes a good fuel for a power station?

Think about the following points:

- amount of energy produced
- cost
- transportability
- combustion products
- availability
- health risks to workers, the public

In what ways is oremulsion better than fuel oil? In what ways is fuel oil better?

Briefing notes: Technologists' group

You work at the Switch Power Station. At the moment, it burns fuel oil, but the management is considering changing to oremulsion.

The power station management want your advice on the following points:

- How much energy is produced when oremulsion is burned? How does this compare with fuel oil?
- What compounds will appear when oremulsion is burned? Compare this with the products from burning fuel oil.
- Will any of these products harm the environment?
- Will it be necessary to alter the power station in any way?

Research

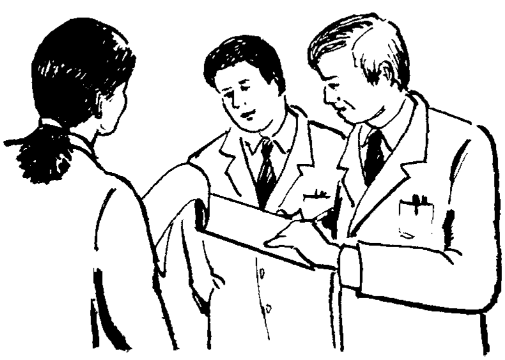
- Will it be necessary to alter the power generating plant in any way, so that it can burn oremulsion instead of fuel oil? Will this be expensive?
- How can you reduce the amount of harmful combustion products released when oremulsion is burned? Will this be expensive?

Briefing notes: Chemists' group

You work at the Switch Power Station. At the moment, it burns fuel oil, but the management is considering changing to oremulsion.

The power station management want your advice on the following points:

- What compounds will appear when oremulsion is burned? Compare this with the products from burning fuel oil.
- Will any of these products harm the environment?
- Will it be necessary to alter the power station in any way?



Research

- How might the environment be harmed by changing to oremulsion? Find out about the combustion products and how they damage the environment.
- How can you reduce the amount of harmful combustion products released when oremulsion is burned? Will this be expensive?

Briefing notes: Environmentalists' group

You live near the Switch Power Station. At the moment, it burns fuel oil, but the management is considering changing to oremulsion.

In the region served by the power station, there are large areas of forests and farmland, as well as a major industrial town. The local authority wants your advice on the following:

- What compounds will appear when oremulsion is burned? Compare this with the products from burning fuel oil.
- Will any of these products harm the environment?

Research

- How might the environment be harmed by changing to oremulsion? Find out about the combustion products and how they damage the environment.
- Are there any alternative ways of generating electricity which would not be so harmful to the environment?

Briefing notes: Business group

You have a factory producing furniture and other wood products. You rely on timber from the local forests, and electricity from the nearby Switch Power Station. At the moment, the power station burns fuel oil, but the management is considering changing to oremulsion.

Your business may be affected by this change. Find out about the following:

- Will the price of electricity be affected by the change to oremulsion?
- What compounds will appear when oremulsion is burned? Compare this with the products from burning fuel oil.
- Will any of these products harm the environment? Could this affect your business?

Research

- How might the local economy benefit from the change to oremulsion? Will the power station management have to invest in any new plant? What new jobs might there be?
- How might the environment be harmed by changing to oremulsion? Find out about the combustion products and how they damage the environment. What effect might this have on local businesses?

Briefing notes: Councillors' group

You belong to the council which runs services in the region around the Switch Power Station. At the moment, the power station burns fuel oil, but the management is considering changing to oremulsion.

The people you represent may be affected by this change. Find out about the following:

- Would electricity generated from oremulsion be cheaper or more expensive?
- How might the local environment be affected by the change to oremulsion? What pollutants might be produced? And what about noise and traffic problems?
- How might local householders be affected? And local businesses?

Research

- Will the power station need to be altered in any way?
- How might the local economy benefit from the change to oremulsion? Could new jobs be created? Might any jobs disappear?

Hearing evidence

You have to make a recommendation to the national government: Should the Switch Power station be allowed to change to oremulsion as its fuel? You can collect evidence from:

The **technologists' group** – they know how electricity is generated using oremulsion, and they may be able to tell you about any necessary modifications to the power station.

The **chemists' group** – they know about pollutants resulting from the burning of oremulsion, their effects on the environment, and how they might be reduced.

The **environmentalists' group** – they know about the local environment and how it might be affected by the change to oremulsion.

The **business group** – they know about local business and industry, and they may be able to tell you of any economic benefits or problems from the change to oremulsion.

(Bear in mind that the technologists and the chemists are employed by the managers of the power station.)

Making a report

You must compile a report to the National Government. Ask each group to prepare a part of the report. You need to write a list of your recommendations, based on their contributions and the evidence you have heard.

Oremulsion – an alternative fuel? – Teacher's Notes

Acknowledgement

This module is based on a unit edited for UNESCO by Jack Holbrook (ICASE).

Introduction

In this module, students are asked to:

- extract and present scientific information from a map;
- compare technical data on two fuels;
- identify criteria for assessing fuels;
- find out about the impact of fuel combustion;
- present ideas about a technological change from a variety of points of view;
- contribute to the production of a balanced report.

Scientific & technological concepts

- fuels;
- combustion;
- atmospheric pollution;
- electricity generation.

Teaching approaches

The module is designed to help students extend their knowledge of combustion and electricity generation and their impact on the environment. It starts with an exercise which, for many students, may be a revision of ideas about fuel-burning power stations. This part might be set as an introductory homework. In the next part, analysis of data is used as an introduction to the idea that many factors determine the choice of fuel for a power station. Finally, students adopt different roles to consider particular aspects in detail. Some of the necessary information is available within the unit; other information will need to be researched.

Notes on the activities

Pages 1 and 2: These pages will help students to summarise the material and energy flows through a power station. These can be summarised as follows:

	in	out
materials	fuel, cold water	ash, warm water, atmospheric pollutants (oxides of carbon, nitrogen, sulphur), heavy metals.
energy	stored energy in fuel	electricity, heat.

You might wish to substitute a map of a local power station for the one on page 2. You will need to judge which aspects will need labelling.

Page 3: Ideally, a fuel is cheap, abundantly available, easily transported, renewable, non-polluting and otherwise harmless. The data here can be used to allow students to compare fuel oil with oremulsion; this will help them to think of the various criteria against which a fuel can be judged.

If students are to carry out a detailed analysis of the data provided, they will have to combine some of the figures. For example, oremulsion is cheaper per tonne than fuel oil, but gives less energy per tonne. Similarly, although both fuels have the same sulphur content, more oremulsion must be burned so more sulphur oxides will be produced.

Pages 4 and 5: Students should be divided into five groups. The briefing notes for the first four groups are in two parts: firstly, questions they can be expected to answer on the basis of the information on the previous pages; secondly, some points to research. For example, the technologists could find out whether the power plant will have to be modified to cope with the change in fuel. Will different burners be needed? In places, the detailed effects of the change will depend on the details of the environment – prevailing wind and so on. Students may have to make some assumptions here.

More than one group may be researching the same question. The intention of this is to reduce the amount of background material you will have to supply. Groups may wish to collaborate at this point.

Page 6: The fifth group is the local councillors. They have their own questions and research. They are also responsible for running a meeting to hear evidence from the other groups, and organising the preparation of a report with contributions from each group. (If your students are not familiar with this type of activity, you may wish to adopt the role of chair of the council yourself.)

Water resources

The water cycle

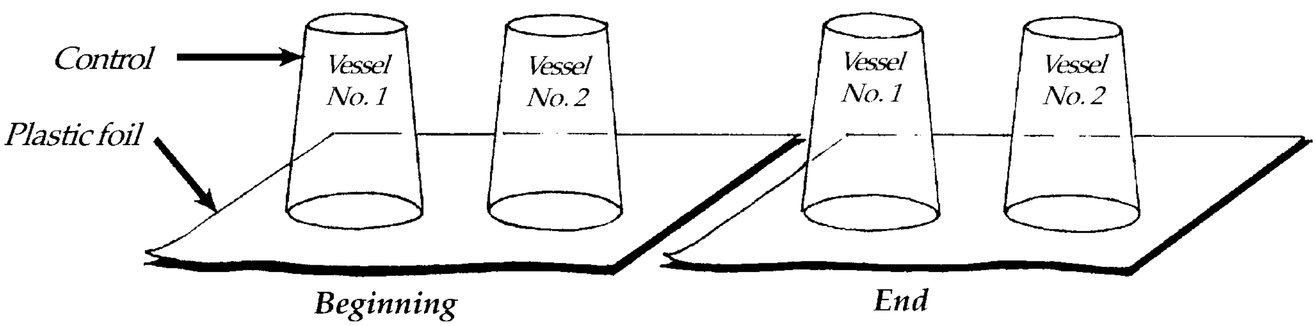
Water is constantly 'disappearing' from some places and 'appearing' in other places. For example:

- Water seems to disappear when you hang out washing to dry.
- Water seems to appear from nowhere onto cold windows (of kitchens or cars).
- When liquid water disappears from a surface, it has changed into invisible water vapour. This is called *evaporation*. The water vapour spreads out into all the space available.
- When water vapour touches a cold surface, some liquid water appears. This is called *condensation*.

Activity 1: Making observations

You can watch water disappear and re-appear. What you should do:

- Turn vessel no. 1 over onto some dry plastic sheet. This is the control.
- Lightly spray water onto the rest of the plastic sheet.
- Turn vessel no. 2 over onto the wet plastic sheet.
- Observe what happens until all the water has completely disappeared from the plastic sheet.
- Copy the diagram and mark on it where you can see liquid water at the beginning and at the end of the experiment.



Activity 2: Applying the ideas

- What will happen if vessel no. 2 is turned over at the end of the experiment?
- Give some other everyday examples of ***evaporation*** and ***condensation***.

Plants and water vapour in the air

The water from puddles, from lakes and from the sea is constantly evaporating to produce water vapour in the air. Plants and soil also play a part in putting water vapour into the air.

Water *evaporates* from bare soil just like it does from puddles, lakes and seas. Plants take in water through their roots and lose it through their leaves. This is called *transpiration*. The two processes together, eg, from a forest or a field of crops, are called *evapotranspiration*.

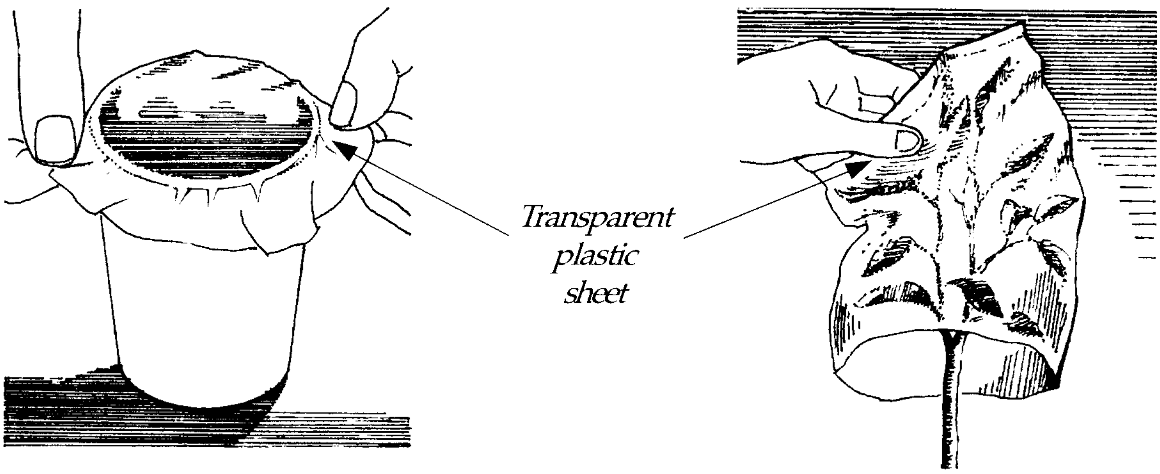
A forest can put between 20 and 50 tons of water vapour into the air per hectare per day. Each year 150 000 km^2 of rainforest are cut down (more than the area of Bangladesh). What effect will this have on the atmosphere? ($1km^2 = 100$ hectares.)

Activity 3: Making observations

Observing the water put into the air by soil and plants

What you should do:

- Cover a plant, but not the soil that it is in, with transparent, waterproof plastic sheet.
- Cover some soil, or compost, in a pot with some transparent, waterproof plastic sheet.
- Place the plant and the pot of soil in sunlight.
- Observe the plastic sheets after 1 hour.



Compost *Plant*

Observations

Copy the diagrams and show on them what you observe at the end of the experiment. Why do you need the transparent, waterproof plastic sheets to show that soil and plants put water vapour into the air?

The water cycle

The diagram shows the water cycle in nature.

a) Water vapour enters the atmosphere as it evaporates from the sea.

b) Water vapour also enters the atmosphere by evaporation from the land and because of transpiration by plants.

c) Water vapour is cooled as the air it is in rises. It may then condense to form clouds and then rain.

d) Most of this rain falls on the sea.

e) Some of this rain falls on land.

f) Some of the rain that falls on land collects into rivers and runs back into the sea.

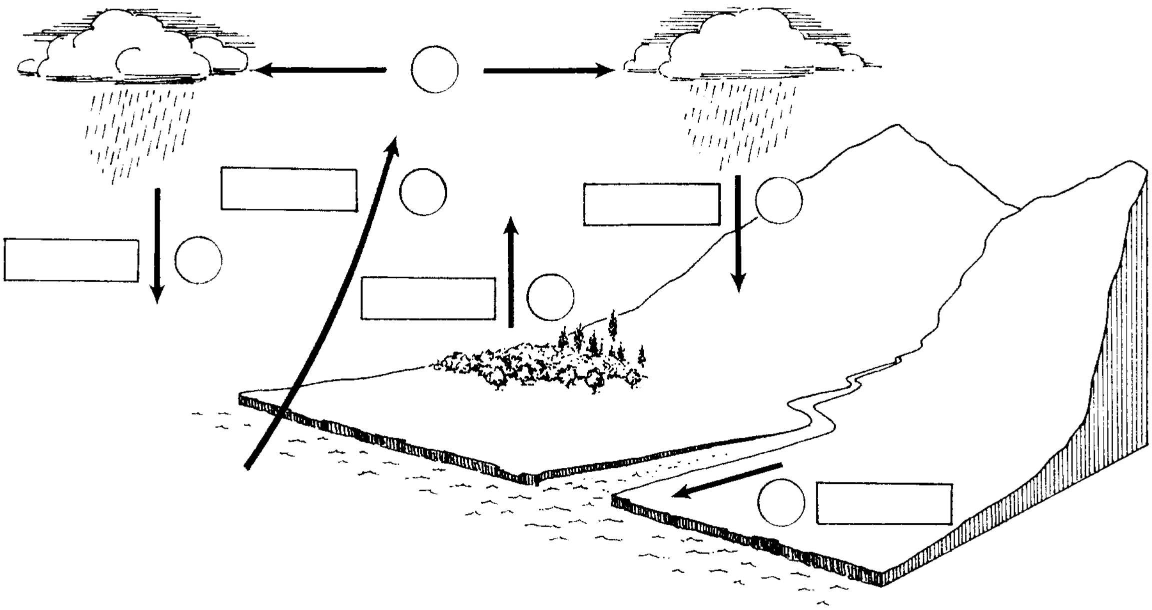
The table shows how many km^3 of water are transferred between different parts of the Earth's surface each year.

where and how transferred	km^3 per year
ocean → atmosphere (by evaporation)	500 000
atmosphere → ocean (by precipitation, ie, rain, snow etc)	455 000
land → atmosphere (by evaporation and transpiration)	75 000
atmosphere → land (by precipitation)	120 000
land → ocean (by rivers)	45 000

- Write the figures from the table into the correct boxes on the diagram.
- What is meant by the term *precipitation*?
- How much more water is evaporated each year from oceans than is returned to oceans by precipitation?
- How much more water falls on land each year from precipitation than is returned to the atmosphere by evaporation and transpiration?
- How is the balance of water between the land and the oceans maintained?
- Groundwater does not need to be included in natures's water cycle. Explain why not.
- Many people depend on groundwater for their supplies of fresh water. Why might they not be able to do this in the future?

Activity 4: Interpreting information

On the following diagram, write the letters **a** – **f** in the correct circles.



Making your own water cycle

When water evaporates, any harmful chemicals or microbes it contains are left behind. So we can make sea water or polluted water fit to drink by evaporating it and then condensing it again. This would be useful in places like Kuwait, Bahrain or Libya where water is scarce but which are by the sea.

However, using fuel to distil sea water is expensive. It is cheaper to use energy from the Sun to evaporate the sea water before you condense it again. The equipment that does this is called a *solar still.*

People in the Andes obtain water by letting water vapour condense on fishing nets placed at the top of mountains. This method works well and is now used in India and in countries around the Arabian Gulf.

Activity 5: Design and test

Your task is to design and test a solar still. When designing the still you should consider the following problems:

- How can you ensure that the sea water container receives as much energy from the Sun as possible, and absorbs as much energy as possible?
- What are you going to use as a cool surface on which the water vapour can condense?
- How are you going to collect the condensed water?* Ideally this should happen all the time or, in other words, you should produce fresh water by a continuous process.

* Try to avoid a laboratory type condenser which is expensive and needs a constant flow of cooling water.*

Here are some cheap and readily available materials that you could use to make your solar still:

- Black plastic sheet.
- Clear plastic sheet.
- Plastic (or wooden) boxes of various shapes.
- Clear glass (or thick, stiff clear plastic).
- Easy to cut plastic tubing (wide bore).

The water cycle – Teacher's Notes

Introduction

In this module students are asked to:

- observe the evaporation and condensation of water;
- observe the contribution of water vapour to the air by soil and plants;
- interpret presented information enabling them to build up a complete water cycle and to allocate figures to the annual amounts of water transferred in various ways;
- design and test a solar still (essentially the water cycle on a small scale).

Scientific & technological concepts

- evaporation;
- condensation;
- transpiration;
- evapotranspiration;
- water cycle;
- precipitation;
- distillation;
- solar still.

Teaching approaches

This module is designed to help students to appreciate the various processes which together add up to the water cycle in nature and to apply this to the small-scale production of fresh water from sea water or contaminated water. The first activity involves first-hand observation of the two main processes involved – evaporation and condensation. The second activity extends the relevant processes to include transpiration. The third activity involves both a qualitative and a quantitative consideration of the water cycle in nature. Finally students are asked to design a solar still from certain materials and to satisfy certain criteria.

Notes on the activities

Page 1: In Activity 1, the 'vessels' should be transparent and should fit tightly, when inverted, against a plastic sheet. Glass or plastic tumblers rather than laboratory beakers should be used.

Page 2: You may wish to extend this experiment beyond the limit of one hour.

Page 3: If you do not wish students to write on the sheet, make separate copies of the diagram, or ask them to make their own copies.

Page 4: In Activity 5, a wide, shallow box is better since this will capture more sunlight. The box should also be lined with black plastic which absorbs energy radiated by the Sun.

Glass or stiff plastic is best for the condensing surface on the top of the box. This should slope (a) to face the Sun, and (b) to allow the condensed water to run down.

The plastic tube can be cut to make a channel for collecting the water. It can be glued to the upper surface of the glass (or stiff plastic). The tube should be longer than the glass at one edge so that it can run (possibly uncut where it is outside of the glass) into a collection vessel. The glass sheet should also tilt slightly to the side of the box where the water is collected.

To make the process truly continuous, it should also be possible to pour more water into the box through a tube going through the side. The system works best if the box is reasonably airtight.

Sources of fresh water

More than 70% of the Earth's surface is covered with water. Even so, many people are short of water for themselves, their animals and their crops. The information in the table helps to explain why.

where the water is	amount of water (km^3 x 1000)	percentage (%) of total
in oceans	1 350 000	96.4
as ice* (mainly the Antarctic ice-cap)	25 000	1.8
groundwater+ (underground in Earth's crust)	25 000	1.8
surface water* (rivers, lakes, etc)	200	0.014
in the atmosphere	13	0.001
in the biosphere (ie, in the bodies of living things)	1	0.001

* = fresh water + = 10% of this is fresh water

The water in oceans, and in 90% of groundwater, is very salty and is unsuitable for people, animals and crops.

Activity 1: Interpreting data

1 The fresh water in ice, the atmosphere and the biosphere cannot easily be used. What percentage of the water on Earth **can** readily be used by people for themselves or for their animals and crops?

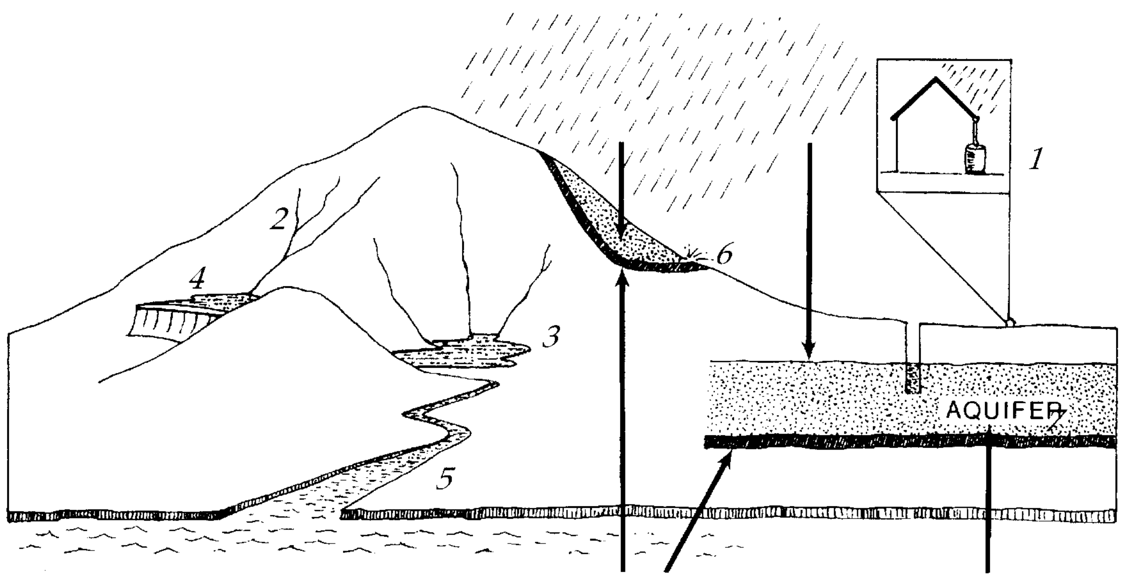
2 Draw a square 100mm x 100mm (or cut it from some graph paper).

- A 10mm x 10mm square then represents 1%.
- A 1mm x 1mm square represents 0.01% and a
- A 2mm x 2mm square represents 0.04%.

Use colours to show the percentages of water in the four main places where it is found on Earth. (You could also distinguish between 'fresh' and salty groundwater.)

Sources of fresh water

Fresh water is water that people can drink or use for their animals and their crops. People get their fresh water either from what is called surface water or from ground-water. Surface water is rain water that has not yet soaked into the ground or gone into the sea. Groundwater is water that is stored in the tiny spaces in certain rocks in the Earth's crust.



The diagram shows the different ways that people can get supplies of fresh surface water or ground water.

Fresh water isn't necessarily safe to drink. It may have picked up harmful chemicals or harmful microbes on its way into streams, rivers, lakes, reservoirs or groundwater.

Activity 2: Interpreting information

1 Match the following labels with each of the numbers 1 – 7 on the diagram.

- lake
- stream
- river
- reservoir (an artificial lake behind a dam)
- spring (water just gushes out of the ground)
- rain water (collected directly, e.g. from roofs)
- well water (from an aquifer)

2 Use the idea of permeable and impermeable rock to explain how an aquifer forms.

3 Which **two** of the fresh water sources on the diagram involve ground water?

4 (a) All the fresh water sources shown on the diagram are renewable. Explain why.
(b) Which source would take longest to renew if it wasn't used sensibly?

Making sure that water is safe to drink

In 1995, more than 5 million people, worldwide, died from water-related diseases. That is about 1 death for every 1000 people. These deaths mainly result from the contamination of water by human faeces. They especially affect developing countries where many people do not have access to safe drinking water and where the waste from human bodies is often not disposed of properly.

To make dirty and contaminated water from a river safe to drink it has to be treated in various ways. The following instructions tell you how you can treat some 'raw' water in the same ways. (However, to be safe, ***you should not drink the water you have treated.***)

Activity 3: Water treatment

Stage 1: Passing water through a grid

- Gently stir the raw water in its container.
- Take 100 cm^3 of raw water from its container.
- Place a grid on vessel no. 1.
- Pour the raw water through the grid.

Stage 2: Clarifying the water

- Add 15 drops of ferric chloride solution to the filtrate in vessel no. 1.
- Quickly stir.
- Add one small levelled measure of sodium alginate.
- Stir until a 'floc' is formed (clumps of solid easily big enough to see).
- Prepare a sand filter in a funnel with a filter paper and one big levelled measure of sand.
- Dampen the sand filter with clean water.
- Filter the water in vessel no. 1 and collect the filtrate in vessel no. 2.
- Rinse the stirring rod.

Stage 3: Disinfecting the water

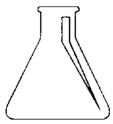
- Add 20 drops of sodium hypochlorite to the filtrate in vessel no. 2.
- Stir with a clean stirring rod.

Stage 4: Trapping dissolved pollutants

- Prepare a charcoal filter in the funnel with a filter paper and two big levelled measures of activated charcoal.
- Dampen the charcoal filter with clean water.
- Filter the water in vessel no. 2 and collect the filtrate in a clean vessel no. 3.

This is the 'treated' water. Is the water clear? Should the treated water be drinkable? ***You should not, however, drink this water.***

Tick the boxes on the diagram below to show the things that are and are not present in the water at each stage of treatment.



Untreated water

	Present	Not Present
water	☐	☐
peat, sand, floating objects	☐	☐
algae	☐	☐
microbes	☐	☐
dissolved pollutants	☐	☐
mineral salts	☐	☐

↓

passed through a **GRID**

↓

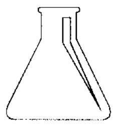
Grid-filtered water

	Present	Not Present
water	☐	☐
peat, sand, floating objects	☐	☐
algae	☐	☐
microbes	☐	☐
dissolved pollutants	☐	☐
mineral salts	☐	☐

↓

passed through a **SAND FILTER**

↓



Clarified water

	Present	Not Present
water	☐	☐
peat, sand, floating objects	☐	☐
algae	☐	☐
microbes	☐	☐
dissolved pollutants	☐	☐
mineral salts	☐	☐

↓

Disinfected with **SODIUM HYPOCHLORITE**

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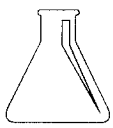


Treated water

	Present	Not Present
water	☐	☐
peat, sand, floating objects	☐	☐
algae	☐	☐
microbes	☐	☐
dissolved pollutants	☐	☐
mineral salts	☐	☐

↓

passed through a **CHARCOAL FILTER**

Tasting several drinking waters

Water that is safe to drink can have several different tastes depending on the substances that are dissolved in it. Groundwater from wells or springs, for example, often contains quite a lot of dissolved mineral salts but may not have needed to be disinfected. Surface water from rivers, lakes or reservoirs may not contain very much dissolved mineral salts but usually contains dissolved substances from the disinfection process.

Activity 4: Tasting tests

In these tasting tests you will taste some **reference solutions** which have known substances dissolved in them. You will then taste several different **drinking waters** whose taste you can compare to the reference solutions.

Be careful with hygiene in these tests. Always use your own tumblers to taste the different samples of water.

How to go about your tasting tests

Identifying some reference tastes

- Rinse your mouth with some 'standard' water then *spit it out.*
- Taste reference solution no. 1 by moving the water about in your mouth *without swallowing* it. Then *spit it out.*
- Note the taste of the water in the table below.
- Repeat the tasting test with the other reference solutions.
- For each reference solution, **cross out** the wrong terms in the 'what it tastes like' line.
- Your teacher will tell you what each solution contains ('tasty substance' line).

reference solution	no. 1	no. 2	no. 3	no. 4
what it tastes like	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated
tasty substance				

Tasting some drinking waters

- Do these tests in the same way.
- Note the taste of each type of water in the table below.
- On the 'what it tastes like' line cross out the words that do not apply.
- Your teacher will tell you the name of the drinking waters that you tasted and will help you to fill in the 'type of water' line, for example, from the labels of bottled water.

drinking water	no. 1	no. 2	no. 3	no. 4
what it tastes like	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated	no taste sour salty bicarbonated chlorinated
tasty substance				
type of water				

Conclusions

- Do all drinking waters have the same taste?
- What gives the taste of a drinking water?

Sources of fresh water – Teacher's Notes

Introduction

In this module students are asked to:

- interpret data, presented in tabular form, on the distribution of water on Earth and on daily inputs and outputs in humans and transpose these into visual form;
- interpret visually presented information on the various sources of fresh water;
- treat a sample of 'raw' water in the same ways that it would be treated by a water company and to understand the purpose of each step in the treatment process;
- undertake tasting tests of various samples of drinking water and relate the tastes to some standard reference solutions.

Scientific & technological concepts

- fresh water;
- aquifer;
- permeable and impermeable rocks;
- filtration/filtrate;
- disinfection;
- chlorinated.

Teaching approaches

This module is designed to help students to appreciate the importance of fresh water to humans (and other living things), where this fresh water comes from, how it can be made safe to drink and the effects that the source and any subsequent treatment of the water can have on its taste. All of the activities except tasting water can be done individually or in groups. Tasting should be done individually though judgements about how best to describe the taste are best discussed.

Notes on the activities

Page 1: In Activity 1, 10% of groundwater is 0.18% of the total water. When added to 0.014% of surface water the total of available fresh water is still less than 0.2%.

On a 100 mm x 100 mm square, surface water is just 1.4 millimetre squares. This exercise in intended to emphasise just how small a proportion of total water is available fresh water.

Page 2: The depletion of groundwater is already a problem in many places. The water level in aquifers is falling because water is being removed faster than it is being replaced. This can also cause salt water to find its way into aquifers.

Pages 3 – 6: Make up samples as follows:

- **Raw water** can be made by putting about 50g of soil or compost into an empty 3 litre bottle, adding about 3 cm^3 of green colouring and paper clips, toothpicks, cut plastic drinking straws etc. to simulate large objects found in rivers. Top up with tap water to 3 litres.
- Suitable **ferric chloride** solution can be made by taking 50 cm^3 of commercial solution and making it up to 1 litre with demineralised water. When the solution becomes cloudy it should be poured away down the sink together with a lot of tap water.
- **Sodium alginate** can be obtained from chemical suppliers. Only 1-2 mg are needed.
- **Activated charcoal** can be obtained from chemical suppliers or for purifying drinking water. If it is not available, barbecue charcoal crushed in a bag with a hammer, can be used.

  [Should ferric chloride and sodium alginate (both required for the flocculation stage) or charcoal not be available these steps should be omitted from the treatment process.]
- **Sodium hypochlorite** solution is prepared by diluting 1 ml of commercial bleach to 1 litre with demineralised water. This very dilute solution does not need any special care in handling.

The '**standard**' water should be water with an average mineral content for the country concerned (e.g. Evian water in France). This water has, by definition, no taste. It should be kept in its original bottle to avoid any change in its taste.

The **reference solutions** should be made up as follows:

- **Chlorinated taste**: 1 drop of commercial hypochlorite (bleach) in 1 litre of 'standard' water;
- **Salty taste**: 1 g of cooking salt (sodium chloride) in 1 litre of 'standard' water;
- **Sour taste**: 100 cm^3 of white vinegar in 1 litre of 'standard' water;
- **Bicarbonated taste**: 1 g of sodium bicarbonate (= hydrogencarbonate) in 1 litre of 'standard' water.

The **drinking waters** should be in similar bottles, labelled 1, 2, 3 and 4, *not* in their original bottles. One of the waters should be a chlorinated tap water, one should be the 'standard water' (i.e. with no taste). The two others should have definite, but different tastes, e.g. Perrier (sour) and Vichy-Saint-Yorre (salted + bicarbonated).

Managing water resources

Having a reliable and safe supply of fresh water is very important for us to stay alive. The way that many of us live our lives means that we use a lot more fresh water than we need just to stay alive. If the number of people in the world increases and they all use more fresh water, we will not be able to supply all the fresh water that is wanted. One way of helping to solve this problem is for each of us to use fresh water more carefully.

Activity 1: Making an estimate

Here's how to estimate how much water you use each day:

Fill in the first column of the table below for the volume of water that you use, on average, each day. Then calculate how much water you use in a year.

In some cases you will need to work out your **share** of the water used in your home. These cases are marked with a * in the table. For example, if your family uses a washing machine to wash clothes 3 times a week this uses 3 x 120 = 360 litres per week. On average, this is 360 ÷ 7 = 51 litres per day. If there are 5 members of your family this is just over 10 litres per day for each member of the family.

You will probably find the following average values helpful:

- Brushing teeth: 0.01 - 1 litre
- Cooking a meal: 1 - 5 litres
- Flushing toilet: 5 - 10 litres
- Washing hands: 1 - 3 litres
- Dish washer: 30 - 50 litres
- Washing machine: 30 - 100 litres
- Shower: 1 - 40 litres
- Cleaning car: 5 - 200 litres
- Drinking: 1 - 2 litres
- Watering garden: 1 - 17 litres per m^2
- Bath: 50 - 150 litres

(Washing clothes or dishes by hand only uses a quarter as much water.)

use of water	how much you use each day	how much you use in a year
keeping your body clean		
drinking		
flushing the toilet		
preparing food*		
washing dishes*		
washing clothes*		
washing a car*		
watering a garden*		
TOTAL		

How much water could you save?

Activity 1: Making an estimate

Discuss ways that you could reduce the amount of water you use without affecting your life too badly.

- How much water could you save each day?
- How much water could 1000 people save each day?
- In towns and cities, a lot of water is lost through burst pipes. Estimate the loss of water through a burst pipe by measuring how fast water flows out of a tap. (For example, you could measure how long it takes to fill a 1 litre bottle.)
  How much water would be lost from a burst pipe in a day?

  How does this compare with the water that 1000 people could easily save each day?

  Which is more important, saving water at home or repairing burst pipes quickly?
- Design a poster to inform the public about the importance of saving water.

Sharing water between different users

Different groups of people with different interests often live in the same area and have to share the same fresh water resources. This can often lead to conflict.

There is a plan to dam the main river in your area, upstream of where you live, to store water and only release it at certain times.

Activity 3: Role play

Each group of people who would be affected has to present a report to the committee that will decide whether or not to build the dam. Your teacher will put you into one of the following groups:

- Farmers (who need water mainly for irrigating their crops).
- Water authority (who need to supply water to people in towns and villages in the area).
- Leisure-time users of water (e.g. for yachting, fishing, etc.).
- Hill farmers who would lose land and in some cases houses as the reservoir forms behind the dam.
- Industrialists who could use the cheap hydro-electricity that could be generated.

Preparing the reports of the various interest groups

You should prepare your group's report to the committee under the following headings:

- A description of the group.
- A statement of the *quantity* of water that your group needs for its activities.
- A statement of the *quality* of water that your group needs for its activities.
- A statement of how the needs of your group would be helped by the dam.
- A statement of how the needs of your group would be harmed by the dam.

Making a decision about the dam

The whole class should now regard itself as the committee that makes the decision. Each group presents its report and is questioned by members of the committee. The committee then discusses the whole matter and reaches a decision, unanimously if possible, otherwise by voting.

Meeting the demand for water

The water that is consumed in homes in different parts of the world depends mainly on two factors:

- How much water is readily available.
- How much water people have got into the habit of using.

The table shows the average amount of water used in homes per person per day in different parts of the world.

part of world	water used (per person per day)
North America	200 - 300 litres
Europe	100 - 150 litres
Developing Countries	5 - 50 litres

In 1990 there were 5.3 billion people on Earth. By the year 2025 it is expected that there will be 8.3 billion. It is also expected that the average amount of water used by each person will also have increased.

The table shows how much water was available per person in 1995 in different regions of the world and how much is likely to be available in 2025.

region of world	water available in 1995 (per person per year in millions of litres)	water likely to be available in 2025 (per person per year in millions of litres)
Africa	5.53	2.46
North & Central America	16.60	12.50
South America	37.00	24.10
Asia	3.60	2.35
Europe	3.96	3.92
Oceania	80.80	61.40

1 How many times as much water do people in North America use in their homes compared to people in Europe? and people in Europe, compared to people in developing countries?

2 In which two regions of the world is water most likely to be seriously scarce in 2025? Give two reasons why this is likely to happen?

Water is officially defined as being scarce when less than 1 million litres are available per person per year. The following countries suffer most from water scarcity (in order, starting with the one where water is scarcest): Kuwait, Bahrain, Malta, Singapore, Libya, Jordan and Cyprus.

Activity 4: Questions

3 On a world map colour in blue the three regions where there is the greatest amount of water per person per year. Colour in red the countries where water is scarcest.

Managing water resources – Teacher's Notes

Introduction

In this module, students are asked to:

- estimate how much water they use each day;
- suggest ways that they could reduce the amount they use;
- compare the savings they could make with the estimated losses from leaking pipes;
- consider competing claims on water resources, present the case for a particular point of view and participate in reaching a balanced judgement;
- compare the amounts of water used by people in different parts of the world;
- consider likely problems in meeting the demand for water during the next quarter century.

Scientific & technological concepts

- estimation;
- projection.

Teaching approaches

This module is designed to help students appreciate just how much water they personally use and the problems there might be in meeting this demand in different parts of the world or in the future. The first activity involves two different exercises in estimation and the second activity involves adopting the roles firstly of a particular user of water resources and secondly of an impartial decision maker. Presented data is then used both to make comparisons and to anticipate possible future problems.

Notes on the activities

Pages 1, 2: It might be worthwhile collecting together the individual results across a whole class in order both to ascertain the range of values and to obtain some average values.

Pages 2, 3: Depending on what teachers know concerning the likely prior knowledge of their students, it might be helpful to provide each group with further background information on a briefing sheet. This should, where possible, relate to local circumstances but should **not** comprise a script for what the group presents in its report. It should, rather, provide the information from which students can infer what the group they belong to would need to say. The information provided to different groups might, of course, partly overlap.

In the final decision-making stage, it might be helpful for the teacher to chair the meeting.

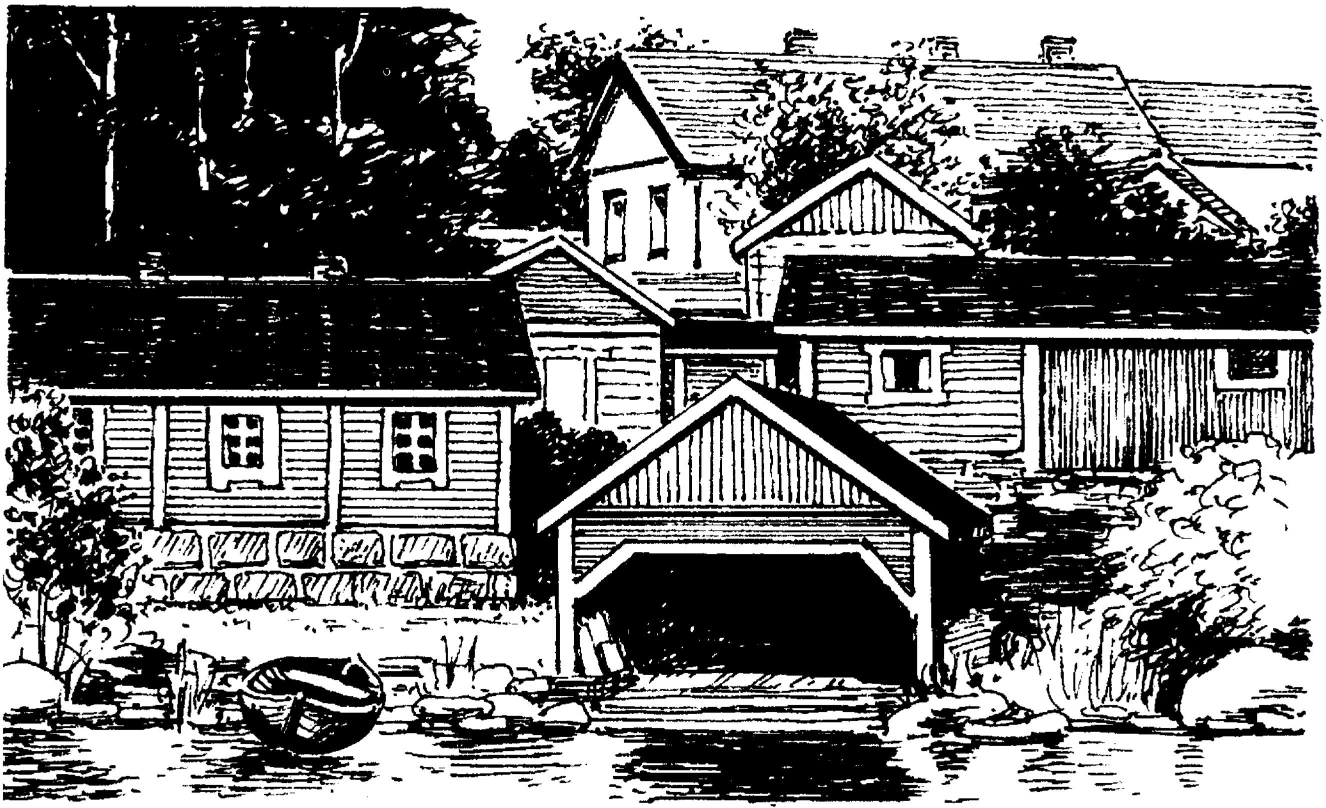
Page 4: For the final part of Activity 4, students need an unmarked outline world map and an atlas for reference.

Forests for the future

The people of Finland live in a country where they are surrounded by forests.

- 70% of the country's surface area is covered with trees.
- 75% of all Finns say they would prefer to live in a wooden house.
- 36% of all Finland's exports are of wood or paper products.

But can the Finns be sure that their forests will still be there in the future?



In Finland, people have built wooden houses for over a thousand years.

Activity 1: Thinking about wood and paper

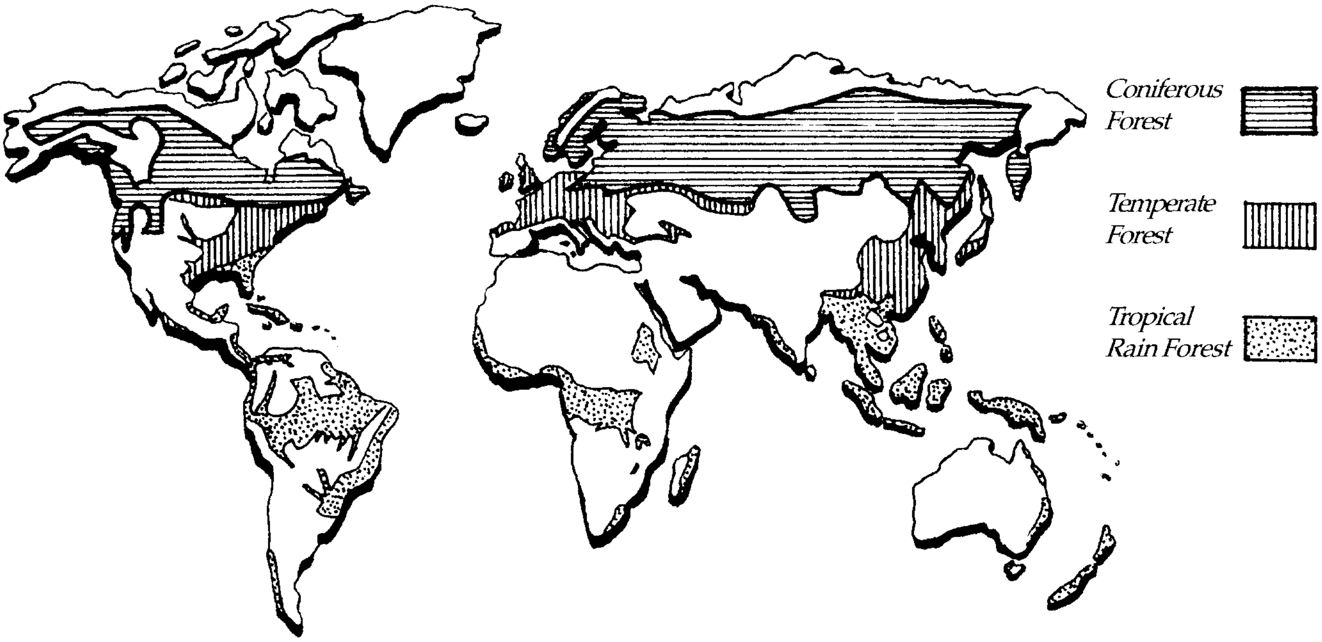
Trees give us wood. A lot of wood is pulped to make paper.

- Make a list of five things which are useful to you, and which come from woods. Compare your list with others in the class.

It is often better to recycle wood and paper, rather than cutting down more trees. Then some wood which has had one useful life is given a second life.

- Think of one way in which wood is recycled, and one way in which paper is recycled. Compare your ideas with others in the class.

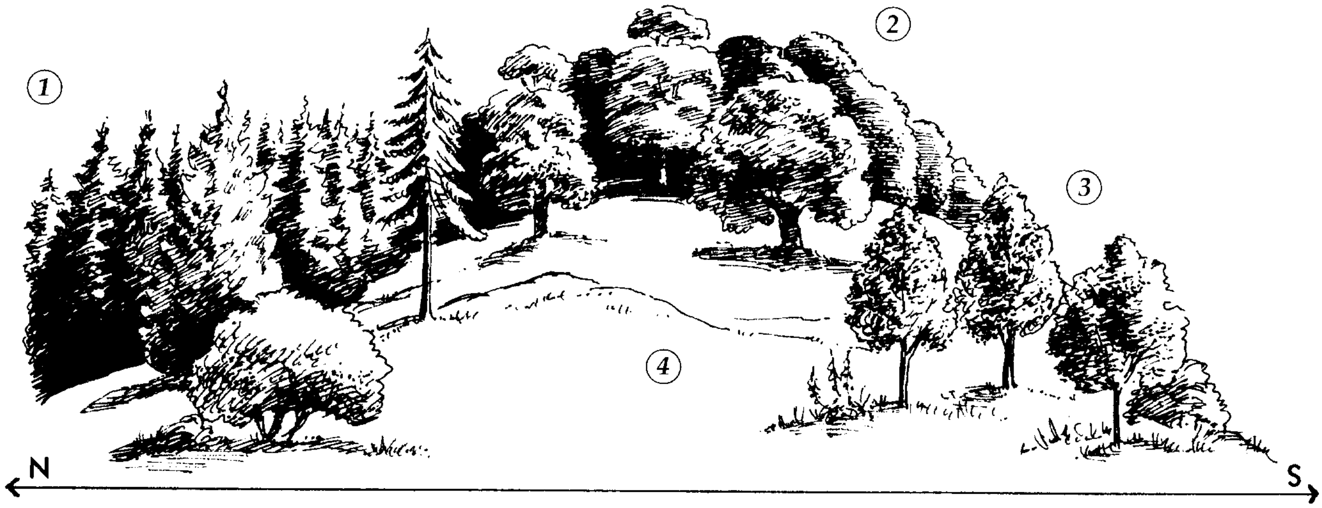
Activity 2: Map interpretation



Look at the map. It shows where different types of forest grow around the world.

- Find out where Finland is on the map. Which type of forest grows there? What type of trees would you expect to find growing in a Finnish forest?
- What pattern can you see in the distribution of forest types around the world? How does this pattern relate to the different climates of different areas?
- Why are some areas of the map unshaded? Explain why Greenland and North Africa are unshaded.

A forest survey



1 *mature conifers*
2 *mature deciduous trees*
3 *young trees, large bushes*
4 *open ground, forest edge*

People who manage forests have to check that the forests are keeping in good shape. A healthy forest can support many different species of plants and animals. The trees grow well so they will be a useful resource in the future.

Here are some ways you can find out about the health of a forest. You need to study different areas within the forest, as shown by points 1-4 in the picture above.

Activity 3: Investigating the diversity of species

At different points in the forest, find out about the following:

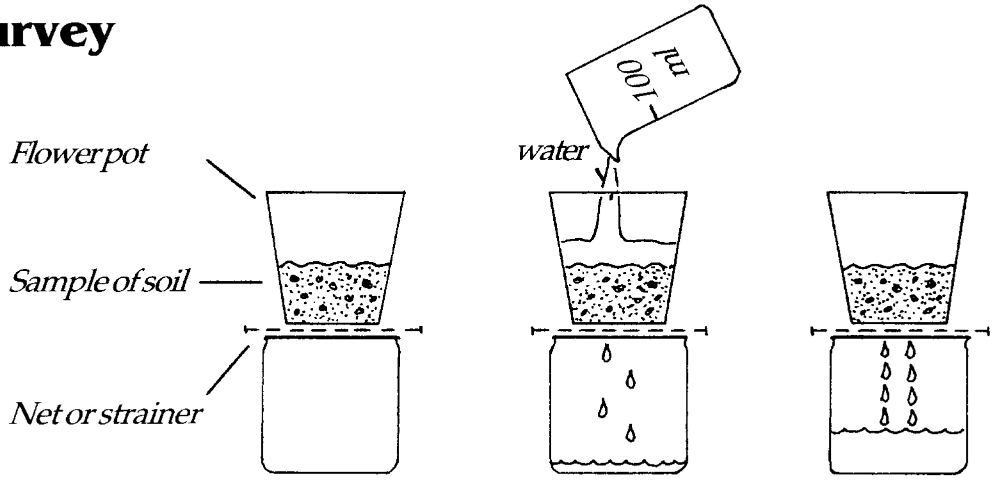
- What types of trees and bushes are growing? How densely are they growing?
- What other plants, grasses etc. are growing? Are there any mosses or lichens growing on the ground or on the trees?
- Can you find any evidence of animals, such as footprints, gnawed pine cones, or paths? Are there any birds?
- Which area of the forest has the greatest diversity of species?

Activity 4: Studying the microclimate

At each of your chosen points in the forest, make the following measurements:

- At ground level and at a height of 1.5 m above the ground, measure temperature, including maximum and minimum over 24 hours; the amount of light; speed of wind.
- When it rains, how easily does the rain reach the ground?
- Can you see any connections between the microclimate and the plants and animals found at each of your survey points?

Soil survey

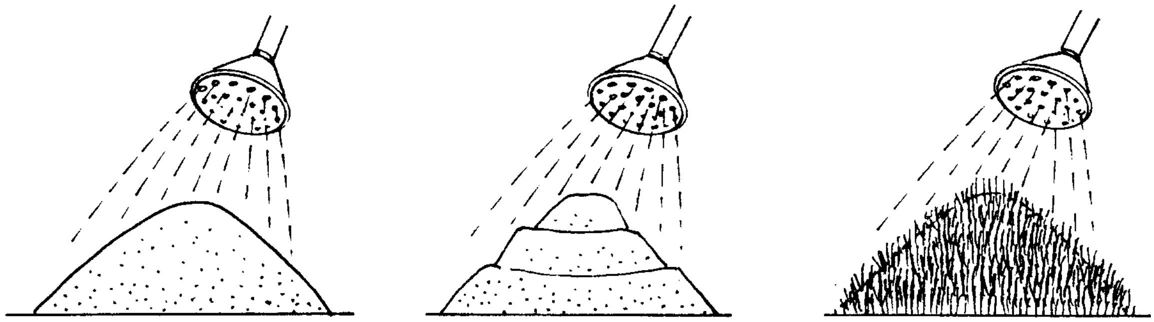


How much water will the soil hold? Here's how to find out.

- To a 100 ml sample of soil, add 100 ml of water.
- Time how long it takes for the water to filter through the soil.
- Measure the volume of water that passes through.

Activity 5: Measuring water-holding capacity

- Collect 100 ml samples of soil from different places in the forest and follow the instructions above.
- Can you identify any differences between the samples from different places?



Make a pile of moist sand. Water with a watering can, gently at first, then harder.

Make small terraces around the mound before you water it.

Sow seeds of fast-growing grass. When they are growing, water the mound.

Trees need water, but some soils don't hold water well. Rain can wash the soil away. How can foresters prevent water erosion?

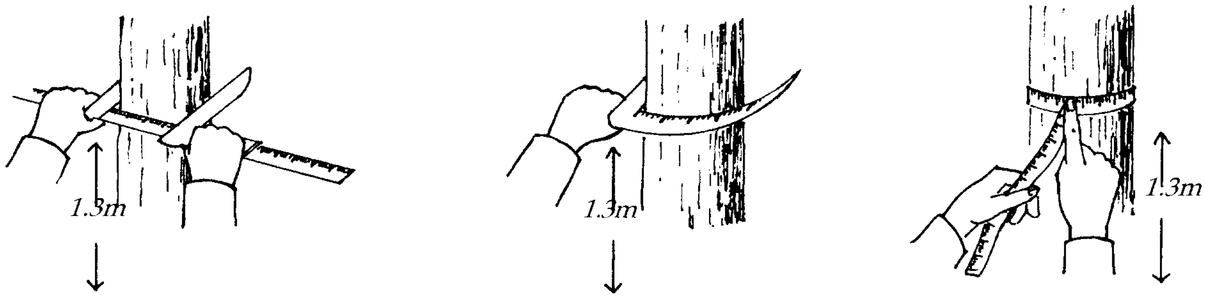
Activity 6: Investigating soil erosion

- Investigate the erosion of soil. The pictures above will give you some ideas; you may have ideas of your own.
- What advice would you give to foresters who want to prevent erosion and save their soils?

The economic value of a forest

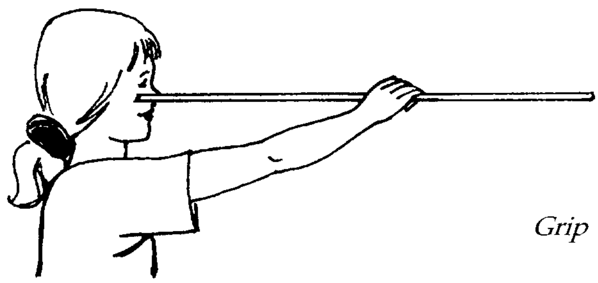
Trees are valuable. The wood they provide has many uses. How can you estimate the value of a tree? and of a forest?

Measuring the diameter of a tree:



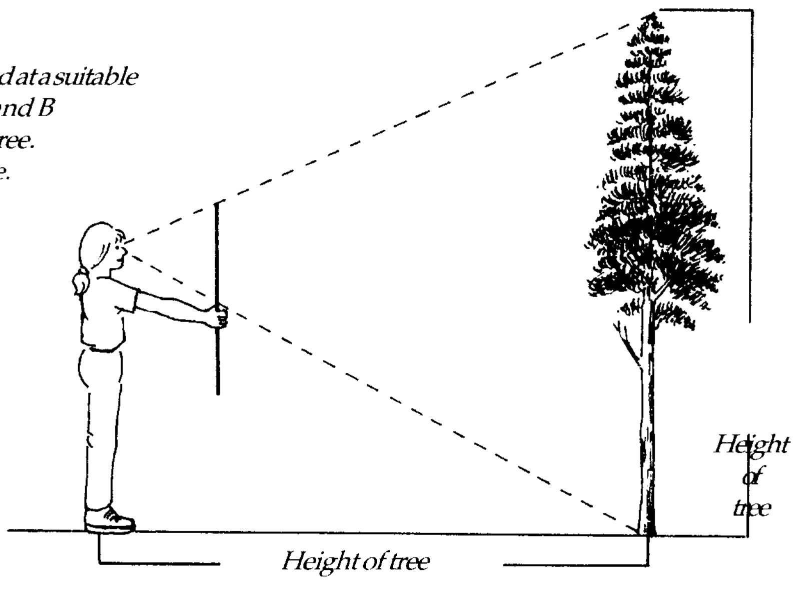
Make your measurement 1.3 m above the ground.

Measuring the height of a tree:



Grip the rod so that the end just touches your cheek.

Hold the rod at arm's length. Stand at a suitable distance from the tree, so that A and B match the top and bottom of the tree. Measure from your feet to the tree.

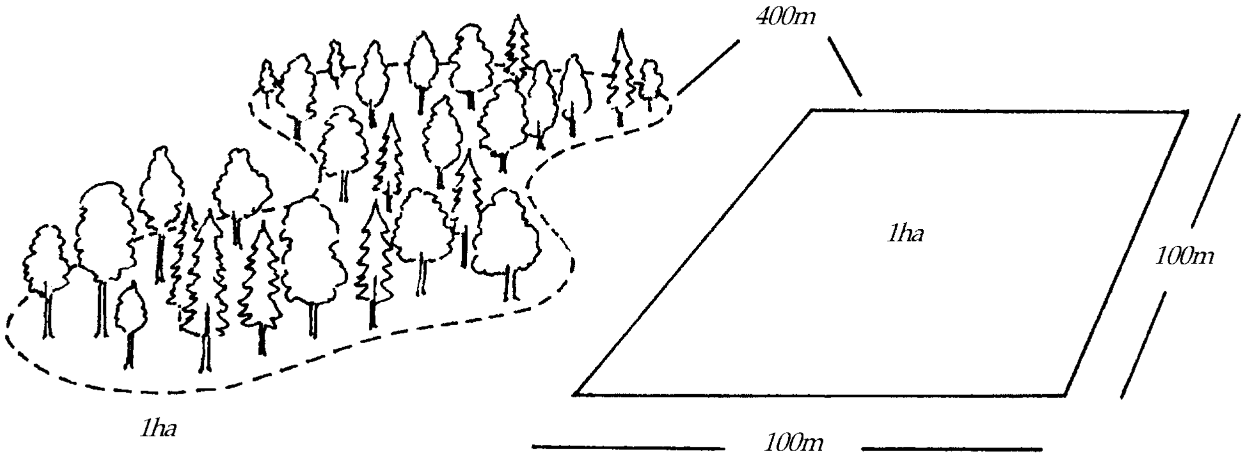


Calculating the volume of a tree:

Compare its shape to a cylinder. $V = \pi r^2 h$

Activity 7: Estimating the volume of a tree

Find a tree. Use the techniques shown above to estimate its volume. Why is your answer only an estimate?



Estimating the area of the forest, and the number of trees:

1 Use a map, or make measurements on the ground.
2 A square, each side of which has a length of 100 m, has an area of 10 000 m^2 (1 hectare).
3 Its perimeter is 400 m.
4 Count the trees in a small area, say 20 m x 20 m. Work out how many there are in a hectare.

Today, satellite photographs are taken to show all the forests of Finland. They can be analysed to find out how densely forested the country is, and how fast the trees are growing.

The natural coniferous forests of Finland have been regenerated by wildfires at intervals of 100-300 years. Now, satellite photos show that the forests are a mosaic of old, middle-aged and young areas.

The forest managers want the forests to be exploited in a sustainable way, so that there will be useful forests long into the future. When they fell trees, they must emulate the effect of fire. They cut small areas, less than 4 hectares, and then replant them.

The oldest forests, especially wilderness areas, should stay intact for nature conservation.

Activity 8: Estimating the economic value of a forest

- Use the ideas shown above to estimate the area of the forest, the number of trees it contains, and the volume of timber.
- Contact a timber firm, or look for prices in a financial newspaper. How much is each cubic metre of timber worth?
- Each 1000 m^3 of coniferous trees produces about 40 m^3 of useful wood each year. What is the value of the wood produced by your forest each year?

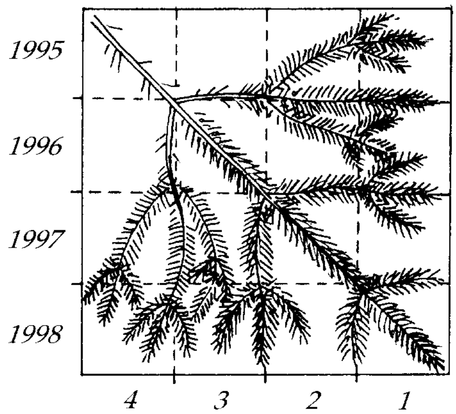
Healthy conifers

Fir and pine trees are covered with needle-shaped leaves. A healthy tree keeps its needles for three or four years. If the needles drop off when they are younger, it can be a sign that the tree is unhealthy.

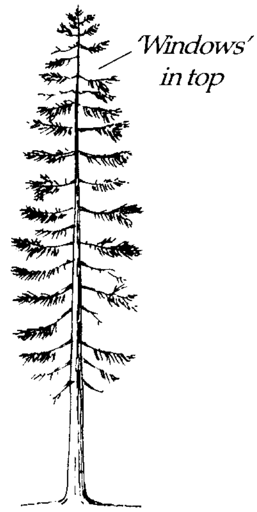
If a tree is losing its needles, or they are going brown, this may be a sign that it is suffering from the effects of pollution. Acid rain can damage the needles, and it can also damage the tree's roots when it gets into the soil.

Each needle has a waxy outer layer, which helps it to retain moisture. Acid rain can damage the waxy layer and the needle dries out.

How to tell the age of a needle

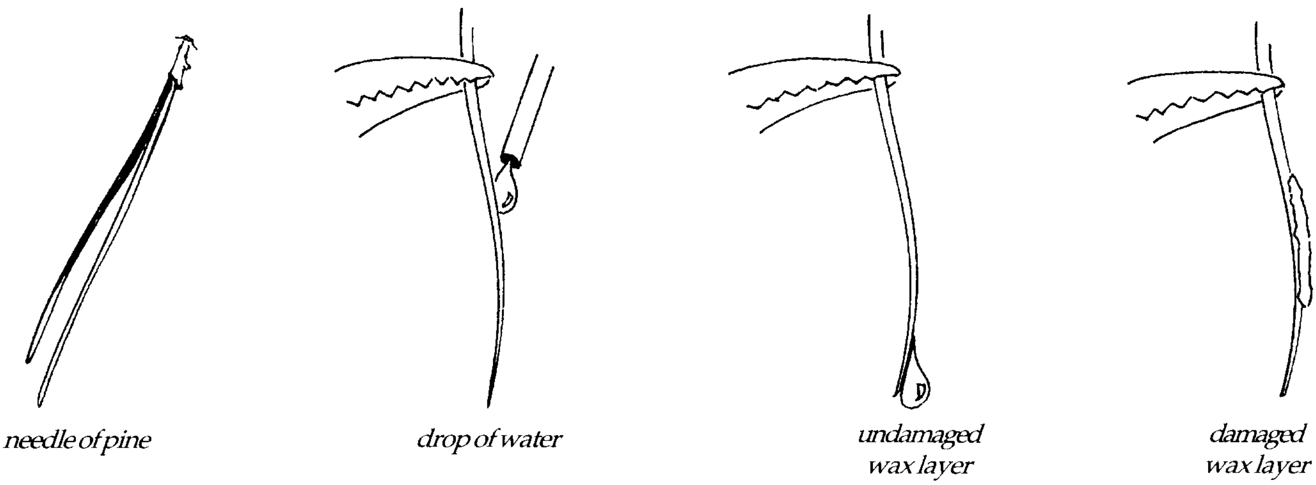


Branch of spruce



A badly-defoliated spruce tree

Testing the waxy layer on a pine needle



Activity 9: Investigating forest health

Examine some conifer trees, using the techniques shown above. How healthy are they?

Forests for the future – Teacher's Notes

Acknowledgement

This module was written by Mervi Skyttä, Finland. It draws on materials developed as part of a collaboration between two Finnish organisations: the Science Teachers' Association (BMOL) and the Forest Association (SMY).

Introduction

In this module, students are asked to:

- assess the economic importance of wood products;
- consider where wood products come from;
- survey various aspects of a forest environment;
- investigate the interaction between water and soil;
- estimate the economic value of a forest;
- assess the health of coniferous trees.

Scientific & technological concepts

- biodiversity;
- sustainability;
- soil erosion;
- pollution;
- vegetation types;
- fieldwork surveys.

Teaching approach

The module provides an opportunity for students to consider, in the context of a practical situation, the broad environmental concepts of biodiversity, sustainability, regenerating capacity, productivity etc. These general ideas can be drawn out of the particular context of forestry. Finland is bound by the principles defined at the Rio Conference on Environment and Development (1992) and at the subsequent Helsinki Conference on the Protection of Forests in Europe (1993), and these govern the development of its forestry policies.

About one third of the Earth's land surface is covered by forests. Finland is situated in the boreal coniferous zone and the corresponding figure is two thirds. Finnish laws governing forestry are aimed at achieving sustainable management and use of the forests. This involves the stewardship and use of the forests which will maintain their biodiversity, vitality and productivity into the future. This module is designed to help students gain an appreciation of these ideas and some of the problems associated with achieving them.

The first page sets the scene; after this, you may wish to select particular pages from the module to make up your own sequence of activities relating to the study of a local forest. Groups of students could be set different tasks: investigating the forest's biodiversity, microclimates, soil types, tree density and so on. Then each group could report back to the class and a joint report produced.

Notes on the activities

Page 1: These activities set the scene. Activity 1 asks students to think about the great variety of uses of wood. You may wish to extend their ideas by pointing to such uses as the production of turpentine for the chemical industry, the extraction of substances used by the pharmaceutical industry, and the production of textiles such as viscose from bark.

Page 2: Activity 2 looks at the main forest types around the world. Finland is in the coniferous forest zone. Students could consider the forest types in their own region, and in other parts of the world that they have visited.

Page 3: At this point, it is desirable to visit a forest. (Note that the permission of the landowner will normally be required.) Students could come to a collective agreement about the location of particular survey points which are representative of the different environments within the forest. Alternatively, the teacher could decide these in advance of the field trip.

You will probably need to provide materials which will enable pupils to identify species of plants and animals. You will also require equipment for measuring temperature, humidity, light level, wind speed and so on.

Page 4: The first activity shows one way of measuring the water-retaining capacity of soil. You could use samples taken during your forest survey, or provide your own samples of different soil types for use in the laboratory. The second activity is laboratory-based. Students should observe the benefits of using terracing and the planting of grasses to stabilise sandy soils.

Pages 5/6: Before looking at these pages, you could ask students which factors they would need to know to calculate the economic value of a forest – its area, tree density, volume of average tree, price of timber etc. The activities on these pages will help students to determine these quantities for themselves.

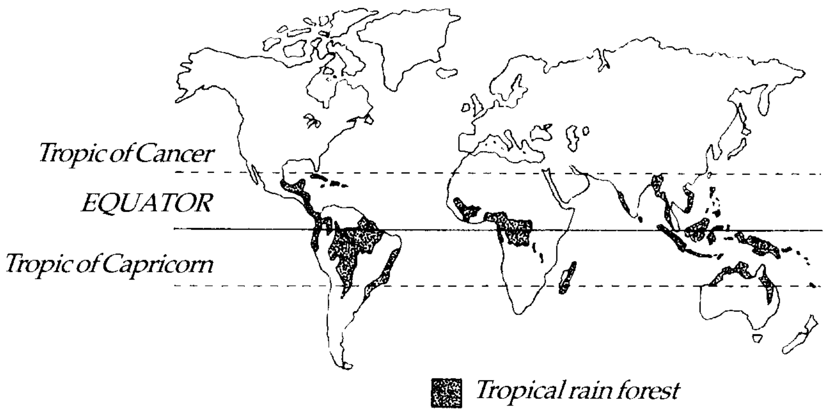
Page 7: Finally, we consider the state of health of the trees themselves. The instructions describe how to assess the needles of fir and pine trees. You will have to provide alternative methods if you are looking at a deciduous forest.

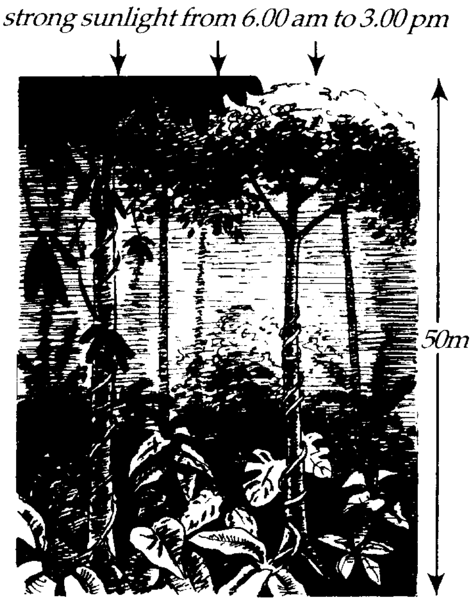
To conclude, you could ask students to discuss what they have learnt about the general environmental ideas of biodiversity and sustainability. As suggested above, these broad ideas are best approached in a gradual way throughout the student's science education.

Further information: The Finnish Forestry Association has a website (www.metla.fi/forestfin/) with extensive background information in several languages, and links to other useful sites.

Tropical rain forests

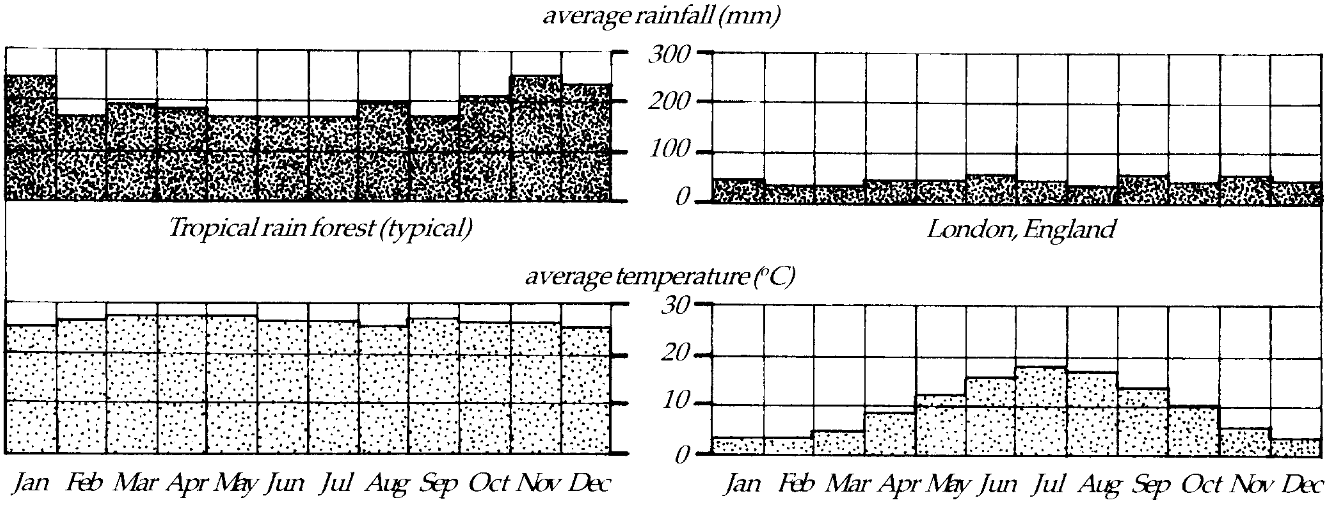
What are tropical rain forests?





very heavy rain, often thunderstorms in the late afternoon of most days

there are hundreds of different kinds of trees and thousands of different plants



Activity 1: Interpreting data

1 (a) In which part of the Earth do tropical rain forests grow?
(b) Why are these forests called *tropical rain* forests?
(c) About what percentage of the Earth's land surface is covered with tropical rain forest? Choose from: 1% 5% 25% 50%

2 Describe the climate (sunshine, temperature, rainfall, etc.) in a tropical rain forest. [You might find this easiest to do by comparing the climate in a tropical rain forest with the climate somewhere else, for example where you live, or with London, England.]

3 Describe what it is like inside a tropical rain forest.

What's happening to the rain forests?

Judging from the information that we get from satellites, there are about 1 billion (1 thousand million) hectares of tropical rain forest.

The table shows approximately how much tropical rain forest is being lost each year, and why.

why the rain forest is being lost	how much is lost each year
cut down to clear the land for agriculture	about 6 million hectares (ha)
severely damaged as selected trees are cut down for timber (wood)	about 4 million hectares

The number of people in the world is increasing all the time, especially in developing countries. These people all need to be fed.

Developing countries also need to earn money by selling things that more developed countries want to buy.

Most of the countries with tropical rain forests are developing countries.

People in developed countries, for example in Europe, in North America and in Japan like to use hardwoods that grow in tropical rain forests. They use woods such as mahogany, ramin and teak to make furniture, window frames, etc.

Only about 2 trees out of every hundred that are cut down are the type that developed countries buy. Most of the other trees are burnt or left to rot.

The direct effect of cutting down areas of forest (deforestation) is the loss of the trees themselves. Many other plants that grow there and many animals that live there (mainly in the canopy, high above the ground) are also lost.

More than half of all the quarter of a million different species of plants that we know about live in tropical rain forests.

Many of the plants in tropical rain forests could be useful to us, e.g. for medical drugs or because they contain genes that would be useful in crop plants.

When species – and their genes – are lost we say that there has been a reduction in bio-diversity.

Another effect of deforestation is that the heavy tropical rain washes away the soil into rivers. This is called soil erosion. Normally the trees and all the other vegetation prevent this from happening, but once the trees are cut down it can happen very quickly. Soil that has been there for thousands of years can be washed away in just a few years.

The rate of soil erosion can be reduced by making sure that the cleared ground is quickly covered with young, growing plants.

Activity 2: Interpreting text

4 About how many hectares of tropical rain forest are being lost each year?

5 What fraction (or percentage) is this of the total area of tropical rain forest?

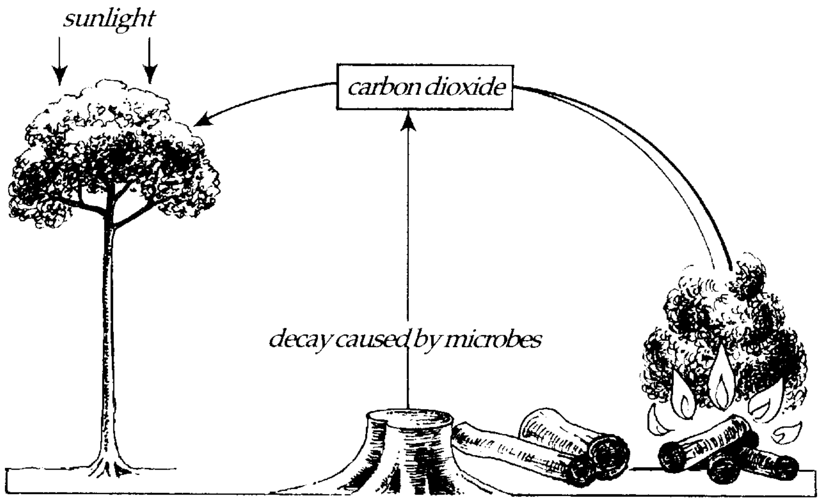
6 Why is tropical rain forest being destroyed at such a fast rate?

7 What will eventually happen if people keep on destroying tropical rain forest at this rate?

8 Explain why destroying tropical rain forests is a very short-sighted policy. Give as many reasons as you can.

Tropical rain forests and the Earth's atmosphere

Tropical rain forests have an important effect on the amount of carbon dioxide in the Earth's atmosphere. This means that chopping them down also has an effect on the amount of carbon dioxide in the atmosphere. The diagram shows why.



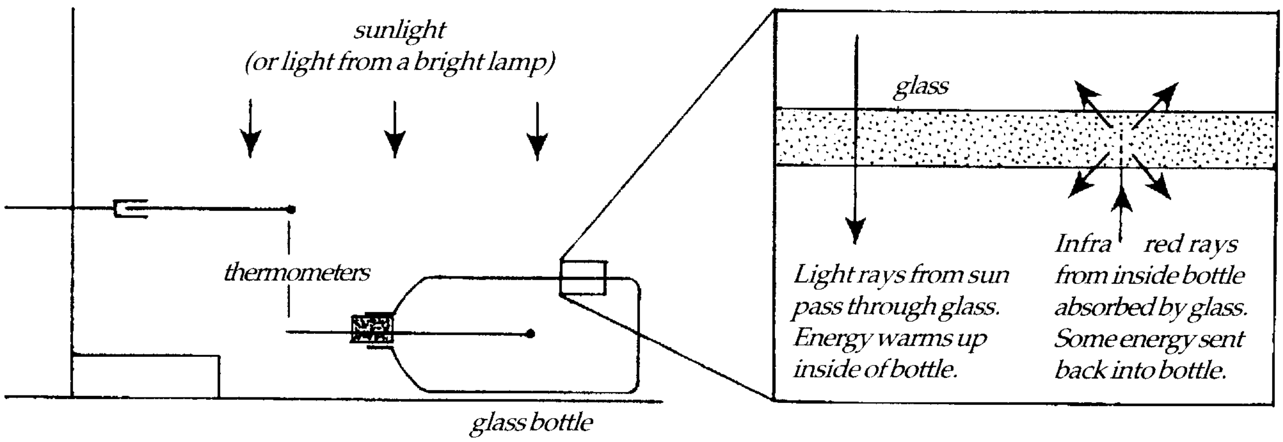
Activity 3: Interpreting a diagram

9 What do growing trees do with carbon dioxide from the atmosphere?

10 What effect will chopping down tropical rain forests have on the amount of carbon dioxide in the Earth's atmosphere? Mention *three* reasons for this effect.

Activity 4: Practical investigation

Carbon dioxide in the atmosphere has a similar effect as the glass in a greenhouse. You can observe this effect for yourself using the apparatus shown below.



11 What happens to the temperature inside the glass bottle compared to the temperature outside the bottle? Why does this happen?

12 What is likely to happen to the Earth if the amount of carbon dioxide in the atmosphere keeps on increasing?

13 Why is the effect of the carbon dioxide in the Earth's atmosphere called the 'greenhouse effect'?

What should be done about tropical rain forests?

Activity 5: Discussing issues and formulating ideas

Use the ideas you have already studied in this module, together with the additional information below, to decide on the best policy for the remaining areas of tropical rain forest.

You should try to take account everyone's point of view, e.g.:

- the poorer people who live in the countries that have tropical rain forest;
- the governments of those countries;
- people in other countries (especially developed countries).

Additional information and points of view

- There are more than 500 species of trees in rain forests but only about 20 of these are used for timber.

- In many developed countries, for example the USA and the UK, most of the forests were cut down a long time ago to clear the land for agriculture. In the past 50 years, however, many trees have been planted in these countries and the area of woodland has been increasing.

- When trees are felled in tropical rain forests, young trees can be planted to replace them. However, these replanted areas often have far fewer different plants than there were in the original forest.

- "Timber from rain forests is often sold too cheaply to developing countries. It should be sold for whatever it costs to replace it."

- "Rain forests belong to the countries where they grow. They should be used for the benefit of the people who live there."

- "Rain forests and the soil they grow on belongs to future generations of people as well as to the people who are alive today."

- "The Earth's atmosphere and the weather that it causes affect all parts of the Earth. So people in all countries should have some say about what happens to tropical rain forests, for example through the United Nations."

Tropical rain forests – Teacher's Notes

Introduction

In this module, students are asked to:

- become familiar with key features of tropical rain forests through interpreting data presented in the form of a map, an illustration and bar-graphs;
- select and use information about the rate, causes and some effects of the destruction of tropical rain forests;
- interpret information about the impact of tropical rain forests (and of their destruction) on the Earth's atmosphere and to relate the likely effect of this to a simple 'greenhouse' experiment;
- reconcile differing points of view to reach a balanced judgement regarding an appropriate policy for the remaining tropical rain forests.

Scientific & technological concepts

- climate;
- carbon dioxide;
- greenhouse effect;
- soil erosion;
- species;
- biodiversity.

Teaching approach

The module begins by providing students with an opportunity – via the interpretation of visually presented information – to acquire an appreciation of what tropical rain forests are like and where they are found. They then study written information about why these forests are under threat and the effect of their destruction on soil erosion and bio-diversity. The effects of tropical rain forests (and of their destruction) on atmospheric carbon dioxide levels are then explored and a simple experiment undertaken to show the likely effect of this. Finally, students use information from all the earlier sections of the module, together with additional information and points of view to decide – individually or via group discussion/debate – an appropriate policy regarding tropical rain forests.

Notes on the activities

Page 1: In connection with Q1(c), it may be worth pointing out to students that the projection used on the world map exaggerates the area of land masses at higher latitudes (and that the Peters projection, although it distorts shape, is better for comparing areas).

Climate data relating to students' own area is preferable, if available, to that for London, England in Q2.

Page 2: It is worth pointing out to students that all the figures are inevitably very approximate, but nevertheless of the right *order*.

The more rapid erosion of denuded soil can be demonstrated using a watering can on two inclined trays of soil, about 1 cm deep: (a) with bare soil and (b) soil on which e.g. grass seeds have been growing for a few weeks.

Page 3: 'Standard' experiments showing the production of carbon dioxide by microbes and when wood burns could be done in conjunction with this section, if desired.

Note: There is no question that there *is* a greenhouse effect and hence global warming due to carbon dioxide and other gases in the atmosphere. If there were not, the Earth would be no warmer than the Moon. There is, however, still some disagreement between scientists about how much, if at all, increased levels of carbon dioxide will increase this effect.

Page 4: This section of the module could be used by individuals to decide for themselves what they think – and why – and to write e.g. a newspaper article on the subject.

However, given the controversial nature of the subject, it is probably better if the issues are *discussed*, either in small groups or by the whole class. An alternative approach would be to *debate* the issue, with different groups of students taking the point of view of different groups of people.

Answers to questions

1 (a) the tropics; (b) because they lie in the tropics and rainfall is high; (c) 5%.

2 High rainfall throughout the year; relatively high temperatures which do not vary much throughout the year; bright sunlight for several hours each day.

3 Hot, dark and steamy.

4 10 million hectares.

5 1%.

6 Population growth; economic demand is growing.

7 Loss of biodiversity; soil erosion, loss of economic resource.

8 Students should make use of ideas from the text, and from elsewhere.

9 Trees absorb and 'lock up' carbon dioxide.

10 Carbon dioxide levels will increase: less is absorbed by growing trees; more is released by trees which decay or are burned.

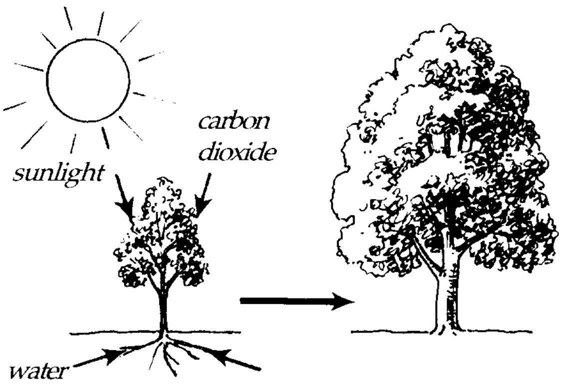
11 It rises higher; heat is trapped inside the glass.

12 It will become warmer.

13 Because carbon dioxide acts like the glass in a greenhouse, trapping heat.

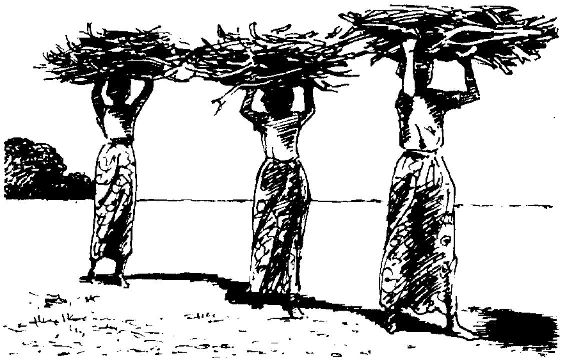
Wood as fuel

Renewable but scarce



As a tree grows it stores **energy** from the Sun in the wood of its trunk and its branches. Energy is stored in the bio**mass** of the tree. We can release this energy by burning the wood. So wood is a **fuel**. As long as there are trees growing more wood is being made. So wood is a **renewable** fuel.

About half of the 6 billion people in the world depend on wood as a fuel for cooking their food. Most of these people live in developing countries. Until 20 or 30 years ago they collected dead wood or cut off just a few branches so that trees stayed alive to continue making new wood. As old trees died, young seedlings grew up to take their place.



As the numbers of people increased, more wood was needed, so people started to chop trees down. Once this started to happen things went from bad to worse: less wood was produced and even more trees were cut down. People (usually women) may have to spend several hours each day walking long distances from their villages to collect the wood they need for cooking their food.

If there are more people to feed, more land is needed to grow food. This often means that woodland has to be cleared for agriculture. In Nepal, for example, there were once large areas of forest and enough wood for everyone. But clearing forests to grow food means that there now isn't enough wood to go round. Wood which was once free is now expensive and poorer people can't afford to buy it.

Activity 1: Interpreting text and images

1 "Wood is a renewable energy source".
   (a) Explain what this means.
   (b) Explain *why* wood is said to be renewable.

2 In many parts of the world, wood is not being properly renewed.
   (a) Why not?
   (b) How does this affect people in those countries?

3 What do you think should be done to help solve the shortage of fire-wood?

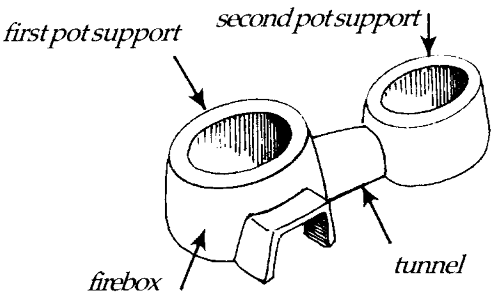
Burning wood more efficiently

In many countries there is a serious shortage of fire-wood. But cooking is still done using a three-stone fire like the one shown on page 1.

This traditional way of cooking works well (it is very **effective**). But it wastes a lot of the energy that is released when wood burns (it is *not* very **efficient**). So one way of helping to solve the shortage of fire-wood is to burn the wood more efficiently. Less fire-wood will then be needed to cook each meal.

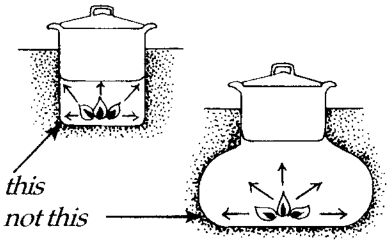
Since the late 1970s, the Intermediate Technology Development Group (ITDG) has been working with local people in many developing countries to produce small stoves that burn wood efficiently. To succeed, these stoves must not only be efficient; they must also be cheap and easy to make from materials that are available locally and people must like using them.

A stove for Sri Lanka

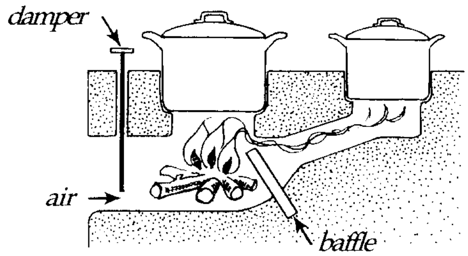


A ceramic (pottery) stove liner is made by firing clay in a kiln. This costs about half a week's income for an average rural family in Sri Lanka. It also provides employment for local potters.

The stove liner is coated with a wet mixture of sand (80%) and clay (20%) and left to dry. The two-pot design matches what most Sri Lankans want: one pot for rice and the other for vegetables. More than three-quarters of the people who have tried it prefer the stove to a traditional 3-stone fire.



For energy to be transferred efficiently, the cooking pots must fit snugly in their holes. Also the firebox should not be much wider than the pot and it shouldn't be too deep.



A baffle can be used to direct the flames against the bottom of the pot. A damper can be used to restrict the flow of air to the fire and control the rate of burning.

The Sri Lankan stove uses 30 – 50% less wood than a traditional 3-stone fire.

Activity 2: Devising explanations

4 The new stove has "caught on" very well in Sri Lanka.
Why do you think this is so? Give as many reasons as you can.

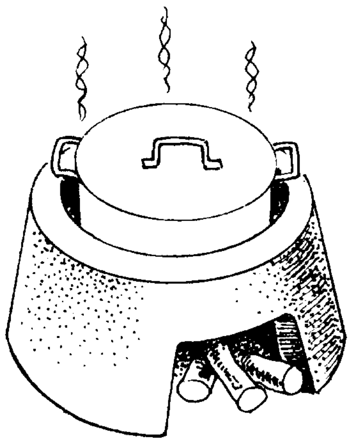
5 "The stove is just as effective as a 3-stone fire but a lot more efficient."
(a) Explain what this means.
(b) *Why* do you think the stove is more efficient? Give as many reasons as you can.

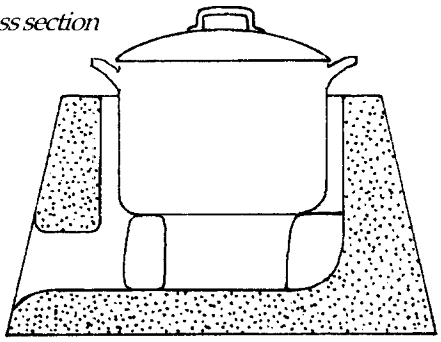
Making a stove and testing its efficiency

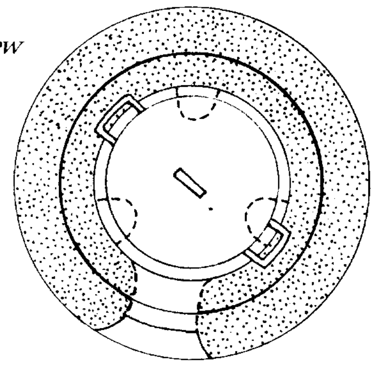
Activity 3: Practical task

Your task is to make a simple stove and to compare its efficiency with an open, 3-stone fire. The simplest type of stove to make is the single-pot Louga stove which is used in Senegal. This stove doesn't need a ceramic liner.

The single pothole of this stove also acts as a chimney. Smoke escapes through a narrow gap all around the pot, heating its sides. The small firebox entrance prevents too much air from reaching the fire. The stove is built using the pot itself as the form. The mixture of sand (80%) and clay (20%) is packed around the pot to get the right shape, then the pot is carefully removed, twisting as you pull. A plastic tube can be used to mould the air passage or this can be carved out later. When the sand+clay is dry, the pothole needs to be made a little wider to make the smoke passage. Small stones or cans are then used to support the pot.







Making the stove 'for real' is a big task and will take a lot of time. Instead, you could make a small-scale model of the Louga stove:

- the cooking pot could be a drinks can or a small laboratory beaker;
- your model stove doesn't need to last a long time so you could use a quick-setting sand+plaster mixture;
- small amounts of wood don't usually burn too well so you could burn a liquid fuel instead (e.g. methylated spirit, diesel fuel, paraffin [kerosene] or vegetable oil) using a small burner with a wick. Alternatively you could use a short candle.

The stoves are designed for cooking, so you could compare the amount of fuel needed to bring some water up to the boil and then to boil a certain amount away:

(a) using the stove;
(b) using the same burner and the same 'cooking pot' in the open.

Wood as fuel – Teacher's Notes

Introduction

In this module, students are asked to:

- interpret textual information about the reasons for the fire-wood crisis in many countries despite wood being a renewable fuel;
- suggest possible solutions to the fire-wood crisis;
- interpret and evaluate data about ways of making cheap, efficient and acceptable alternatives to the traditional fires used for cooking;
- make a simple stove and compare its efficiency with that of a traditional fire.

Scientific & technological concepts

- energy;
- biomass;
- fuel;
- renewable;
- efficiency.

Teaching approaches

The module begins with information about the importance of wood as a fuel for billions of people and about why this energy source, though renewable, is not at present sustainable. After brainstorming and then discussing possible solutions to the problem, students are provided with information, via text and diagrams, about a partial solution to the problem – replacing inefficient 3-stone fires with more efficient stoves – and asked to interpret and evaluate this information. Finally, students are given guidelines for making a stove – full-scale or, more probably as a working scale model – and for finding out how much less fuel it needs than an 'open' fire to do the same job.

Notes on the activities

Page 1: Teachers may care to encourage students to distinguish between 'renewable' and 'sustainable'.

The brainstorming in Q3 is probably best done individual → small group → class and the pros and cons of the various suggestions then more thoroughly discussed. Possible suggestions include:

- population control;
- proper management of forest areas (which may include planting/re-planting schemes, coppicing, etc.);
- using firewood more efficiently so that less energy is wasted and less wood needed. [This idea is explored in the next section of the module.]

Page 2: The material from which a stove is made has itself to be heated up. This can make it less efficient than an open fire over a short period of time. However when used for longer periods, e.g. for cooking, the energy needed to heat up the stove is more than compensated for by less energy being lost immediately to the surroundings, mainly by convection, especially if there is any wind at all.

Page 3: For a fair comparison between a stove and an 'open' fire:

- The stove should be thoroughly dried out before the comparison is made. [This can be done by using it before testing it and/or with the help of a hairdryer.]

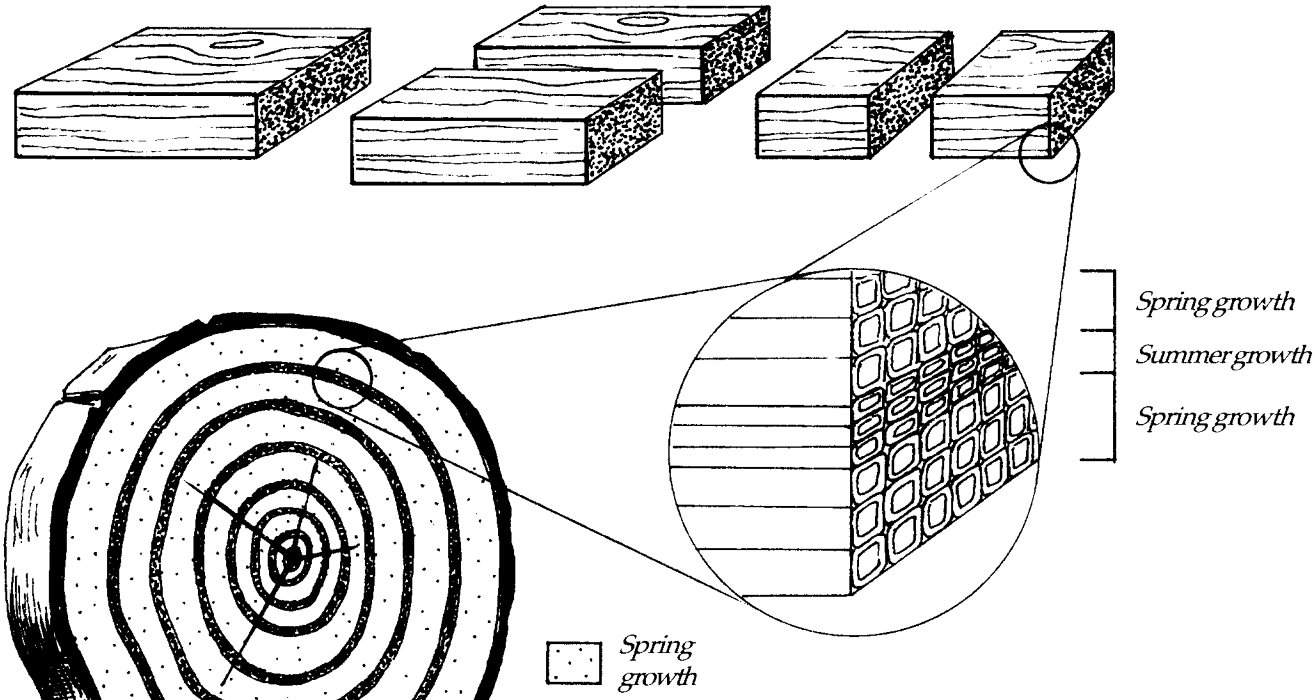
- The test is best done out-of-doors, which is where 3-stone fires are generally used. [Failing this, the test should be done in draughty conditions, if possible.]

Wood as a structural material

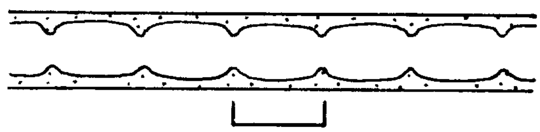
The lines that you can see running along a piece of wood are called the **grain**.

If you cut the piece of wood like this, you have cut it **along** the grain.

If you cut the piece of wood like this, you have cut it **across** the grain



If you look at wood through a magnifying glass or binocular microscope, you can see that it is made of lots of long, hollow fibres. Each fibre is made from lots of cells joined end-to-end.



The piece of wood came from a tree trunk. When you look at the cut end of a tree trunk you can see growth rings. These show each year's growth.

Activity 1: Interpreting information

1 Why does wood have a grain?

2 What happens to the fibres in wood
(a) when you cut the wood along the grain?
(b) when you cut the wood across the grain?

3 Some of the hollow fibres in a piece of wood have a larger diameter than others. Explain why.

4 How old is the tree trunk shown in the diagram? Explain your answer.

5 The wood from trees that grow in tropical rain forests do not have growth rings. Suggest why.

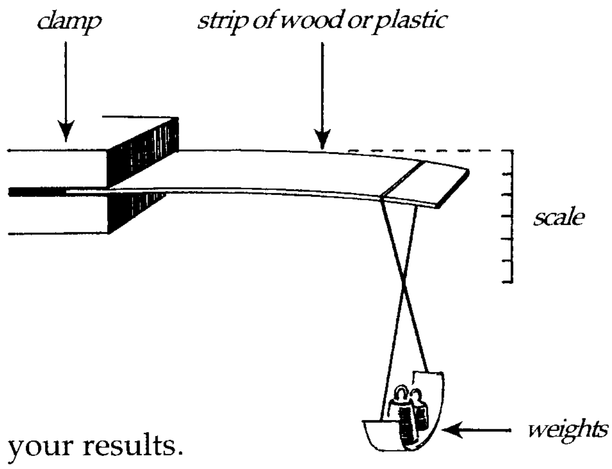
Testing wood: how stiff? how strong?

Materials that are used for buildings and to make furniture must be:

- **stiff** – they mustn't **bend** too easily when forces act on them;
- **strong** – they mustn't **break** too easily when forces act on them.

Activity 2: Testing stiffness

The diagram shows the set-up you could use to compare the stiffness of wood and plastic.



6 Decide:
- how you would carry out tests for stiffness and what measurements you would make;
- how you can make a fair comparison between wood and plastic.

7 (a) Carry out the tests and record your results.
(b) What do your results tell you about the stiffness of wood compared to plastic?

8 A strip of steel is 15 times stiffer than a strip of wood the same shape and size. The strip of steel is 750g and the strip of wood is 50g.
(a) How many times heavier is the strip of steel than the strip of wood?
(b) How does the stiffness of wood compare with the stiffness of steel *weight for weight?*

Activity 3: Testing strength

You can also use the set-up shown above to test the strength of a strip of wood. Just keep increasing the load until the wood snaps.

Safety note: *Place a tray of sand below the weights so they don't do any damage when they fall.*

9 Compare the strength of the same type of wood *along* the grain and *across* the grain.

10 Wood is made of long hollow fibres 'glued' together (see section 1 of this module). How can you explain the difference in the strength of wood along and across the grain?

11 A piece of steel and a piece of wood are the same shape and the same size. The steel weighs 15 times as much as the wood and tests show that it is 10 times stronger. How does the strength of wood compare with steel *weight for weight?*

12 Why is wood a good material for buildings and furniture (a good *structural* material)?

13 (a) Compare the strength of different types of wood (along the grain).
(b) How is the strength of each wood related to its weight (or its density)?

Problems with humidity

When a tree is alive, the hollow fibres in the wood are filled with a watery solution called sap. There is usually about the same amount of water in the wood as there is solid material. When a tree is chopped down for timber, most of the water slowly evaporates until only about 10-15% is left. The wood is then seasoned and is ready to be used for making things.

After the seasoned wood has been used to make things, the amount of water in the wood does not always stay the same. This is because the amount of water vapour in the air – the humidity – changes.

When the surrounding air is dry, the water content of wood can fall as low as 5%. When the surrounding air is very humid (damp) the water content of wood can rise as high as 25%. The table shows what happens to a piece of wood when the humidity changes.

	length (along the grain)	Width (across the grain)
dry	100 cm	10 cm
damp	99.5 cm	9.5 cm
change	0.5 cm	0.5 cm
percentage (%) change	0.5% ($^1/_2$%)	5%

Activity 4: Devising explanations

14 (a) What happens to *both* the length and the width of the piece of wood when it is moved from a dry place to a damp place?
(b) What *difference* is there in the changes to the length and to the width of the wood? How can this difference be explained?

15 A new wooden door is fitted to a house during dry weather in the summer. The door fits perfectly. A few months later during cold, wet weather, the door won't close properly. Explain why.

16 Wooden floors are usually made from long narrow boards about 15 cm wide.
(a) Why aren't wider boards (e.g. 50 cm wide) used*?
(b) Why can long boards be used without causing any problems*?
[* You could use figures from the table in your answers.]

Activity 5: Practical investigation

Compare the percentage change, along and across the grain, when:

- a dry piece of tropical hardwood is made very damp;
- a dry piece of softwood is made very damp.

(a) The dry pieces of wood should have been kept in a warm place for a few days before they are measured.
(b) Pieces of wood can quickly be made very damp by putting them in a pressure cooker for a few minutes.
(c) Small pieces of wood will only change in length by a few millimetres. Try to think of some way of measuring this, or of magnifying the change.

Wood as a structural material – Teacher's Notes

Introduction

In this module, students are asked to:

- interpret visually presented data about the structure and growth of wood;
- plan and carry out comparisons of stiffness and strength using the simple apparatus with which they are provided;
- interpret data on the stiffness and strength of wood and steel and relate this to their densities;
- apply information about why the moisture content of wood varies and how this affects wood in practical situations;
- compare the swelling/shrinking of different types of wood due to changes in humidity.

Scientific & technological concepts

- grain;
- cells;
- stiffness;
- strength;
- density;
- sap;
- humidity.

Teaching approaches

The module begins by providing students with the opportunity to relate the fact that wood has a grain to its microscopic structure. Details of the microscopic structure are also related to the growth pattern of wood. Students then plan and carry out tests: firstly to compare the stiffness of wood and plastic; secondly, to compare the strength of wood along and across the grain and to relate this to the structure of wood. Data is also provided to enable students to compare the strength and stiffness of wood compared to steel in relation to their densities. Finally, students are given information about the seasoning of wood and data about how seasoned wood swells and shrinks with changes in humidity. These ideas are then applied to practical contexts and students are also asked to compare the amount of swelling/shrinking in different types of wood.

Notes on the activities

Page 1: It is recommended that students examine actual specimens of wood and count the annual rings in actual cross-sections of trees as well as interpreting the diagrams provided. Students could also look at microscope slides of wood in both longitudinal section and cross-section.

Question 2: When you cut wood along the grain, you are separating layers of fibres. When you cut wood across the grain, you are cutting the fibres themselves.

Question 4: There are 6 lots of spring growth so the tree is 5 - 6 years old.

Question 5: Trees for tropical rain forests grow at the same rate all the year round. Students should be able to infer this, but if they have already done the module on tropical rain forests they can apply their knowledge that in tropical rain forests the temperature and rainfall are more or less constant all the year round.

Page 2: Stiffness – Question 6: Thermosoftening plastics – e.g. polyethene, acetate or acrylic – are more flexible than thermosetting plastics and give a better contrast with wood. Wooden strips should have the grain running along the length of the strip (as in a ruler).

Question 8(b): Weight for weight, wood is as stiff as steel.

Strength – Question 9: Wood is usually 30-40 times weeker across the grain than it is along the grain.

Question 11: Weight for weight wood is usually stronger than steel.

Question 12: Wood is very stiff and very strong for its weight/density.

Question 13: Balsa wood, white softwood and a tropical hardwood would give a good range of densities. The solid material in different types of wood is very similar, so the strength is more or less directly proportional to the density.

Page 3: Question 16: 50cm wide boards could vary in width by as much as 5 cm (though a variation of 1-1.5 cm would be more usual indoors). So if they fit tightly in damp conditions there would be large gaps in drier conditions. With narrower boards the cracks would be much narrower, though there would be more of them. The length of the boards doesn't matter so much because the shrinkage is only one-tenth as much along the grain.

Activity 5: If 2-3 cm cubes of wood are used, a micrometer could be used to measure them. Alternatively a lever arrangement could be devised to amplify any change in length/width.

Materials made from wood

Wood is:

- a good structural material that is used in buildings and for making furniture;
- a renewable energy source that is used as a fuel by billions of people.

Wood is also used to make many other useful materials including paper, plywood, chipboard and charcoal.

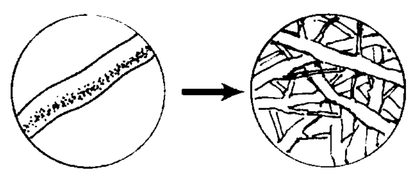
Paper

Huge amounts of paper are used each year. In developed countries, each person may use up half a tonne (500 kg) of paper each year. People in developing countries use much less paper but on average use at least 5 kg per year.

Paper is made from the fibres in wood. The wood from conifers such as pine have longer fibres than hardwoods from tropical rain forests and are better for making paper. Conifers grow in temperate climates, for example in Europe and in North America.

How paper is made

The boxes below show the various stages in the process for making trees into paper, but they are *not* in the correct order.

The fibres in the bundles are separated by 'cooking' them with chemicals such as sodium hydroxide (caustic soda) solution.	If the paper is for printing or writing, it is coated with a mixture of gelatine and alum (aluminium sulphate) dissolved in water.	The 'pulp' of roughened up fibres is poured on to a flat mesh. Most of the water drains away leaving a flat sheet of tangled fibres. This paper is then dried.
The bark is removed from trees. The wood is cut up into pieces and then ground up into small bundles of fibres using huge stones.	The separate fibres are then 'roughened up' in a machine called a beater. The fibres can then hold together better and make a stronger paper.	

Activity 1: Discussion questions

1 Sort out the above stages in the papermaking process into the correct order.

2 Write down all the different uses of paper that you come across in your everyday life.

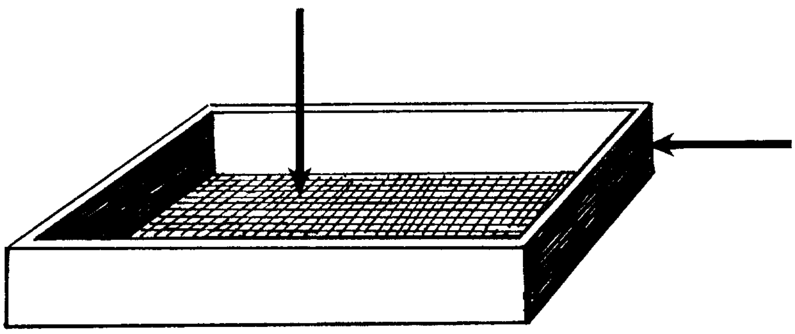
3 It takes a lot of trees to make all the paper you use each year. Suggest ways of reducing the number of trees that are needed to make paper for you.

4 Tear small samples of different types of paper and examine the torn edge with a hand lens or a microscope. Make a note of any differences that you observe.

Making your own paper

Activity 2: Practical exploration

Use fibres from different types of wood, matchsticks or straw to make some paper. For stage 4 of the process you will need a special frame as shown below.



5 Simmer your starting material with 10% sodium hydroxide solution in a conical flask for at least an hour (longer if possible).

SAFETY:
Sodium hydroxide is caustic and very corrosive.
Eye protection is essential.
To avoid 'spitting' the solution should ***not*** *be vigorously boiled.*
Water should be added to the mixture to replace that which has evaporated.

6 Separate the fibres from the solution using a large kitchen sieve over a sink. Rinse the fibres for a few minutes by running tap water into the sieve.

7 Roughen up the fibres by grinding them with a pestle and mortar or putting them in a liquidiser for a couple of minutes.

8 Add water so that the suspension of fibres is very runny. Stir well and keep stirring as you pour the suspension into a paper-making frame, held over a sink. Your partner should jiggle the frame from side to side as you pour in the suspension so that the fibres form an even layer.

9 Allow the water to drain through the frame, then carefully peel out the wet paper on to a smooth board.

10 Let the paper dry. You can, if you like, speed up the drying by laying several layers of newspaper and then another board on top of your paper and applying pressure. Repeat this until most of the water has been squeezed out of the paper.

11 If you want to write on the paper, paint the surface with a solution of gelatine in water and allow to dry again.

If other members of the class have made paper from different starting materials, you could compare the appearance and the strength of the different papers.

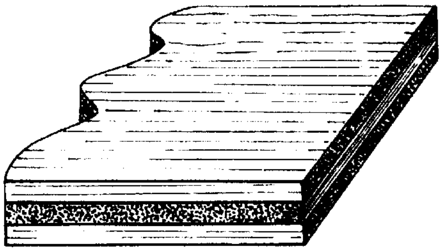
Plywood and chipboard

Wood is a very useful structural material but it can sometimes cause problems:

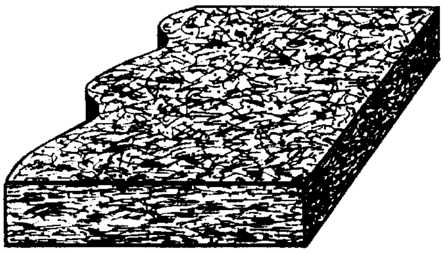
- it is not as stiff or as strong across the grain as it is along the grain;
- it swells (or shrinks) in damp (or dry) weather and it does this more across the grain than it does along the grain.

For some purposes, plywood and chipboard are more useful materials than wood:

- they can be made into large flat sheets;
- the strength and stiffness of the sheets is the same (or very similar) in both directions.



plywood



chipboard

Activity 3: Practical investigation

12 (a) Examine samples of plywood and chipboard. Use a hand lens if one is available.
(b) Describe what each material appears to be made from.
(c) Explain why sheets of each material have the same stiffness in both directions.

13 (a) Make some 2-ply plywood by glueing two thin sheets (veneers) of wood together with the grain of one sheet at right angles (90°) to the grain of the other.
(b) Repeat, but this time have the grain in the two thin sheets running in the *same* direction.

14 (a) Carry out tests to compare the strength and stiffness of *both* types of home-made plywood in *both* directions.
(b) Explain the results of your tests.

Charcoal

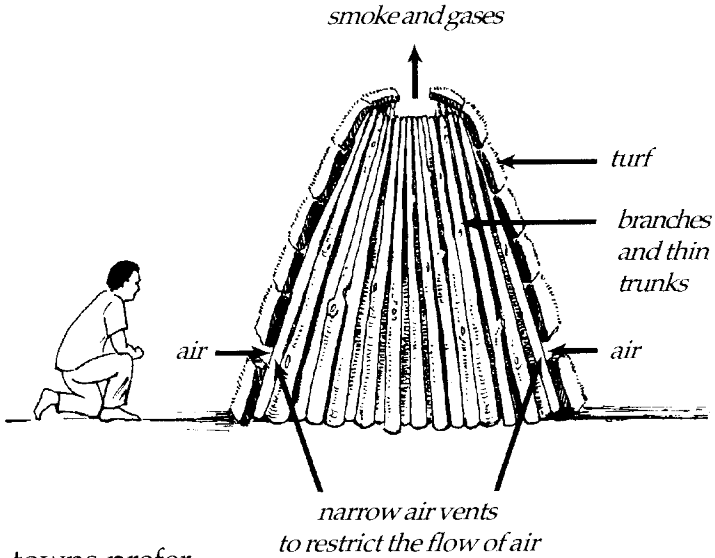
Comparing wood and charcoal as fuels

In countries where wood is the main fuel used for cooking, people in towns often use charcoal made from wood rather than wood itself.

	combustion products (what is produced when it burns)	energy released (kilojoules per gram)
wood	mainly carbon dioxide, water vapour and smoke (carbon specks) + some carbon monoxide, sulphur dioxide, hydrocarbons and ash	16
charcoal	mainly carbon dioxide + some carbon monoxide	33

Charcoal is made by *partly* burning wood so that most of the carbon in the wood is left behind unburnt.

The diagram shows how this can be done in a charcoal kiln. The process takes several days. It takes 10 kg of wood to make 1 kg of charcoal.



Activity 4: Questions

15 What is charcoal?

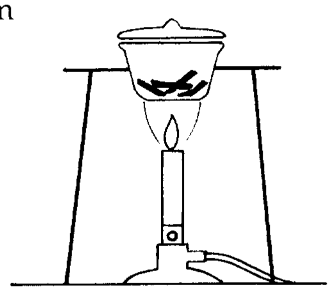
16 Why do you think people in towns prefer to cook using charcoal rather than wood?

17 Charcoal is much more expensive than wood. Explain why.

18 Why does the wood inside a charcoal kiln only *partly* burn?

Activity 5: Making charcoal

Make some charcoal from matchsticks or small pieces of wood. You should weigh the crucible (a) empty (b) before heating and (c) after heating so that you can work out how much wood was needed to make 1 gram of charcoal.



Carefully lift the crucible lid every few seconds using tongs. The idea is to let the gases produced by the wood escape (and let the flammable ones burn) but to let the wood itself burn as little as possible. Continue until no more smoke or yellow flames can be seen.

Materials made from wood – Teacher's Notes

Introduction

In this module, students are asked to:

- interpret information (presented in various forms) about how a number of materials are made from wood and about what these materials are used for;
- make some of the materials by a simple small-scale method.

Scientific & technological concepts

- fibres;
- suspension;
- strength;
- stiffness;
- combustion (products);
- carbon.

Teaching approaches

Students are introduced to any – or all – of the following wood products: paper, plywood and chipboard, charcoal. Information about how paper is made and about the amounts we use is presented for interpretation. Step-by-step instructions are then provided for students to make some paper of their own. The internal structure of both plywood and chipboard is examined and related to their consistent strength and stiffness in different directions (unlike wood itself). These properties are then tested on samples of plywood made by students themselves. Data comparing wood and charcoal as fuels and information about how charcoal is made are presented for interpretation. Students then make some charcoal for themselves.

Notes on the activities

Page 1: A simple way of approaching Question 1 is for students to cut out copies of the boxes and paste them in the correct sequence.

Question 2 is probably best approached individually, then in small groups, then at class level. The activity could be extended by attempting to estimate the annual mass of paper used, per person, under each category.

Ways of reducing the demand on trees for making paper include:

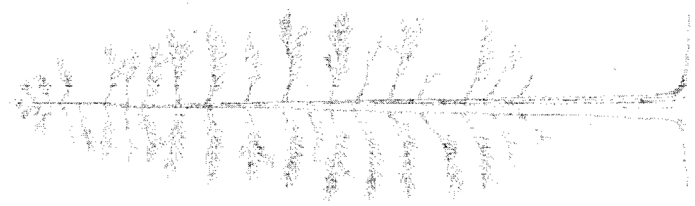
- using less paper (though students should be asked what alternatives they propose for various purposes);
- re-cycling waste paper (though the fibres are degraded on each re-cycling).

Page 2: To get a really even layer of fibres undisturbed by the effects of pouring, the frame can be placed on a tray, the suspension of fibres poured in, then the frame lifted up off the tray.

Page 3: If possible, actual samples should be available for students to examine. Plywood has similar properties in each direction across a sheet but is, of course, different across its thickness. Chipboard is the same in all directions. (It is isotropic.) Students' own 2-ply can be made from thin sheets of balsa wood.

Page 4: A small can with a hole in the lid and small holes just above the base can be used instead of a crucible. The gases coming from the hole in the lid should be lit. When these change from yellow to blue they are mainly due to carbon monoxide, and the charcoal making process is complete.

Forest resources



Understanding biodiversity

We are fortunate to live in a world with a great variety of living creatures. No-one knows how many living species there are - perhaps 10 or 100 million. This variety of life is known as biological diversity or **biodiversity**. Biodiversity exists at three different levels:

The variety of species: The myriad different species that exist on Earth, on land and in water, defy the imagination. Most are insects or other invertebrates. Mammals and other vertebrates - including humans - represent only one per cent or less of all species.

The variety of individuals within a species: Think of a species such as the dog. There are many different types (called breeds), and within each breed, each individual dog is different by the colour of its fur, its size, and other characteristics. This richness and diversity is contained in the genes of animals, plants and micro-organisms. It is the key to the ability of a species to adapt to a changing environment.

The variety of communities: Each community (or ecosystem) of plants and animals living together is unique. Each ecosystem is linked to others that may be nearby or thousands of kilometres away. Ecosystems together form the complex web of life.

The picture on page 2 shows the great diversity of plants and animals associated with one tree.

Activity 1: Interpreting information

Here are four examples of ecosystems. Discuss the biodiversity of each, and put them in order, starting with the most biodiverse.

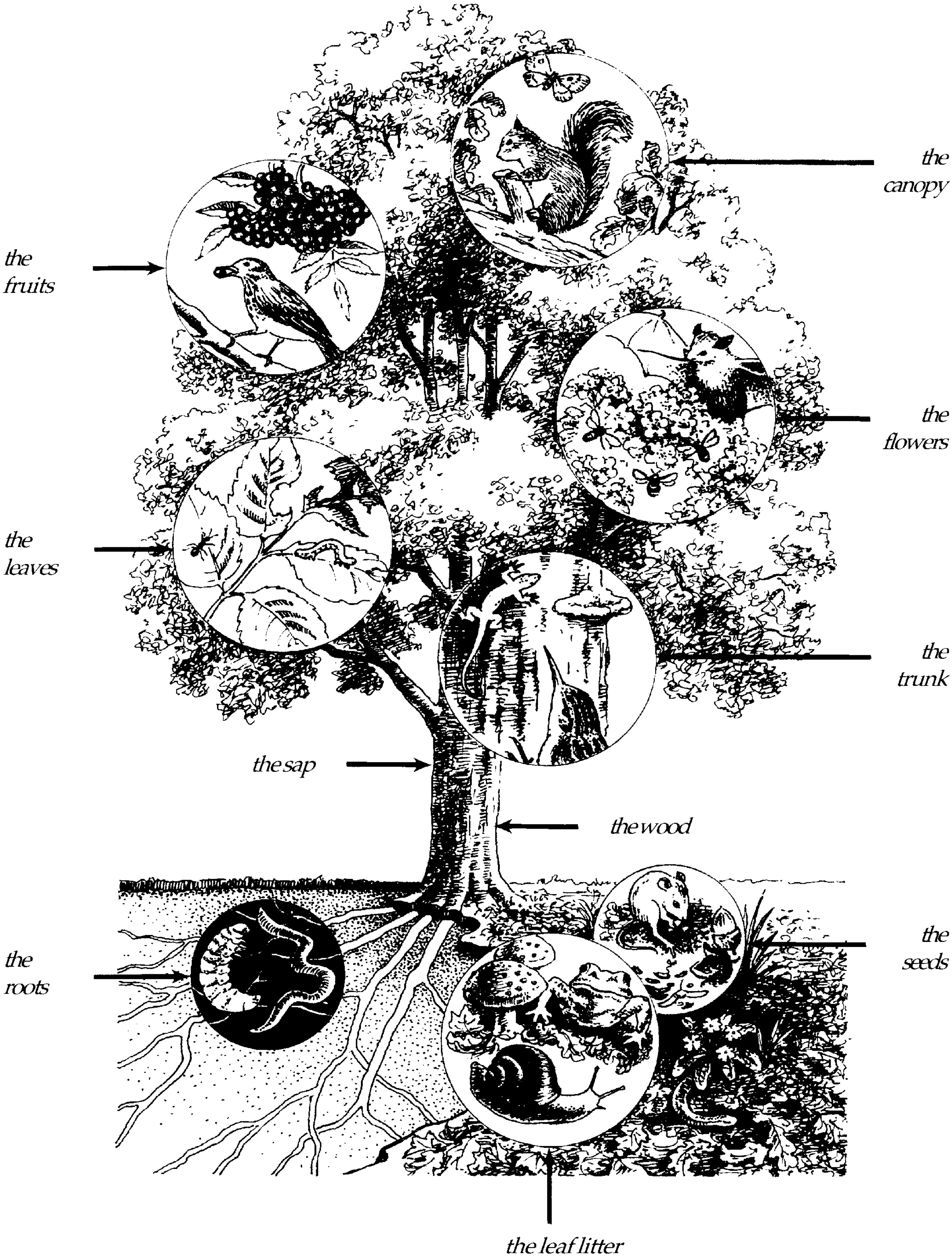
- *A sand dune.* Two or three varieties of grass grow here, along with a few other species of flowering plants. The plants are visited by insects, and at night, when it is cooler, small mammals emerge from their burrows.

- *A farmer's field.* The farmer is growing maize, and has sprayed the field with herbicide (to kill weeds) and with pesticides (to kill unwanted insects). In this way, he hopes he will have a good crop.

- *A school yard.* The ground is covered with tarmac so no plants grow. The children come out to play, and frighten off the starlings which have been eating scraps of food from the rubbish bins.

- *An area of woodland.* The trees here were planted 200 hundred years ago. A rich variety of plants, including mosses and grasses, are growing. Birds, animals and insects have colonised the woodland, and mammals have made their homes here too.

Biodiversity – a web of life



- **the canopy** — used by butterflies, spiders, beetles and many other insects, birds, arboreal mammals, snakes, vines
- **the leaves** — home for frogs
food for caterpillars
nest material for ants and birds
- **the trunk** — home for lizards, birds, insects
colonised by fungi, mosses, lichens, orchids
- **the wood** — eaten by insects
infected by microscopic fungi
used as timber or firewood
- **the sap** — harvested for rubber or for medicines
- **the flowers** — provide nectar for insects, birds, bats
- **the fruits** — decomposed by moulds and bacteria
eaten by insects, birds, mammals
- **the seeds** — food for ants, birds, mammals
- **the leaf litter** — turned into humus by moulds, fungi, bacteria, insects, snails shelter for insects, frogs, reptiles, birds, mammals
- **the roots** — exchange nutrients with underground fungi
eaten by insect larvae, worms

Activity 2: Interpreting the diagram

Study the diagram of the tree. Make a list of all the ways in which humans are part of this ecosystem. In what ways do humans benefit from the tree? In what ways might humans damage the ecosystem?

Biodiversity in crisis

In 1992, the Earth's Summit was held in Rio de Janeiro, Brazil. The conference discussed urgent measures to address the global decline of biodiversity. The Convention on Biological Diversity has now been ratified by over 160 countries world-wide.

The problem is that exploitation of the Earth's resources has resulted in the decline of biodiversity:

- Many species have become extinct.
- Many species are dwindling in numbers, so that their genetic diversity is reduced.
- Many ecosystems have been wiped out.

This extinction of species is the most dramatic since the extinction of the dinosaurs, 65 million years ago. One species is responsible for this decline: humans. People have been cutting down forests, eating wild animals, fishing the seas, polluting water, draining marshes and using chemicals to control pests for thousands of years. Losing biodiversity threatens the survival of the world's web of life. It also threatens the economic and cultural survival of human societies.

Activity 3: Understanding the value of biodiversity

List all the materials present in your everyday life that are derived from the natural environment:

your clothes	wool, cotton, leather
your house or school building	wood, bamboo, palm and other construction materials
the food you eat	rice, wheat, corn, sweet potato, vegetables, meat, fish
medicines	from medicinal plants
the fuels you burn	wood, oil, coal, gas
books and paper	from tree pulp or rice
drinking water	from a well, bore hole or dam

Think about where each of these come from. For some, it may not be obvious how they depend on the natural environment. Try to explain how they do - for example, water quality depends on vegetation cover to filter out sediment and impurities.

Now think about what would happen if some of these aspects of biodiversity were to disappear, or were degraded to the point where they could not be used any more. Could you find substitutes?

Gardening with biodiversity

Activity 4: Designing a school community garden

Design and establish a garden in the grounds of your school. You will find some ideas below.

You will also find some ideas about the importance of biodiversity. For each idea about gardening, explain how it is linked to ideas about biodiversity.

Ideas about gardening

- Grow plants that you know grow well locally. Make sure that they suit your soil and climate. Ask people in your community what plants grow well, and how to grow them.
- Grow a variety of different plants, not just one type. Include vegetables, fruit, herbs and medicinal plants.
- Choose your site carefully. You need to be near a source of water; your garden will need to be protected from domestic animals and other sources of interference.
- Find out about natural control of pests and weeds.
- Recycle waste materials to make compost.
- Use a mulch to save water.
- Use recycled materials for containers, plant stakes, tools and so on, rather than buying new ones.

Ideas about biodiversity

- Living creatures live in ecosystems; the different members rely on each other to survive.
- Ecosystems have many interdependent members.
- If an alien species is introduced to an ecosystem from outside, it may not fit in. It may fail to survive, or it may overpower the other species.
- Some plants species naturally repel insects and other pests.
- In an established community, dead materials are naturally recycled.
- Water, like many other natural resources, can become scarce and should be conserved.
- Many materials, once taken from the environment and used, can never be used again, ie, they are not renewable.

Celebrating biodiversity

Biodiversity is important for us. We are all part of the web of life, and everything we do has an impact on the rest of that web. Let's celebrate biodiversity!

But it's difficult to get the message across. We need to remind other people - and ourselves - to make wise use of natural resources. Advertisements tempt us to consume more goods, we want more comfortable lives, we want to have more things. But our natural desire to exploit our environment more and more is leading to the decline of the very biodiversity on which our survival depends.

You can help people in your community to think about the impact of their decisions. What's needed is something that will remind people every day of the importance of biodiversity.

One idea is to make a 'Living Earth Mural'. This could be at your school, or somewhere else in your community, somewhere where a lot of people will see it every day and be reminded of its message. Your aim should be to deliver a positive message to the local community and future generations of students about biodiversity and its conservation.

Activity 5: Making a mural

- Choose a theme: either a particular environment or the whole globe, to illustrate the unique beauty and rich value of the Earth's biodiversity.
- Decide where your mural will go on display. Remember, you want it to be seen by many people over the next few years.
- Use natural materials - leaves, driftwood, clay, wool, natural dyes and so on. Recycled materials can be used too.
- Incorporate man-made objects to show the impact of humans on the natural environment.
- Try out your ideas before you make the mural. Do people understand your message?

Activity 6: Making the most of your mural

- Use your mural as a meeting place to discuss environmental issues.
- Organise events near your mural - story-telling, drama, poetry, music.
- Hold debates and other meetings to discuss environmental issues.
- Use your mural as a focus for events to celebrate World Environment Day on 5 June each year.

Understanding biodiversity – Teacher's Notes

Acknowledgement

This module is based on a module on biodiversity developed for UNESCO by Jean-Paul Orsini, environmental and community consultant, of Swanbourne, Western Australia.

Introduction

In this module, students are asked to:

- develop their ideas about biodiversity and the interdependence of living creatures;
- identify areas of greater or lesser biodiversity, and the pressures which tend to reduce biodiversity;
- understand the value of biodiversity;
- design and establish a garden which takes account of biodiversity;
- make a mural to celebrate biodiversity and to remind their community of its importance.

Scientific & technological concepts

- biodiversity;
- genetic diversity;
- food webs and chains;
- ecosystems;
- recycling.

Teaching approaches

Biodiversity is a broad concept. To grasp the scientific idea, students need to have some understanding of many ideas from biology: food webs and chains, genetic diversity, ecosystems and so on. This module cannot hope to teach all of these things. Instead, it sets out to convey a general idea of biodiversity and its importance to humans, and to suggest two extended activities (creating a garden and making a mural) which will help to reinforce these ideas.

You can treat these extended activities as alternatives to each other, or they can be adapted as suggested below.

Notes on the activities

Pages 1, 2, 3: The basic ideas of biodiversity are introduced here. In Activity 1, students can apply them to considering some situations of greater or lesser diversity. Activity 2 shows the great range of creatures which depend on a single tree.

One problem with teaching about biodiversity is that, in order to have a true appreciation of its significance, students need to have detailed knowledge of the inter-relationships within a specific ecosystem. We can only hint at this here. However, you might choose at this point to make a detailed study of one convenient ecosystem, such as part of the school grounds. You could emphasise the fact that the ecosystem extends below ground level and into the atmosphere; you could also look in detail at the human impact. You could interview local people to find out how the environment has changed in their lifetimes.

Page 4: Now we consider the human impact more explicitly, in the political context of the Rio Earth's Summit of 1992. You could consider previous occasions in the Earth's history when there have been marked declines in the numbers of species.

Activity 3 will help students to identify the different ways in which they themselves may have a damaging impact on the environment. You could use a map to mark the places of origin of some of the items which students use or consume regularly; this will serve to emphasise our increasing global interdependence.

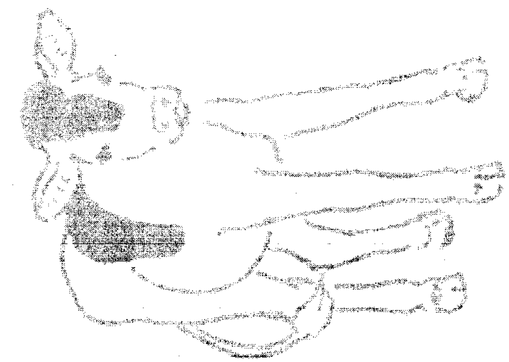
Page 5: Activity 4 could lead to the creation of a school or community garden. If you do not want to embark on such an extended enterprise, students could still tackle this as a design exercise. They should be able to say how their design reflects the different points under the heading *Ideas about gardening*, and how these relate to the broader *Ideas about biodiversity*.

As an extension exercise, you could ask students to design a garden which does not reflect good practice – perhaps with just one or two species of alien plants, use of synthetic chemicals for weed and pest control, and so on.

Page 6: We all need regular reminding of the importance of diversity and the effects of our everyday actions on the environment. A mural illustrating some aspect of this issue can help to do this. The design of a mural will also allow students to demonstrate their ideas at their own level.

As an alternative to a mural, students could design a poster or advertising leaflet, write and perform a play, and so on.

Genetic variation



Cloning sheep

Dolly is the most famous sheep in the world, ever. She is a clone. She is the first animal ever to be cloned from another adult animal.

Scientists at the Roslin Research Institute in Scotland took a cell from the udder of a sheep, Dolly's 'mother'. Then they managed to grow Dolly from this single cell. Dolly doesn't have a father, because no sperm was needed. She has exactly the same genetic characteristics as her mother.

There are lots of clones in the world:
Identical twins are clones. They started off as a single cell in their mother's womb. The cell divided in two, and each cell developed into a separate person. Identical twins have the same genetic characteristics as each other, because they came from a single cell.

Orchids produce beautiful flowers. Many are cloned. The grower has an attractive plant. She takes single cells from the plant and grows each one into a separate plant, identical to the original one. She knows just what their flowers will be like, and it's better than collecting rare plants from the rainforest.

Scientists have cloned crop plants. It's easier than cloning animals. Take a carrot – choose one which grows well even in a drought. Divide it up into separate cells. Now grow each cell to make a new carrot. The result is millions of carrots, all able to grow well in a drought.

Japanese scientists have cloned cattle. They grew eight identical calves from the cells of their 'mother'.

Activity 1: Discussing clones

Bob and Tom are identical twins. Bob has short hair, but Tom likes to grow his long. They both have blue eyes and wear spectacles. On sports day, Bob and Tom came first and second in the 100 m race.

- What would you expect to notice if you looked at Bob and Tom?
- Why are identical twins identical in some ways but not in others? Give your ideas.

Mary and Jane are twins, but they are not identical. They grew from two different eggs in their mother's womb. Mary has short hair, but Jane likes to grow hers long. They both have blue eyes and wear spectacles. On sports day, Mary and Jane came first and second in the 100 m race.

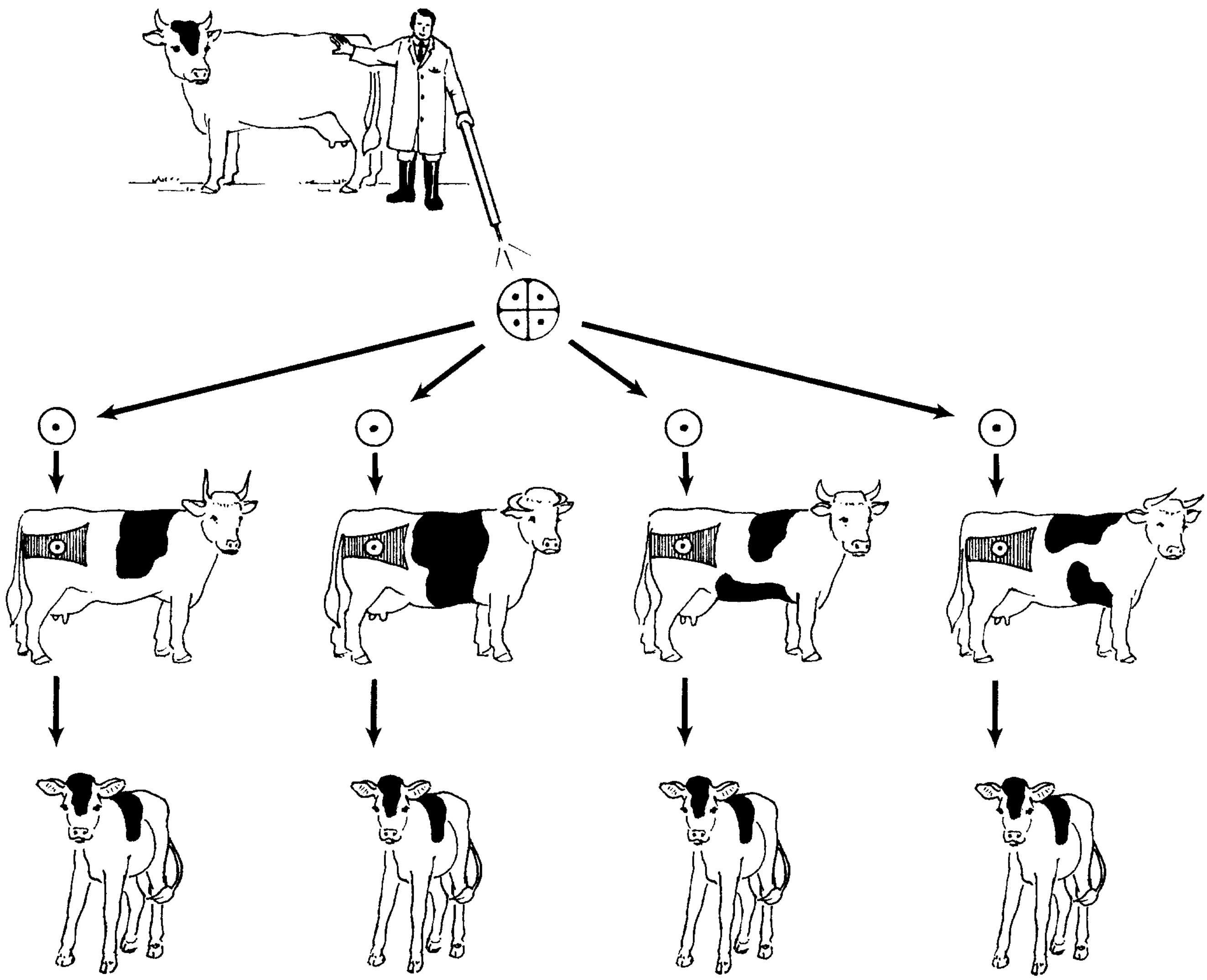
- How could you tell if twins were identical or non-identical?

Dolly has exactly the same genetic characteristics as her 'mother'. She was grown from one of her mother's cells.

- Why might we think that Dolly and her mother are really twins? Are they like identical twins, or non-identical twins?

Clone-it-yourself

Here's one way to make four cloned calves. Study the diagram and read the explanation below. The idea is straightforward, but there are several difficult steps along the way.



When the mother cow has mated with the bull, she has a fertilised egg cell in her womb. The cell divides in two, and then in four. It has become an embryo.

Remove the embryo – that's tricky. Separate the four cells – that's tricky, too.

Implant each cell in the womb of a 'host mother' cow. The host mother's womb must accept the cell and make it grow – that's tricky.

Each cell grows into a normal, healthy, baby calf.

Activity 2: Interpreting the diagram

1 On the diagram, label these things:

the mother cow; the host mothers; the calves; the embryo; the implanted cells.

2 Are the host mothers genetically identical to each other?
How can you tell from the diagram?

3 Are the calves genetically identical to each other? How can you tell?

4 Dolly the sheep was genetically identical to her mother. She was grown from a cell from her mother's udder. Are these calves genetically identical to their mother? How can you tell?

Cloning Dolly – how it was done

Dolly was the first animal ever cloned from a cell taken from the body of an adult animal. Scientists took a cell from the mother sheep's udder. An udder cell is different from a skin cell, or a muscle cell, or a nerve cell. They managed to persuade it to start developing into a complete sheep, not just an udder.

They had to put the nucleus of one of the udder cells into an egg cell. The nucleus of a cell carries the creature's genetic information. They combined (fused) an udder cell with an egg cell from another sheep.

The diagram on the next page shows how the scientists did this. The boxes below contain information about their experiment.

What the scientists did ... and why

Cells taken from mother's udder and stored in special conditions ... where they are prepared for the experiment.

One udder cell selected, complete with its nucleus ... because the nucleus carries the mother's genetic information.

Udder cell fused with the empty egg cell ... so that the egg cell now has the mother's genetic information.

Egg cell taken from host mother sheep and its nucleus removed ... ready to receive udder cell nucleus.

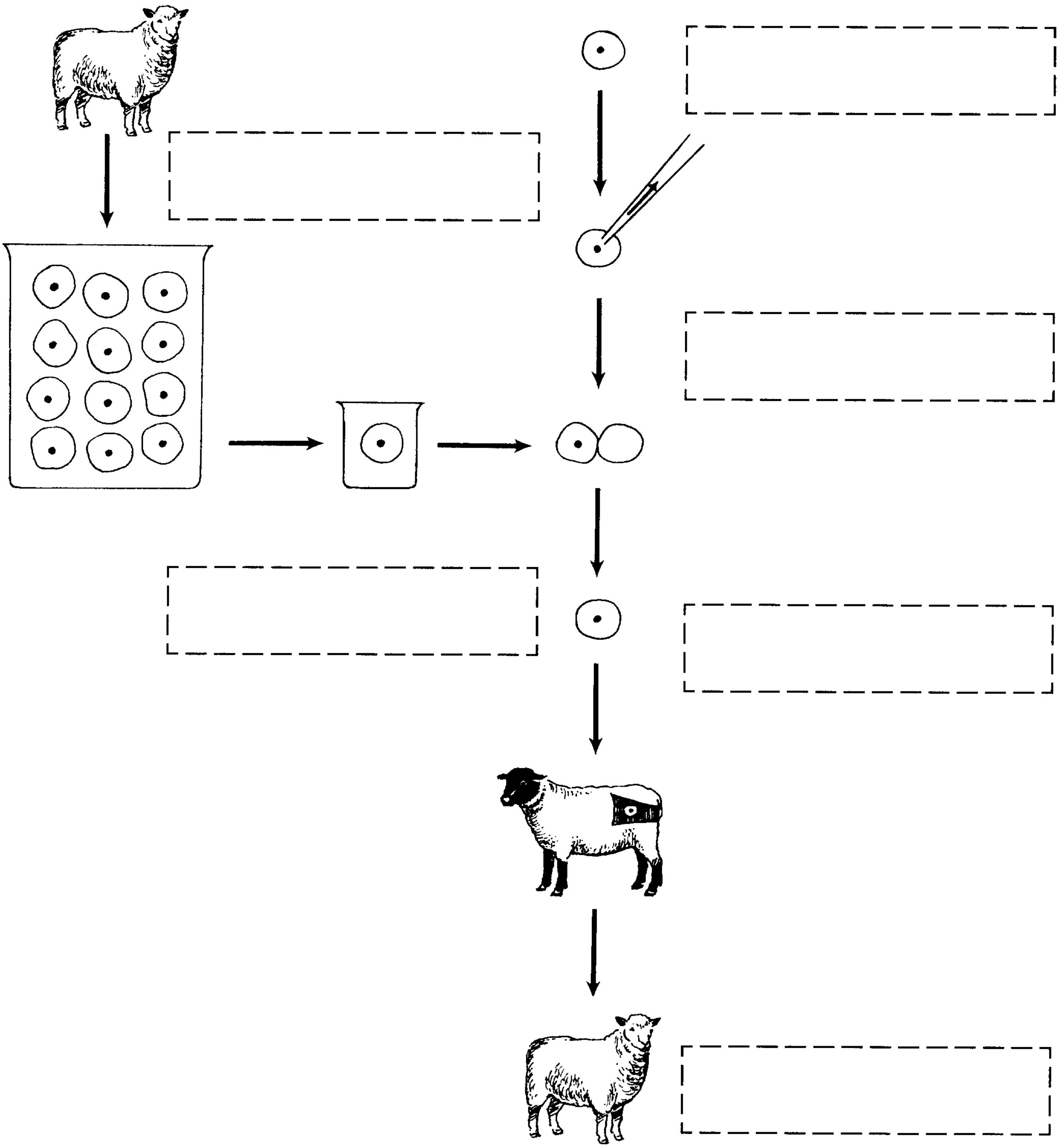
Egg cell implanted in host mother sheep ... where it will grow into a lamb.

Dolly is born, genetically identical to mother sheep... because her first cell nucleus came from her mother's cell.

Activity 3: Completing the diagram

1 The diagram below and the boxes on the last page contain information about how Dolly was cloned. Read the information in the boxes and decide where each one belongs on the diagram. Cut them out and stick them on the diagram.

2 Using the completed diagram, explain to someone:
- how Dolly was cloned;
- why Dolly had exactly the same genetic information as her mother.



Is cloning all wrong? Is cloning all right?

People worry about cloning. It is quite a new technique, and scientists are finding new uses for cloning every day. Some may benefit us all; others may bring problems. Which ones would you allow?

Activity 4: Debating cloning

Study the different statements about cloning. Decide which cloning activities should be allowed, and which you would ban.

By dividing up the cells of an embryo, a farmer could produce a whole herd of identical cattle.

An orchid-grower can clone cells from an orchid to produce thousands of identical orchids.

Scientists could produce a genetically-engineered cow which produced a useful drug in its milk. Then they could clone it, just like Dolly, and send the copies round the world.

Using the Dolly-cloning technique, a farmer could clone an adult sheep which he has chosen because it gives a lot of wool, milk or meat. He would have a flock of these valuable sheep.

You could go to a clinic and have a few cells removed from your body. These could be cloned and grown in a woman's womb to produce a clone of you – or even lots of clones of you!

Some couples need help to have a baby – they have a test-tube baby. The embryo could be divided in two or more, so that they would have identical twins – or even quadruplets – instead of just one baby.

Cells taken from your body could be frozen and stored for years. Later, when you are old, they could be grown to make tissue which could cure you of a disease, such as Parkinson's disease.

Medical researchers might discover a mouse that could contract AIDS. It would be useful for testing anti-AIDS drugs. They could clone this mouse and have many clones available for their tests.

Cloning sheep – Teacher's Notes

Acknowledgement

This module was written by Patrick Reygel (Belgium).

Introduction

In this module, students are asked to:

- discuss the nature of twins;
- develop an understanding of genetic inheritance;
- understand the meaning of the term 'cloning';
- learn about two cloning techniques;
- take part in a debate about the acceptability of cloning.

Scientific & technological concepts

- cells and nuclei;
- genetic inheritance;
- cloning.

Teaching approach

The module is designed to help students understand a little about cloning technology and its implications, so they can better understand items in newspapers and other media on current developments in this field.

A good starting point would be to find a selection of current items about recent developments in this field, ask students to scan them, and then discuss what their current understanding of this field is. (Developments are so rapid, and widely reported, that it would be inappropriate to reproduce any such items here.) Students should feel free to express any fears they may have, make jokes about armies of cloned zombies, and so on. The teacher's role at this stage is to listen, summarise, and point to the need for informed debate on the subject.

This discussion can then lead into the module itself. This provides information about clones and cloning techniques, and finishes with some points for debate.

Note that cloning is not the same as genetic engineering, in which the genetic information in a cell is altered, usually by importing genes from another organism. The two technologies often come together, since the techniques for growing individuals from single cells are common to both.

Notes on the activities

Page 1: This page will remind students of Dolly, the famous cloned sheep. Note that she was not the first cloned animal; she was first to be cloned from an adult cell. (The point here is that the cells of an adult have been differentiated; they are either nerve cells, or liver cells, or bone cells, or one of the 200 or so other cell types. Once a cell has become differentiated in this way, it is very difficult to reverse the process and make it divide into anything other than cells of its own type. You do not need to get into this deep water with your students!)

The text points out various types of clones, including identical twins. The discussion questions will encourage students to think about the fact that some characteristics are inherited while others are environmentally-determined. Many are a bit of both; for example, you may be a fast runner because you have good muscle and bone structure (inherited) and you may practise a lot (environmental).

Since Dolly is genetically identical to her mother, they are more like identical twins than mother and daughter.

(Note that, technically, the term clone refers to the collection of all the individuals which have been cloned, not just one individual. Also, it could be argued that identical twins are not truly clones, since cloning implies asexual reproduction, but for the purposes of this module they are as genetically similar as two cloned orchids or sheep.)

Page 2: Students should label the diagram. The host mothers are shown to be non-identical by their different markings. There are two ways to show that the calves are identical: by their appearance, or by tracing their genetic inheritance back to the same single cell. However, unlike Dolly, they are not identical to their mother, since half their inheritance comes from their father.

At this stage, it is not necessary to refer to cell nuclei, genes, DNA or any other aspects of the mechanism of inheritance.

Pages 3, 4: Students should complete the diagram on page 4 by sticking on the explanatory text boxes from page 3. As printed, the boxes are in a fairly logical order; if you feel your students will find this too easy, rearrange the boxes on the page before photocopying it.

Page 5: This page suggests some uses for cloning technology. There are several ways you could use it:

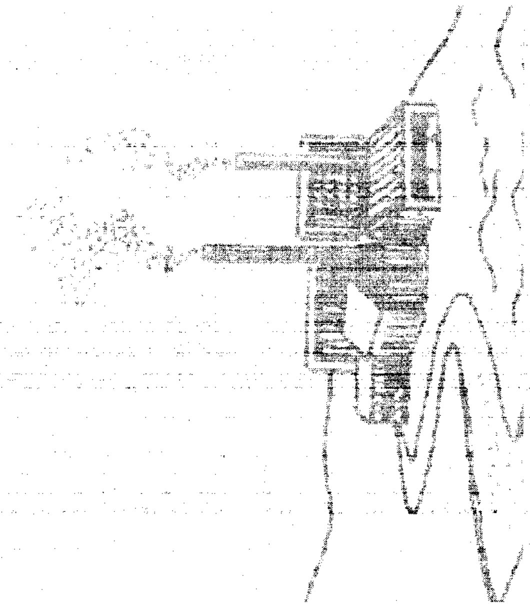
Working individually, students could consider each point in turn and note down reasons for and against permitting the activity described. Then a class discussion could be held to share ideas.

Students could cut out the boxes and arrange them from least acceptable to most acceptable. They could present reasons for banning those they find least acceptable, and for permitting the most acceptable.

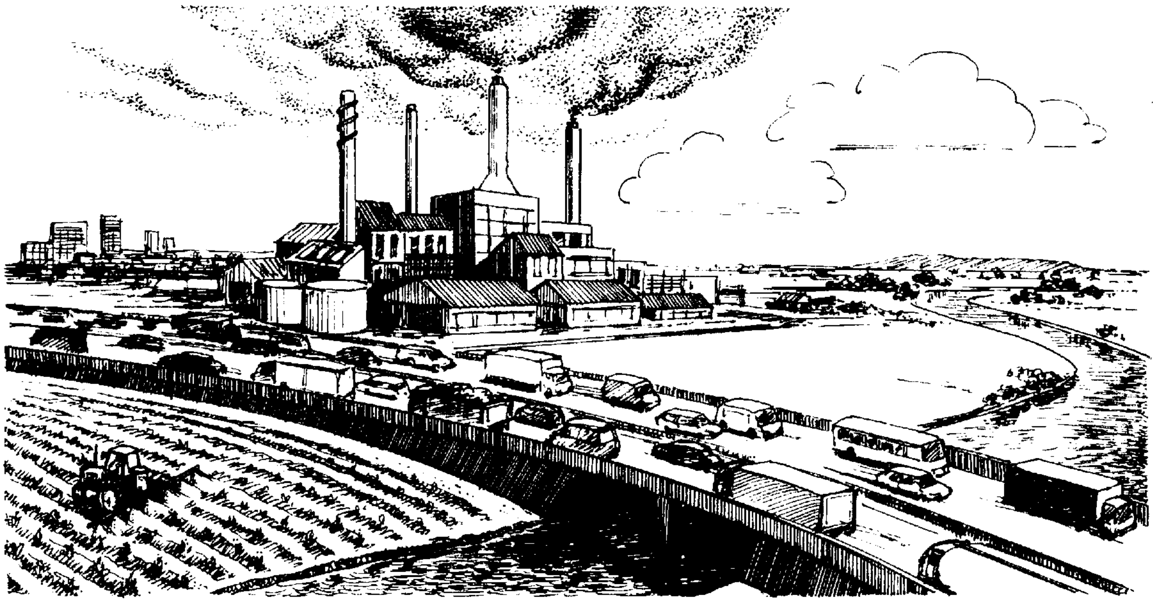
Using external resources, students could find out about the current state of cloning technology. Then they could discuss which of the boxes represents an already available technique, and its implications.

You could set up a more formal debate on cloning, using the ideas in the boxes as stimulus material.

Pollution



Investigating pollution



In 1920, a Norwegian archaeologist called Thor Heyerdahl sailed across the Pacific Ocean. He described how he spent weeks at sea without seeing anything which could suggest that there were other people in the world. However, while sailing in the Atlantic in 1970, he reported that not a day passed without some form of plastic container, beer can or other rubbish drifting close by, suggesting that other men were around.

Pollution is an ever-increasing problem. It takes many different forms, including: **Air pollution** **Water pollution** **Soil pollution**

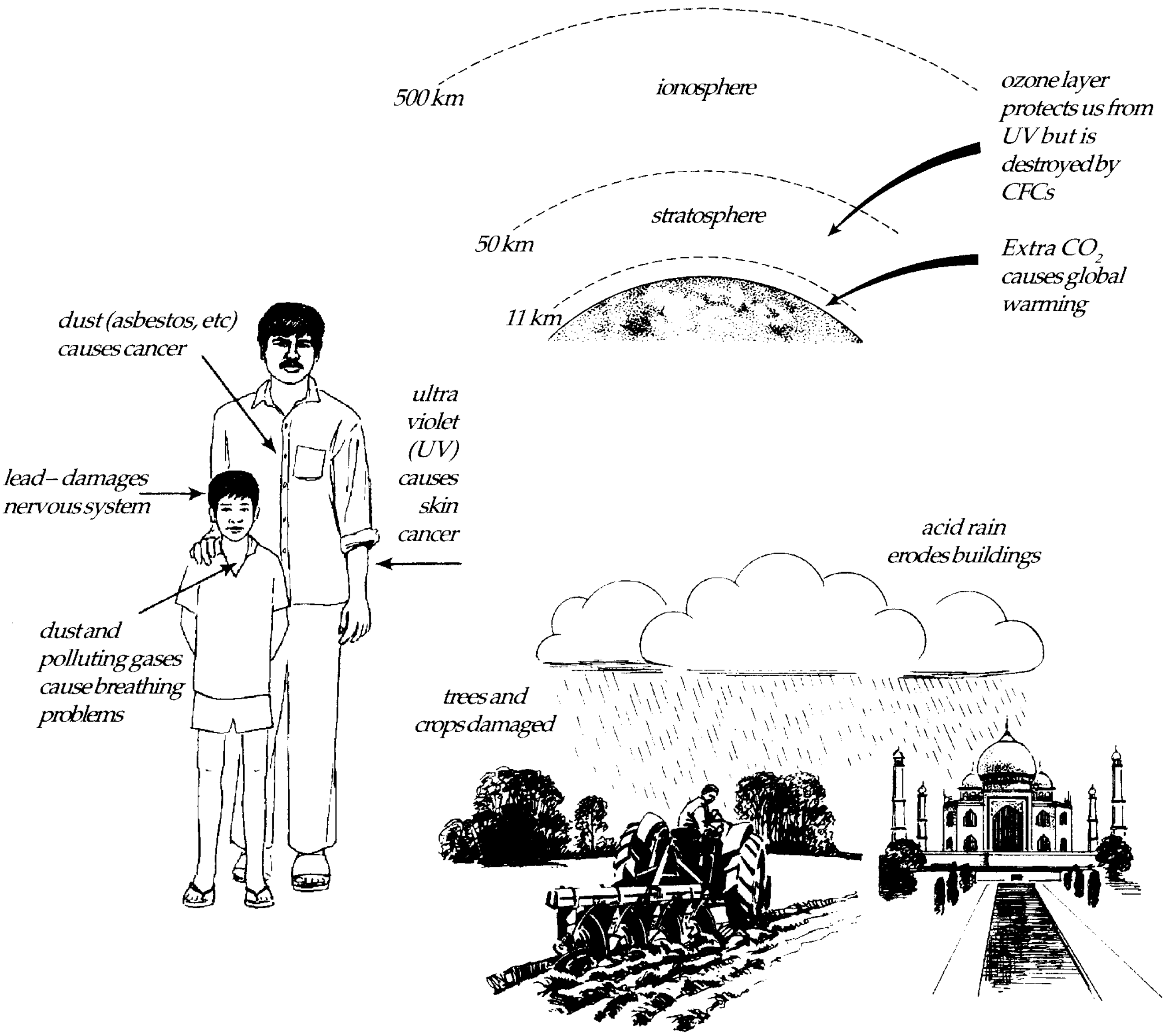
You can find out more about these on the information sheets.

Activity 1: Questions for discussion

Study the information sheets which give some ideas about the different types of pollution.

1. What examples of pollution have you noticed in your own locality? List them under the headings: **Air pollution** **Water pollution** **Soil pollution**
2. What sources of pollution can you identify in your own locality? (Are you responsible for any pollution yourself?)
3. What effects of pollution can you identify? Think about:
   - problems for people's health;
   - problems for other living organisms – animals, plants;
   - general damage to the environment – land, sea and atmosphere.
4. Do you know of any measures which are taken to reduce the amount of pollution?

Air pollution – information sheet



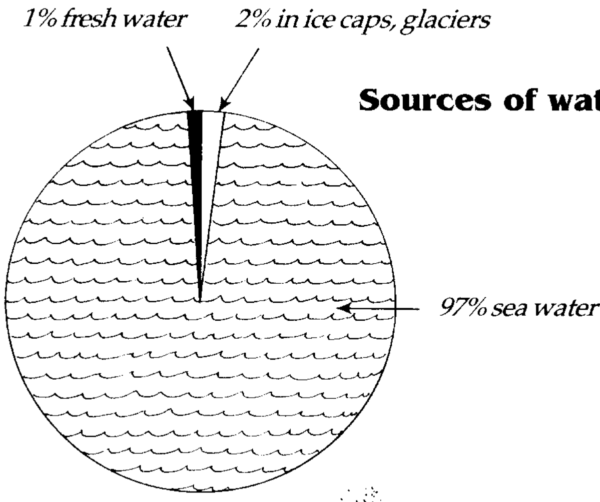
sources	pollutants
burning of fuels – by industry, homes	CO_2, CO, SO_2, NO_X, dust particles
burning of fuels – by motor vehicles	CO_2, CO, SO_2, NO_X, dust particles, lead
industrial plants – chemicals, fertilisers, cement, paper	particulates, fluorides, H_2S
agriculture – crop spraying, field burning	organic phosphates, smoke, soot
natural sources – volcanoes, fires	CO_2, SO_2, smoke, soot
nuclear – fuel preparation, weapons testing	uranium dust, radioactive gases and dust
refrigerators, air-conditioners, production of foam and perfumes	CFCs

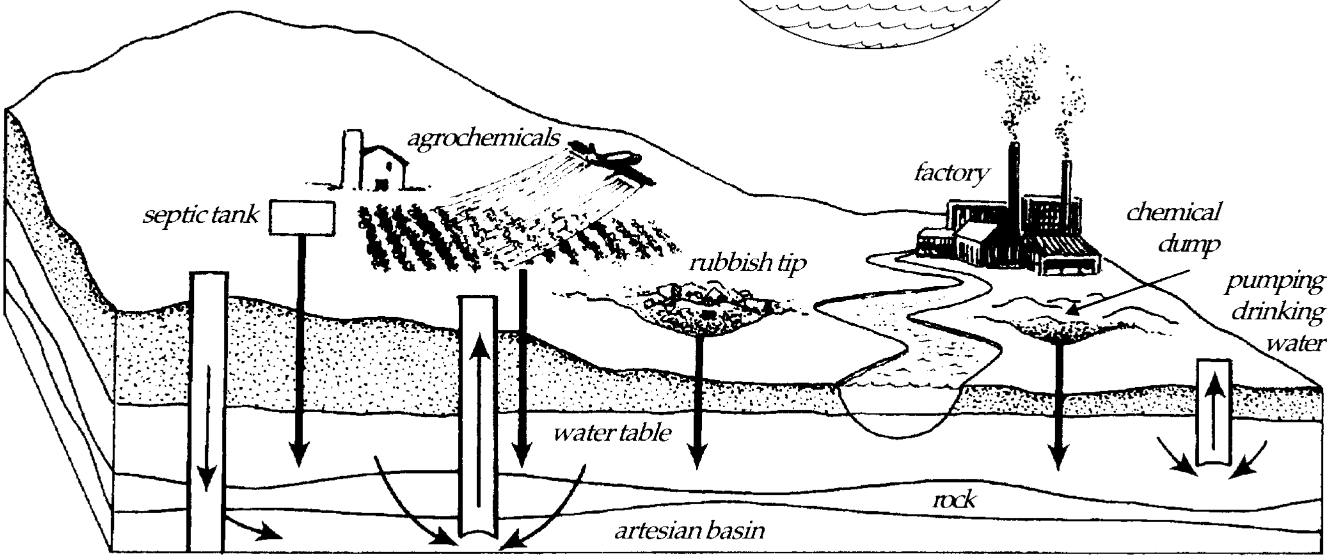
Water and soil pollution – information sheet

Sources of groundwater contamination:

Groundwater is usually the best source of drinking water.

Sources of water





types of water pollution	examples
physical	higher temperature – decreases dissolved oxygen increased cloudiness – decreases photosynthesis by plants foam, froth, radioactive contamination
chemical	salts – make water brackish toxic metals (mercury, lead etc) – poison living creatures acids and organic chemicals – also poisonous pesticides and herbicides – accumulate in food chain
biological	bacteria, algae, viruses, protozoa, parasites – cause disease in humans and animals

Soil pollution

- dust from the air
- pollutants carried by water (including agricultural chemicals)
- dumping of solid waste (including domestic, industrial and medical)

Measuring pollution

The instruction sheets show simple methods for measuring air pollution and water pollution.

Activity 2: Preliminary measurements

Decide whether you are going to measure air or water pollution.

- If you choose air pollution: Set up a testing station in a secure place, at school or at home. After a month, report your results to the rest of the class.
- If you choose water pollution: Your teacher will provide you with a sample of water to test. Report your results to the rest of the class.

Now that you know how these techniques work, you can use them to investigate sources of air and water pollution in your locality.

Activity 3: An extended study – Air pollution

Prepare a map of your area showing important industries, busy traffic zones, railways, residential areas, green belt areas, farms.

Find out which way the prevailing wind blows, and mark this on your map.

Decide on some sensible places to sample the air for dust. Check with your teacher that it is practical to set up testing stations in these places.

Set up dust sampling stations at the places you have chosen. After a month, prepare a report to show your results. Try to identify the likely sources of any pollution you have detected.

Activity 4: An extended study – Water pollution

Prepare a map of your area showing important industries, busy traffic zones, railways, residential areas, green belt areas, farms.

Find out where drinking water comes from in your area, and mark this on your map. (There may be many different sources, for people, farm animals, wild animals.)

Are there any other places where people come into contact with water, for example, when swimming or washing?

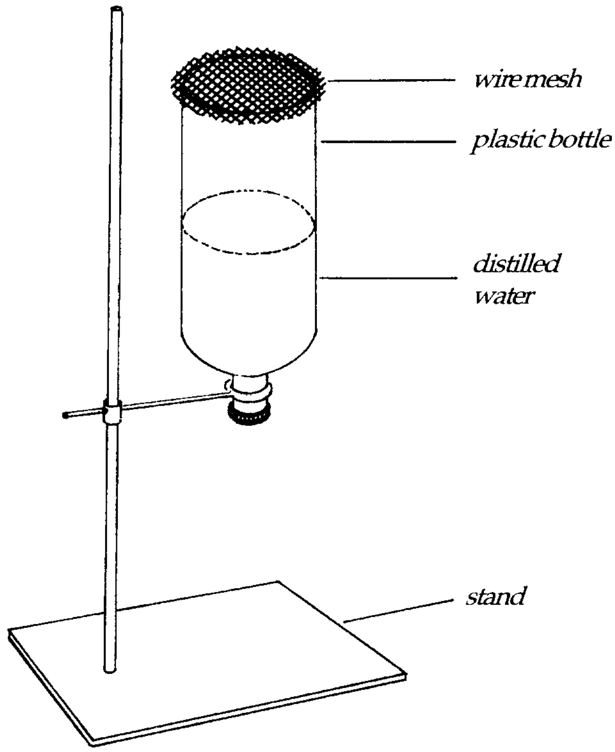
Collect samples of water from different sources. Check with your teacher that it is safe to do so.

Test your samples. Prepare a report to show your results. Try to identify the likely sources of any pollution you have detected.

Air pollution – instruction sheet

Materials required

- plastic bottle (1 litre capacity);
- stand;
- wire mesh;
- distilled water;
- filter paper and funnel;
- balance;
- hotplate;
- evaporating basin.



Method

Make your dust collector as follows:

- Cut the plastic bottle to make a wide-mouthed container.
- Fit wire mesh across the top, to prevent large objects from getting in.
- Fix the bottle on a stand.
- Half fill with distilled water.

Place the dust collector where you want to collect dust, about 2 m above the ground. (Make sure it is somewhere where it will not be disturbed by people, animals or birds.)

Check from time to time, adding distilled water to maintain the level. After 1 month, bring your collector into the lab.

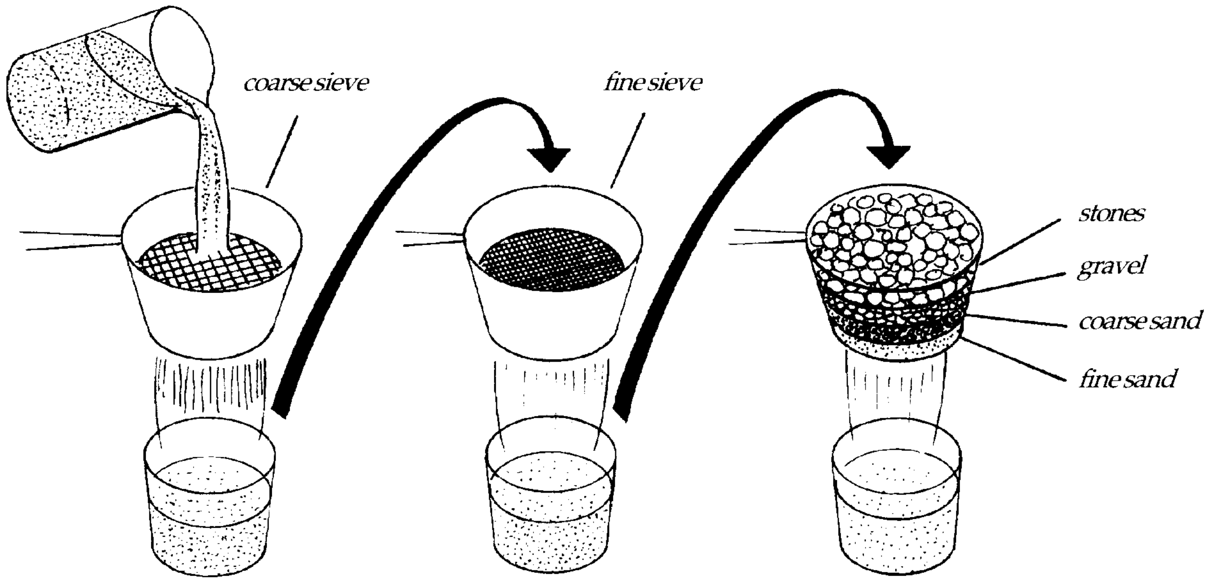
Filter the liquid; weigh the filter paper before and after to determine the mass of insoluble dust.

Collect the filtrate in an evaporating basin and evaporate; weigh before and after to determine the mass of soluble dust.

Compare your results with those of others in the class. Does this method seem to give reliable results? (If you used bottles of different sizes, you will have to take account of their different areas.)

Water pollution – instruction sheet

Materials required



- vessels for collecting water;
- measuring cylinder (2 l);
- pots with stands;
- filter funnels;
- coarse sieve;
- fine sieve;
- filter materials (coarse sand, fine sand, gravel, stones);
- pH paper;
- water testing kit (optional).

Method

Collect water samples. Wear protective rubber gloves if necessary.

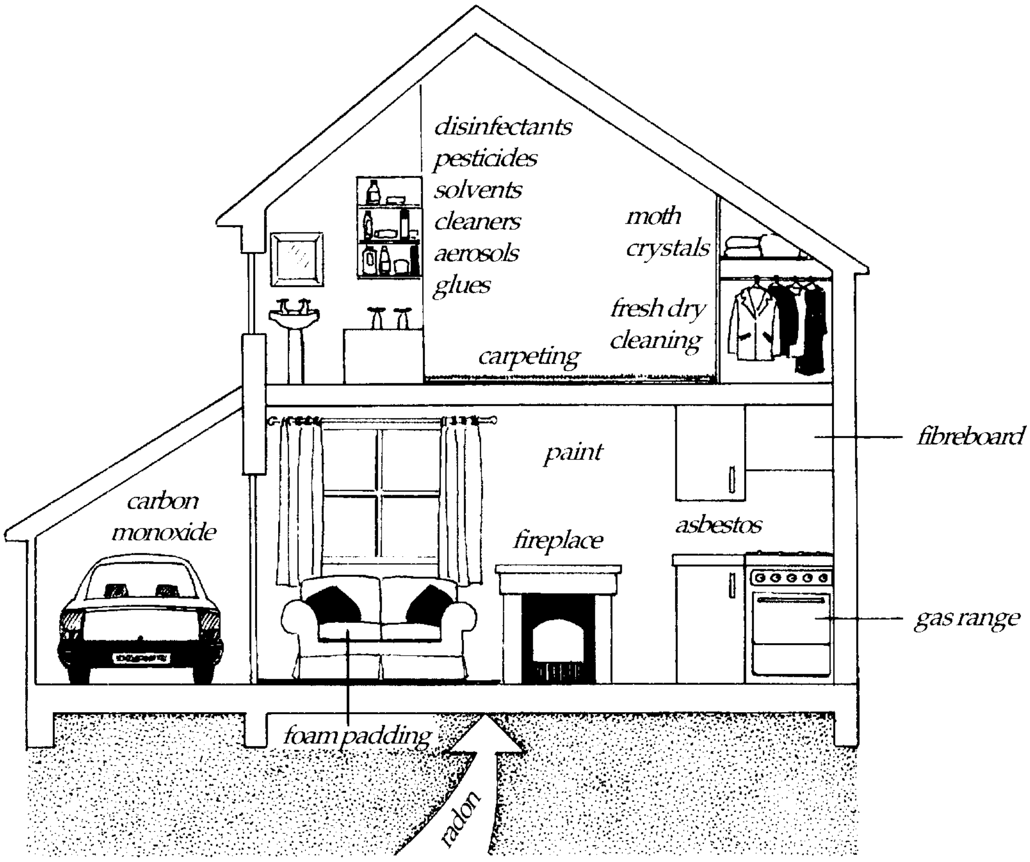
Set up three filters as shown above.

Pour one sample through pot 1. Collect the filtrate and pass it through pot 2, then pot 3.

Test the water before and after filtering. You could test

- acidity (pH);
- oxygen content;
- smell;
- colour.

Pollution in the house



Indoor pollution levels are often higher than levels outdoors.

- Polluted air may be the cause of sick building syndrome (eyes, nose and throat congestion, lethargy, nausea).
- Smoke, including tobacco smoke, is an important indoor pollutant. It can cause lung cancer.
- A badly-adjusted gas cooker or fire may produce poisonous carbon monoxide gas. So may a car's exhaust.
- Some building materials, such as asbestos, produce hazardous dust.
- A well-ventilated building is less hazardous.

Activity 5: Identifying sources of pollution at home

Make a list of possible sources of air pollution in your own home. The picture above may give you some ideas. Can you say how these might affect you?

Suggest ways in which you might reduce air pollution in your home.

How well-ventilated is your home? Sometimes people reduce the ventilation of their home, by using draught excluders, keeping windows shut, and so on. What reasons might they have for doing this?

Some people use air-fresheners or incense sticks to perfume the air. Does this help to reduce air pollution?

Pollution priorities

Many human activities pollute the environment – industry, transport, agriculture, homes, tourism and leisure. As the economy develops, it is important to control any possible increase in levels of pollution. Sometimes a modernised industry is less polluting than a traditional one, but sometimes it is more polluting.

Economic development is important, because it can bring jobs and a higher standard of living. But it may also bring more pollution, which damages the environment and reduces the quality of life for local people – and for the rest of the world.

In this activity, you can think about how to reduce the effects of pollution in your own locality.

Activity 6: Debating priorities

In this debate, you will be working in groups representing various local people. Here are the groups:

- industrial owners;
- industrial workers;
- farmers;
- fishermen;
- tourists;
- government officials;
- local children;
- local villagers/townspeople.

Working in groups, identify local sources of pollution which are important to the people you represent. Try to decide how seriously they affect people. Put them in order, from most serious to least serious. Think about how each source of pollution might be reduced.

Now present your thoughts to the other groups. Remember that their ideas may be different from yours, because different things may be important in their lives.

Try to draw up an agreed list of priorities. Which sources of pollution have the most effect on people? Can you agree about how they might be reduced?

If your ideas are put into practice, there will be winners and losers. Who will benefit? Who will have to pay the price of reducing pollution?

Investigating pollution – Teacher's Notes

Acknowledgements

This module is based on a series of activities developed by Dr Neelima Jerath and colleagues of the Punjab State Council for Science and Technology, India.

Introduction

In this module, students are asked to:

- think about local sources of pollution (air, water and soil);
- learn how to measure air and water pollution;
- survey air and water pollution locally;
- identify sources of air pollution in their own homes;
- establish priorities in the reduction of local pollution, with reference to economic development and a variety of interest groups.

Scientific & technological concepts

- pollution (of air, water, soil);
- greenhouse effect;
- ozone layer;
- groundwater;
- air and water purity;
- acid rain;
- food chains;
- economic development and inter-dependence.

Teaching approaches

Pollution is a very broad topic, with many aspects – local, national and international; chemical, physical and biological. This module focuses on local sources of air, soil and water pollution and their effects. It only touches on more global aspects of pollution, such as the enhanced greenhouse effect and damage to the ozone layer; also, it does not consider in depth ways of reducing pollution.

Notes on the activities

Page 1: This page introduces the idea that pollution has been increasing over the years, as has our awareness of pollution. The discussion questions give students an opportunity to review their existing knowledge. The information sheets (pages 2 and 3) can be used to stimulate and develop their awareness.

Pages 2,3: These pages take the form of information sheets about air, water and soil pollution. The information they contain is presented in the form of diagrams, tables and lists, since this will allow students to extract information relevant to their own level of knowledge and understanding.

Page 4: Students can make simple measurements of air and water pollution. Firstly, they should make a single measurement in order to learn the technique. Then they should plan a series of measurements in their locality. They should explain their choices of locations, predict what they will find, and then carry out their measurements.

Air pollution measurements: Note that these will require to be carried out over a period of weeks.

Water pollution measurements: For preliminary measurements, you might wish to provide a sample of ready-made 'polluted water', prepared by mixing water with, for example, soil and dye. If students are to investigate water samples from polluted sites, you will clearly have to be aware of any safety implications.

After these measurements, you and your students might visit a local pollution control laboratory, or you could invite a local official to speak to the class and answer their questions.

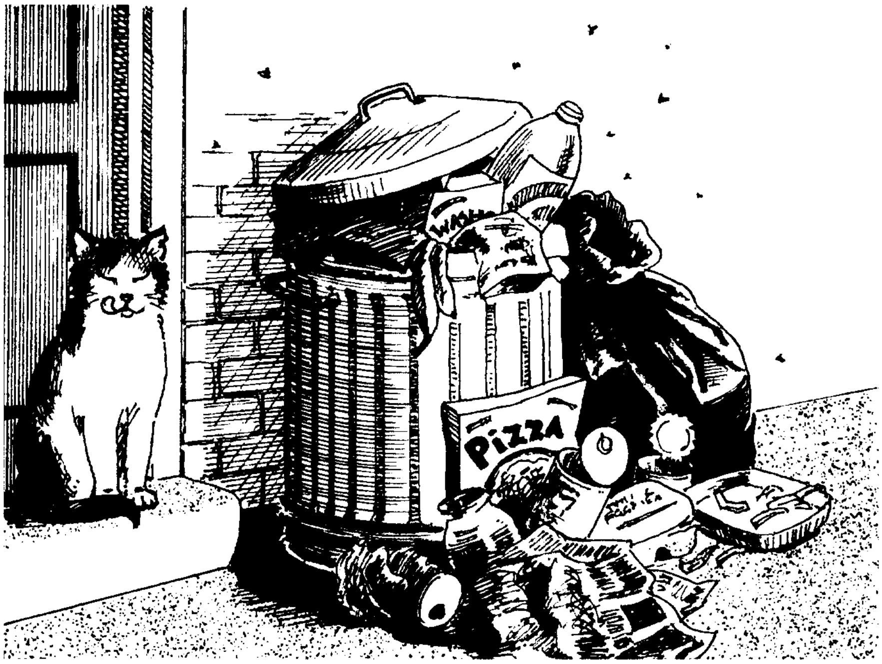
Pages 5,6: These pages give instructions for simple techniques for studying air and water pollution.

Pages 7: This page brings home to students the idea that there are sources of air pollution in their own homes. Some are clearly more significant than others, and this will vary from house to house, and from country to country.

Ventilation is essential to reduce domestic air pollution, but people may reduce ventilation to stop draughts, keep warm air in or noise and smells out.

Pages 8: Finally, students are asked to think about competing priorities in terms of pollution and economic development. They are asked to work in groups representing different groups in society; you may wish to choose different groupings, according to local circumstances. Through the discussion, you should try to point out that any pollution control measure has its costs as well as its benefits, and society must decide to set some priorities. Although the debate is set in a local situation, it is inevitably the case that local sources of pollution have a wider impact, and that local people may suffer from pollution which has a distant source. This is another aspect which you should seek to draw out in the discussion.

Sorting out waste



Many different household activities produce waste. There's waste from cooking, waste packaging, waste paper, old clothes, garden waste and so on. It can be a problem to dispose of this waste, especially in urban areas. If piles of garbage are left lying around in residential areas, or around shops and offices, they cause nuisance. They attract insects and stray animals and create an offensive atmosphere. Due to biological and chemical decomposition, gases are produced with noxious smells. Rubbish can be a major source of diseases, so it has to be dealt with properly.

It's often a good idea to re-use waste materials. Paper and glass can be recycled. Food waste and garden rubbish can be turned into useful compost. This is better than tipping them all in a dump. If waste materials are to be re-used, they must be sorted so that all items of one type are collected together. Many communities have special bins to collect materials for re-use.

Activity 1: Discussion

Before going on to investigate how waste can be recycled, think about how waste is handled in your own community. Discuss the following points, and share your ideas with the rest of the class.

- How is waste removed from your own home or compound?
  How is it removed from your school?
- Are there any systems for collecting and re-using particular types of waste?
  Do you know where any special bins are?
- What is the final destination of your waste? Does it go to a dump?
  Do you know where the dump is?

Classifying waste materials

Here are some different types of waste materials – you can probably think of more:

- plastic bags
- tin cans
- cardboard packets
- newspapers
- food scraps
- ashes
- rags
- glass bottles
- garden rubbish
- paper bags
- plastic bottles
- waste paper

We can think of several different ways to deal with this rubbish:

combustion	some can be burned to provide warmth.
composting	some can be turned into compost (natural fertiliser) for use in gardens or fields.
decomposition	some can be put into a digester where it will decompose to make biogas (methane), a useful fuel.
re-use	some can be re-used, so that it doesn't go to waste.
recycling	some can be recycled to make new items from the same materials.
dumping	some may be completely useless and will have to be dumped or buried.

Activity 2: Collecting and classifying waste

Make a collection of at least twenty waste materials, including as many as possible from the list above. (You will need a variety of samples for the practical activities which follow.)

For each, decide which of the methods listed above would be a suitable way of dealing with it. Give reasons to support your ideas.

Show your answers in a table like the one shown below. You can test some of your ideas in Activity 4.

type of Waste	methods of disposal	reasons
vegetable scraps	composting, decomposition	because vegetable scraps rot quickly
glass bottle	re-use	because glass can be cleaned and re-used

Activity 3: Making a league table

What are the most satisfactory methods of disposing of waste? It wouldn't be sensible to dump some wood if you could burn it, and it would be better to re-use it than to burn it.

- Put the six methods of disposal listed in the table above into a 'league table', from the most desirable to the least desirable. You may have to judge that some are equally desirable.

Waste materials decaying

Waste materials often end up in the environment. They may be left lying around, or they may be carefully dumped. What happens to waste materials in the environment?

Activity 4: Investigating decay

Find a suitable place where you can leave samples of your waste materials for a period of several weeks. Cut samples of similar sizes and test them as follows:

- Expose some samples in direct sunlight.
- Place some samples in a damp, shady place.
- Place some samples in open ground and water them regularly to keep them wet.
- Bury some samples underground.

In your investigation, you should:

- Predict how different materials will decay, using your scientific knowledge.
- Observe the samples every week, and record any changes in their appearance.
- Find out if the mass of each sample changes as it decays.
- Explain what your findings tell you about how different waste materials should be disposed of.

Encouraging better waste management

Most people understand that it is a good idea to dispose of waste materials carefully, to re-cycle some, compost others and so on. But they need to be encouraged to do this. Here are some more ideas for making good use of waste materials:

- Glass bottles may be melted down and added to new glass, to make new bottles.
- Combustible wastes may be burned to release useful energy, but undesirable fumes and gases may also be produced.
- Animal and plant wastes may be degraded under suitable conditions (absence of oxygen, temperature between 20°C and 35°C, presence of micro-organisms) to produce biogas. The residual slurry, rich in compounds of nitrogen and phosphorus, is used as fertiliser.
- Alternatively, these organic wastes may be rotted down in a covered pit to produce compost, a natural fertiliser.
- Old car tyres are often recycled for repairing shoes.

Activity 5: Encouraging better waste management

By now, you should be able to identify some waste materials which could be put to better use. But how can you encourage people to sort their rubbish, so that useful materials aren't wasted? Here are some suggestions:

- Design and make a waste bin for a particular type of recyclable waste material. In one school, pupils designed waste bins shaped like pineapples to collect organic materials which could be rotted down to make compost.
- Design and make a biogas digester. Fill it with rottable material. Find a way of collecting any methane gas it produces.
- Identify suitable places in your neighbourhood where recycling bins could be sited.
- Look around your neighbourhood to identify suitable sites for waste dumps. Where will a dump have the minimum adverse effect on people, other animals, and plants? Will water supplies be affected?
- Set up a Waste Disposal Task Force in your school. Can you find ways of reducing the total amount of waste which your school produces? Could more waste materials be sent for recycling?
- Site suitable waste bins around your school. Arrange a schedule of members of your task force to empty them regularly, disposing of the contents in the best possible ways.
- Run a competition in your school or community to devise posters or slogans which encourage wise use of waste materials.

Sorting out waste – Teacher's Notes

Acknowledgement

This module is based on *Pineapple-Shaped Waste Bins,* developed by four Nepalese teachers: Mrs Ishwari Dhungana, Mr Rudra Kafle, Mr Nanda Lal Tripathi and Mr Shanker Man Shrestha. It is Unit 4 in the UNESCO sponsored publication *Promoting Students' Scientific and Technological Thinking.*

Introduction

In this module, students are asked to:

- think about the way in which their own waste materials are dealt with;
- learn about different ways of disposing of waste materials, and suggest when these are appropriate;
- investigate how different waste materials behave in different environments;
- put into operation at least one method of encouraging better handling of waste materials.

Scientific & technological concepts

- combustion;
- composting;
- decomposition;
- re-use;
- recycling;
- environmental impact.

Teaching approaches

This module encourages students to think about waste materials and their impact on the environment. It helps them to develop their scientific understanding of how waste materials can be dealt with.

The module leads from an assessment of the current situation, through a scientific investigation, to a practical application of what students have learned.

Notes on the activities

Page 1: This page introduces the general question of waste materials and how they are dealt with. The activity prompts students to review the way in which their own waste materials are dealt with.

Page 2: Students should bring examples of waste materials from home. They are asked to consider appropriate ways of disposing of them. The text outlines briefly six different approaches.

In Activity 3, students should rank methods of disposal. The final ranking may be somewhat arbitrary, but the exercise will prompt students to consider the relative merits of each method. The outcome might be something like this (although the ranking of combustion is most debatable):

most desirable	re-use
2nd	recycling
3rd	decomposition
4th	composting
5th	combustion
least desirable	dumping

Page 3: This investigation will require considerable planning. You may be able to set aside a suitable area at the school where samples of waste materials can be left outside undisturbed for several weeks.

Students should at least be able to determine which materials decay quickly, which decay more slowly, and which do not show signs of decay in the time available. They should link this finding to their ideas about waste disposal.

Page 4: Finally, students are asked to devise ways of encouraging others to dispose of their waste materials more appropriately. They should choose at least one of the ideas suggested in Activity 5, or come up with ideas of their own.

Noise pollution

Noise is any unwanted sound. Noise can increase stress. Very loud noise can damage your hearing, or even make you completely deaf.

Activity 1: Identifying sources of noise

Read the following statements. Who might say each of these things?

- The weaving machines are very old and noisy. We have all learned to lip-read so that we can chat at work.
- I have the television set on all day. It keeps me company.
- When I was young, I used to walk in the countryside at night. Then, you could experience complete silence. There's nowhere around here like that any more.
- The village is quieter since they built the by-pass. And there aren't so many fumes.
- I can only do my homework if there is some good music to listen to on the radio.
- I can tell when it's lunchtime, because of the terrible noise coming from the school playground.
- The drills we use make lots of noise and vibrations. But without the coal, there would be no electricity to keep our homes lit and our factories working.
- All day long, I hear the sewing machine going in my neighbour's flat. Sometimes it's good to know there's someone there, but sometimes it gets too much.
- I used to be woken by the birds singing at dawn. But I never hear that now.
- Every night, I am woken by people leaving the club and slamming their car doors.

Now, list the different sources of noise mentioned. Can you add any more to the list?

Which of these sources may be harmful to someone's health? Try to list them from most harmful to least harmful. (The information sheet on Noise pollution may help you.)

Noise pollution Information sheet

Sources of noise

- industrial machinery
- radio and television
- construction work
- vehicles, trains, aircraft
- children playing
- household gadgets

The decibel scale

Each step of 10 dB on the scale represents an increase of 10 times in the loudness. So, for example, 50 dB is 10 times louder than 40 dB.

140 dB	threshold of pain
110 dB	truck horn
100 dB	jet aircraft at 300 m
80 dB	door slamming
60 dB	loud conversation
30 dB	rustle of paper
0 dB	threshold of hearing

Noise pollution in the home

source	noise level (dB)	source	noise level (dB)
television	65 - 67	radio, tape recorder	75
ceiling fan	45	extractor fan	51
refrigerator	44	air conditioner	61
electric grinder	82	flush toilet	76 - 80
vacuum cleaner	87	sewing machine	68
washing machine	61	pressure stove	74
hand pump	70 - 75	generator	80 - 85

Reducing noise pollution

Here are some ideas about reducing noise pollution.

Reduce noise at source: Design quieter machines and cars; reduce vibrations by standing machines on absorbent materials; re-route traffic and aircraft; turn down volume controls on radios and televisions; forbid noise in public places at night.

Reduce noise between source and hearer: Build barriers to reflect or absorb noise; keep doors and windows closed; fit double glazing; use heavy curtains and soft furnishing to absorb noise.

Reduce noise at hearer: Wear ear protectors.

Activity 2: Decision-making

How could you reduce noise in your environment?

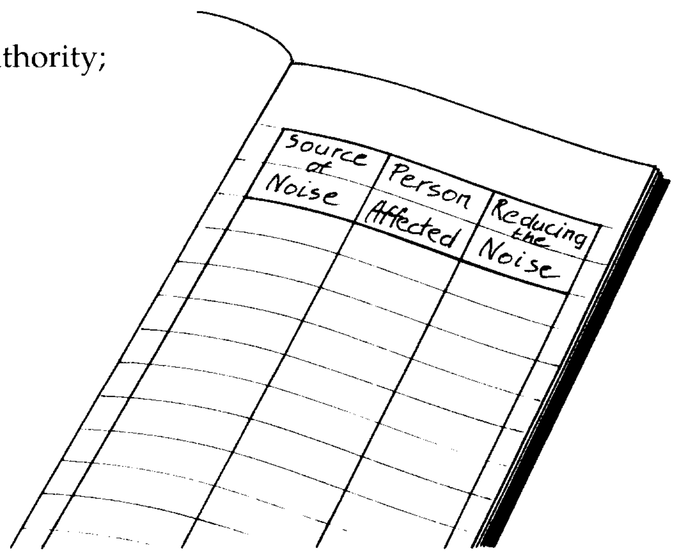
Start by thinking about your home:

- Identify sources of noise.
- Decide which are the most serious. What harm do they do?
- Suggest ways in which they could be reduced.

Now think about another environment you are familiar with: a factory or office, a city street, a park or playground, your school. Suggest some ways of reducing noise there.

Here are some ways you could present your ideas:

- as a poster;
- as a letter to the local authority;
- as a table.



Noise pollution – Teacher's Notes

Acknowledgement

This module is based on a series of activities developed by Dr Neelima Jerath and colleagues of the Punjab State Council for Science and Technology, India.

Introduction

In this module, students are asked to:

- identify sources of noise pollution;
- consider the problems caused by noise pollution;
- use the decibel scale;
- suggest ways of reducing noise pollution.

Scientific & technological concepts

- sound;
- noise pollution;
- reflection and absorption;
- decibels;
- hearing damage and deafness.

Teaching approaches

Noise pollution has increased in recent decades. This module asks students to consider the many sources of noise and how they may be controlled.

Notes on the activities

Page 1: This page introduces the idea of noise. The statements for discussion are intended to highlight the range of sources of noise. Students should realise that one person's enjoyable sound may be another's noise pollution. The information sheet (page 2) can be used to stimulate and develop students' awareness.

The activity goes on to encourage students to think about the harmful effects of noise, and to prioritise them to establish which are most harmful.

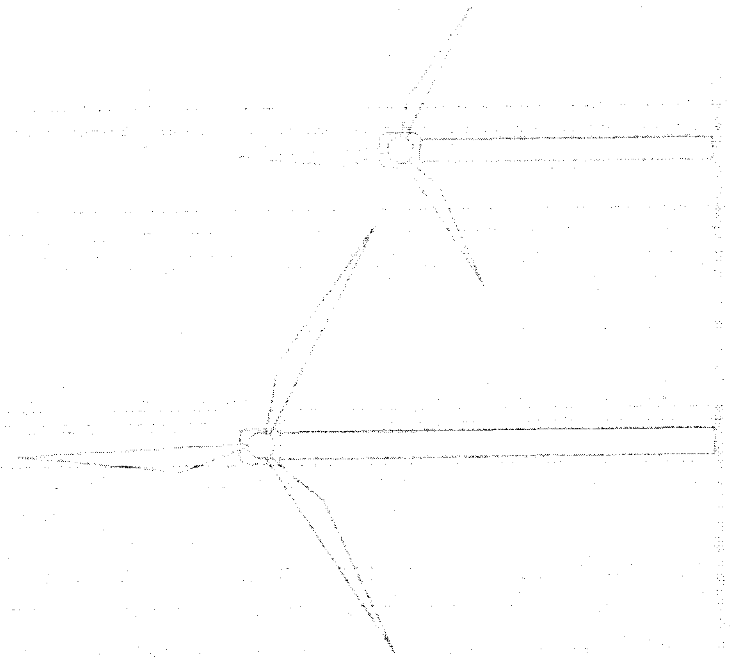
Page 2: This page takes the form of an information sheet about noise pollution. The information they contain is presented in the form of tables and lists, since this will allow students to extract information relevant to their own level of knowledge and understanding. You will have to decide the extent to which you can expect your students to understand the decibel scale.

If a sound level meter is available, you could demonstrate its use, and measure the noise levels of various sources, e.g. conversation, shouting, an electric drill. Students could make measurements of noise levels at different times and at different points around the school.

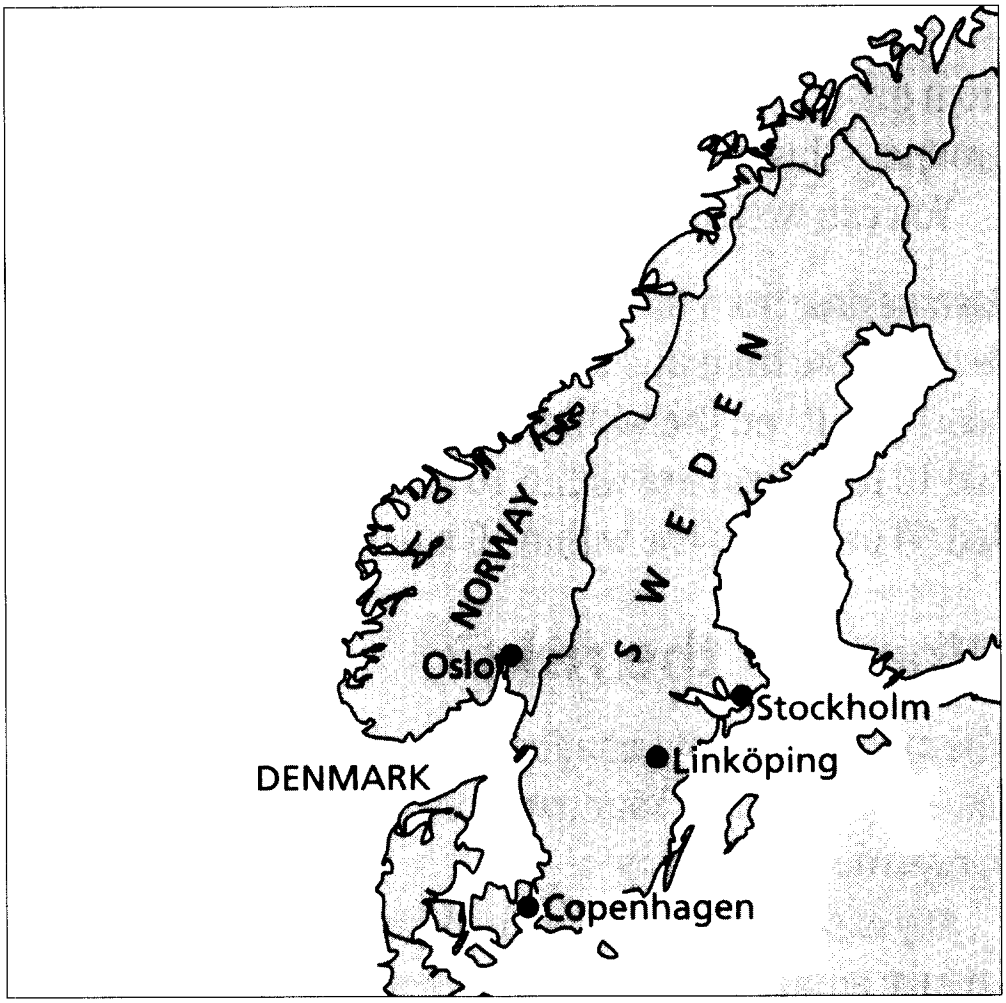
Page 3: Students can make some practical suggestions for reducing noise in a familiar environment. Start by considering their homes; then move on to other situations.

You might invite a factory inspector or trade union health and safety officer to talk about workplace noise and how it can be controlled.

Generating electricity



Combined heat and power



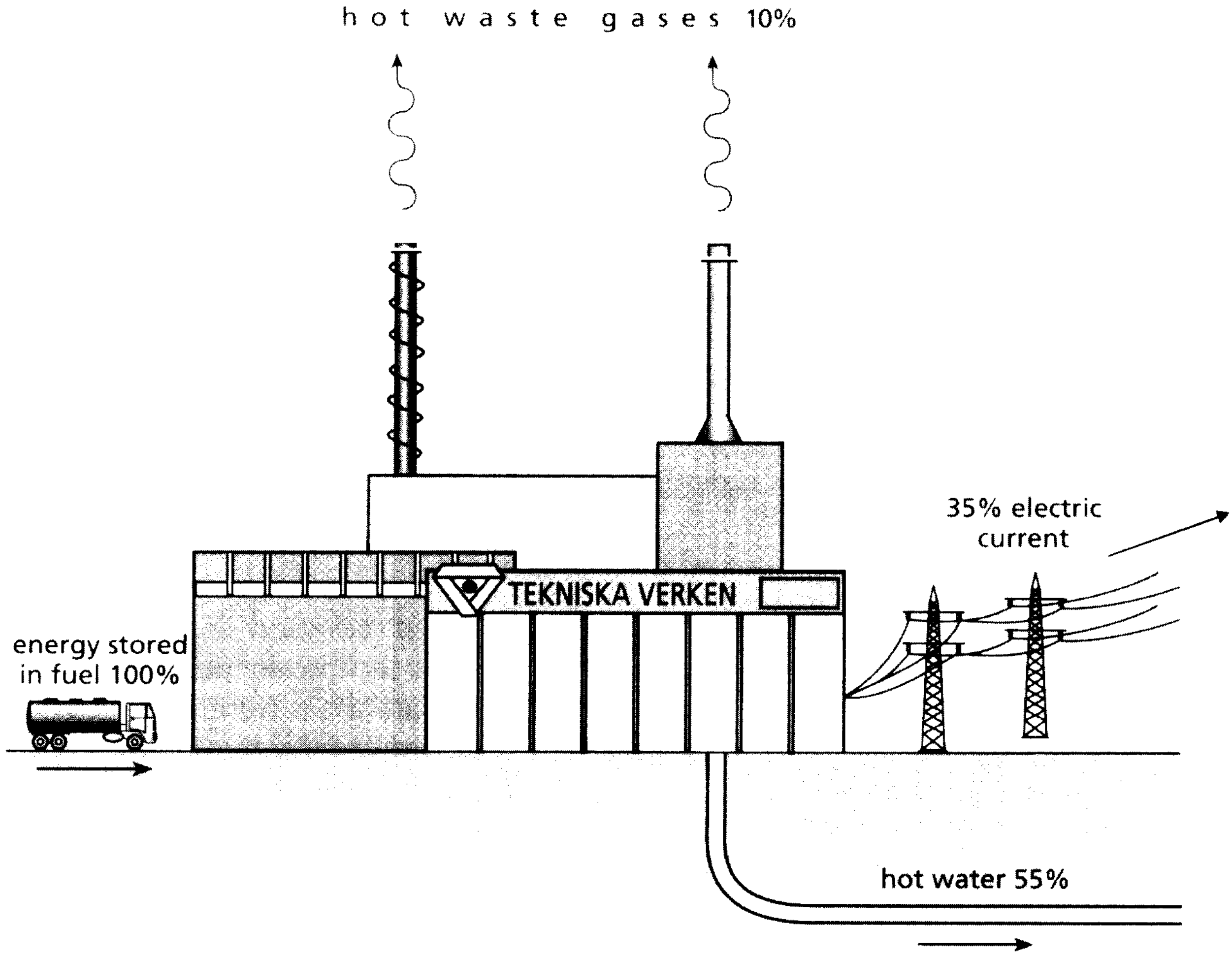
Linköping is in Sweden, where winters are cold.

If you lived in the Swedish city of Linköping, you would probably benefit from a way of heating which is unfamiliar in most parts of the world. You would be connected to the city's district heating scheme.

Hot water is fed along a system of pipes into homes, offices and factories. Out of 66 000 households in Linköping, 50 000 are connected to the district heating network. Instead of a gas or electric boiler in every house, hot water is supplied by a publicly-owned company. The hot water passes through radiators to heat each room.

The hot water for the district heating scheme comes from a power station. Like other power stations, this produces electricity. However, it has been specially designed to supply hot water as well. Such a power station is called a combined heat and power (CHP) plant. It makes very good use of the energy supplied by the fuel it burns. Only 10% is wasted as hot gases from the plant; the rest is transferred to the hot water and electricity supplies.

Energy transfers at the CHP plant



Activity 1: Discussion – District heating for all?

A CHP plant connected to a district heating scheme makes good use of the energy from fuel. Shouldn't every town and city have a scheme like the one at Linköping? Draw up two lists to show the advantages and disadvantages of a scheme like this.

Here are some points to consider:

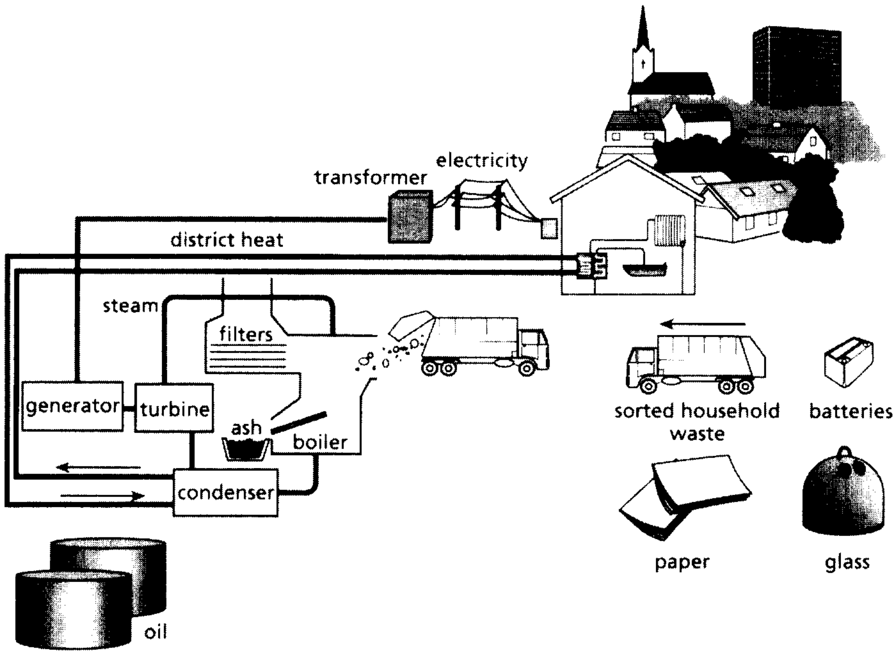
- Do you live in an area where winters are cold? Does your home need to be heated?
- How is your home heated at present? How would it have to be altered to make use of district heating?
- What work would have to be done to bring hot water pipes to your home?
- Why should a CHP plant be built close to the district it is supplying?
- What would happen if a CHP plant broke down?

The ins and outs of a CHP plant

The CHP plant at Linköping burns household waste as well as oil. If the waste was not burned in this way, it would have to be dumped in landfill sites.

In Sweden, people are conscious of the need to make good use of the rubbish they produce. Each household produces about 750 kg of waste every year. This is sorted for recycling, and anything that can be burned is sent to the CHP plant. Each year, the people of Linköping recycle 5000 tonnes of paper and 900 tonnes of glass. They send 34,000 tonnes of rubbish to the CHP plant. The plant collects more waste from other towns and cities in southern Sweden. A magnetic sorter removes any iron. It burns 200 000 tonnes of waste and 30 000 tonnes of oil each year.

When rubbish is burned, a lot of ash is produced – 45 000 tonnes every year. This is dumped in landfill sites. The waste gases from the furnace burning the rubbish contain substances that could harm the environment – such as nitrogen oxide, hydrogen chloride, mercury and dust. These are removed in two ways:



Household waste is sorted. Some is burned at the CHP plant.

- Chemically, by adding ammonia to neutralise the acid;
- Electrostatically, by using electrostatic precipitators to remove dust.

The cleaned flue gases go out through the stack. The dust and neutralised chemicals go to the dump.

Activity 2: Interpreting information

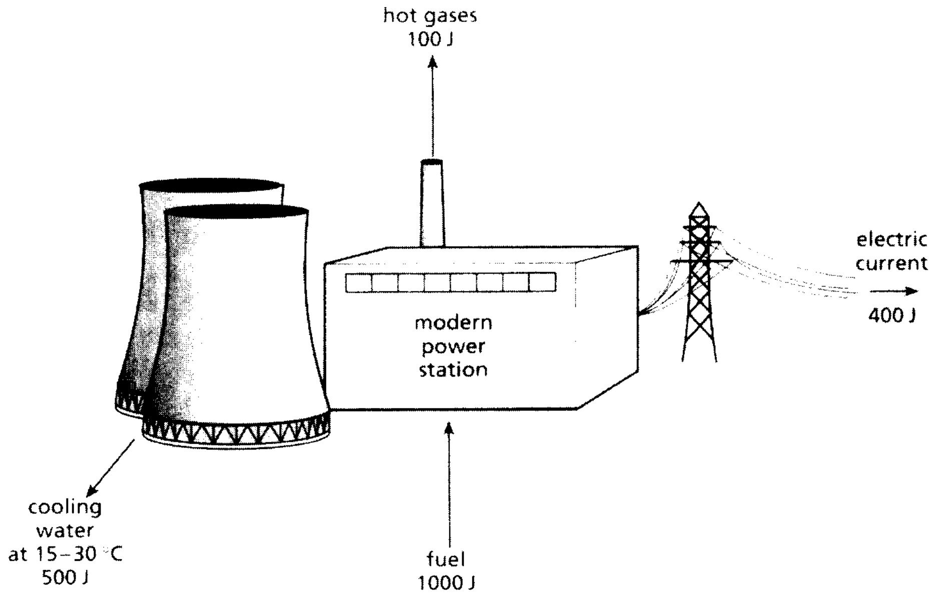
Use the information you have read, your knowledge of science and your own ideas to draw a diagram to show:

- All the materials and energy that go into the CHP plant;
- All the materials and energy that come out of the CHP plant.

Activity 3: Researching environmental protection

Use a textbook or other reference sources to find out about electrostatic dust precipitators. Make a list of all the ways in which the Linköping CHP plant has been designed to reduce damage to the environment.

Energy transfers in a conventional power station



A CHP plant makes good use of the energy from burning fuel. The Linköping plant wastes only 10% of the energy resources supplied to it.

A conventional power station wastes much more than this. Even a well-designed, modern gas-fired power station wastes about 50% of the energy from burning the gas – it is about 50% efficient. The first power stations were only about 10% efficient, so power engineering has come a long way.

Activity 4: Calculating energy efficiency

Here's how to calculate the efficiency of a power station:

$$\textbf{Efficiency} = \frac{\textbf{useful energy output (J)}}{\textbf{energy input (J) x 100\%}} \textbf{ x 100\%}$$

Look at the diagrams of the conventional power station (this page) and the Linköping CHP plant (page 2).

- What is the efficiency of the Linköping CHP plant?
- What would its efficiency be if it was only supplying electricity?
- What is the efficiency of the conventional power station shown on this page?

Making the most of energy

All power stations waste energy. It is impossible to make a power station that is 100% efficient; there will always be some waste. Also, the steam from the boiler must be condensed after it has passed through the turbine. The condenser uses cold water, which comes out hot.

Warm water from the condenser has to go somewhere, usually into a nearby river. This thermal pollution can be harmful to plants and animals living in the river.

Activity 5: Generating ideas

Occasionally, good use is made of waste energy from a power station. For example, some of the waste hot water can be piped to greenhouses so that tender crops can be grown all year round.

Suggest some other ways in which waste hot water from power stations might be used.

Supply and demand

The Linköping CHP plant provides the city with electricity and hot water. Unfortunately, they use them at different times. They use electricity most during the day (at work) and in the evenings (at home). They use their heating systems most in the evenings and mornings (when it is coldest).

Electricity must be generated whenever the consumer wants it – electrical energy cannot be stored. So the CHP plant produces hot water even when it is not required. An accumulator tank stores 20 000 m^3 of hot water during the daytime, and supplies it to the district heating scheme at night.

Activity 6: Design task

Design a suitable tank for storing 20 000 m^3 of hot water.

- What dimensions will your tank have?
- How will you keep as much energy in the water as possible?

Energy for Linköping

Linköping now has three CHP plants. It also has several oil-fired hot water plants (which do not generate electricity). The city's electricity comes from a variety of sources:

5% from hydroelectric and wind power schemes;

60% from CHP plants;

35% from the National Grid.

Activity 7: Data presentation

Draw a diagram such as a pie chart to show the different sources of electrical power used in Linköping.

Explain why it is a good idea to have several sources of electricity supply, rather than relying on a single, large power station.

Combined heat and power – Teacher's Notes

Acknowledgement

This module is based on Unit 37 of *The World of Science*, produced by the Association for Science Education (UK) and published by John Murray.

The information in the module is based on the Gärstad CHP Plant, Linköping, Sweden. Data was supplied by Tekniska Verken i Linköping AB.

Introduction

In this module, students are asked to:

- consider the benefits and disadvantages of a district heating scheme;
- find out about environmental control measures used at power stations;
- calculate and compare the efficiencies of different types of power station;
- suggest how better use might be made of waste water from power stations;
- design a storage tank for hot water;
- explain the desirability of multiple electricity supply systems.

Scientific & technological concepts

- electricity generation;
- energy transfers;
- energy efficiency.

Teaching approaches

The module gives students an opportunity to consider authentic data concerning a CHP plant and district heating system at Linköping in Sweden. Students should have a simple understanding of how a thermal power station works.

The module is most appropriate for students who live in an area where winters are cold; in other areas, they could be asked to explain why a CHP scheme would be less viable.

Another issue which could be raised by this unit is that of recycling versus burning of waste. It is difficult, without detailed data, to decide whether waste paper should be recycled, or burned for its energy content.

The module is self-contained, and it could be used as an extended homework activity.

Notes on the activities, answers to questions

Page 2, 3: These pages introduce the idea of a district heating system supplied by a combined heat and power (CHP) plant.

Some points for consideration in the discussion (Activity 1):

- In some countries, few homes have central heating systems with radiators, which would be required for connecting to a district heating scheme.
- If a CHP plant breaks down, many people will get cold. This can be avoided by having several plants supplying a single district.
- In many countries, the climate is such that people do not require much home heating for appreciable parts of the year. This means that CHP is relatively inappropriate.

Page 3: Activity 2 encourages students to think about the energy and material inputs and outputs for a CHP plant. This should emphasise to them the rules of conservation of matter and energy.

Activity 3 requires them to find out about electrostatic dust precipitators, and to list environmental protection measures associated with a CHP plant.

Page 4: Activity 4 requires students to calculate energy efficiencies. Answers: 90%; 35%; 40%.

Activity 5 requires some brainstorming. In practice, little use is made of waste hot water from thermal power stations.

Page 5: The design task (Activity 6) will emphasise to students the great volume of hot water which must be stored for a CHP system, in order to match supply to demand. This could be extended to a practical task, in which students model such a system on a reduced scale using, say, 2 litres of water instead of 20 000 m^3.

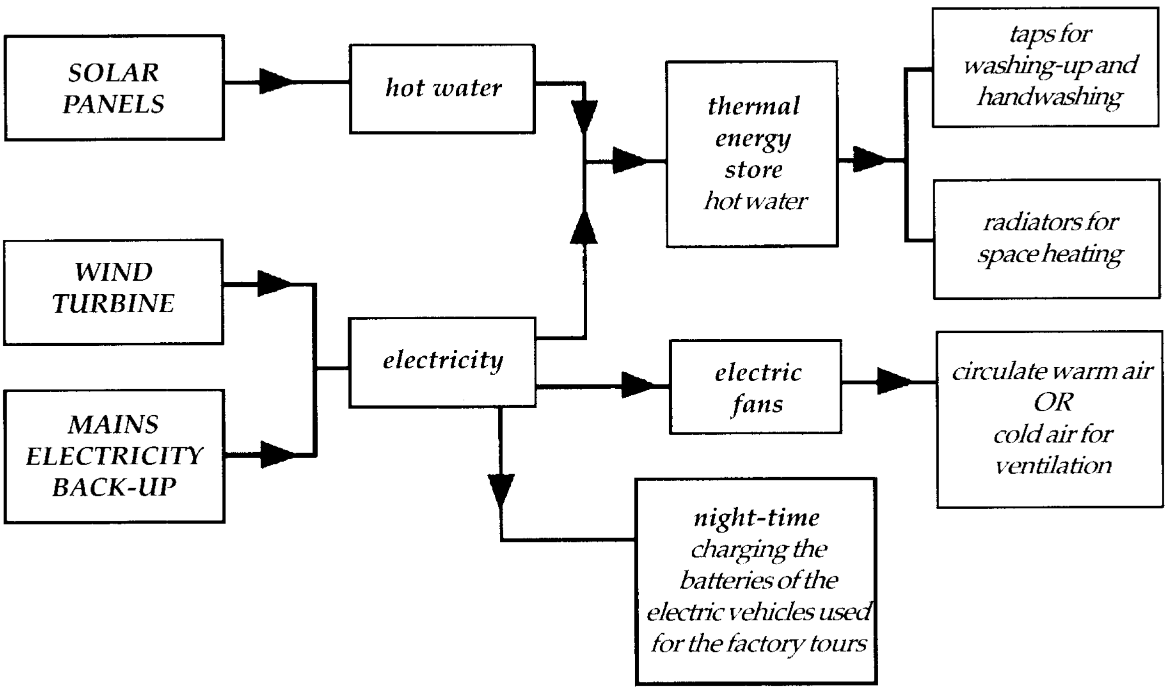
Activity 7 emphasises the importance of multiple supply systems.

Solar heating

The Trading Post

The Body Shop is a well-known company, with shops selling cosmetics in many countries around the world. The company is based at Littlehampton in the south of England. Here, there is a visitors' centre known as the Trading Post. The Trading Post uses solar energy to provide hot water, and for much of the 'space heating' - to keep the building warm on cold days. The roof and walls are well-insulated, and double glazed windows help to reduce heat loss from the building.

Water is heated using solar panels on the roof. Hot water is stored in a large tank - the 'thermal energy store'. This supplies hot water for washing, and for the radiators which heat the building. There is a wind turbine at the Trading Post, to generate electricity. This electricity can also be used to heat water. Sometimes mains electricity must be used for heating.



Activity 1: Evaluating an environmental policy

The Body Shop has a well-established environmental policy. This includes a commitment to:

- reduce the environmental impact of their operations;
- improve energy efficiency;
- use renewable energy wherever possible.

Explain which features of the Trading Post help The Body Shop to meet the commitments of its environmental policy.

Why must the Trading Post have a mains electricity back-up system?

Hot water - supply and demand

The Trading Post has about 500 visitors every day. This creates a demand for hot water in the toilets and the cafeteria.

- About 300 people use the toilets each day. Washing your hands uses about 1 litre of hot water. A running tap can use up to 10 litres per minute.
- About 200 people use the cafeteria each day. The washing-up is done by hand. A sink or large bowl holds between 15 and 20 litres of hot water.

Activity 2: Estimating demand

Use the information above to estimate how much hot water is needed in the Trading Post each day:

- for hand-washing in the toilets;
- for washing-up in the cafeteria.

Hot water is supplied at about 60°C. Heating 1 litre of water from 10°C to 60°C requires 0.21 MJ of energy. How much energy is required in the Trading Post each day for hot water?

- There are seven solar panels on the roof of the Trading Post with an area of 10 m^2. They are arranged on the south and west facing roof slopes.
- The average solar radiation at Littlehampton is 10 MJ per m^2 per day, but this varies greatly through the year, as the table shows.

Approximate percentage of the solar energy provided each month:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	5	6	10	12	13	13	13	12	8	4	2

Activity 3: Estimating supply

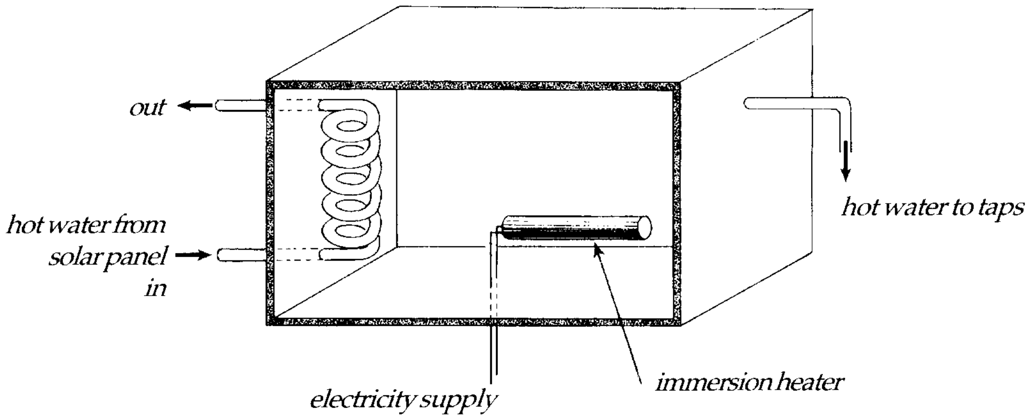
If you assume an efficiency of 25%, how much energy is available from the solar panels on an average day? How much hot water at 60°C will this provide? During which months could the solar panels possibly provide all of the hot water needed? And during which months will a back-up supply of energy be needed?

A thermal energy store

The Sun shines during the day, but we need to keep warm at night. We need to store some of the Sun's energy so that it is available during the hours of darkness. The Trading Post uses a thermal energy store to do this. A thermal energy store is simply a large tank of water. The water is heated during the day, so that we can make use of the heat at night. There are two ways to heat the thermal energy store at the Trading Post:

- Pipes pass through the tank, carrying hot water from the solar panels on the roof.
- An electrical immersion heater heats the water, using electricity from the wind turbine.

Water is useful for storing energy, because it takes a lot of energy to heat water up. The tank is well-insulated, so that it will take longer to cool down.



Activity 4: Interpreting a diagram

The thermal energy store tank has been carefully designed, using scientific ideas.

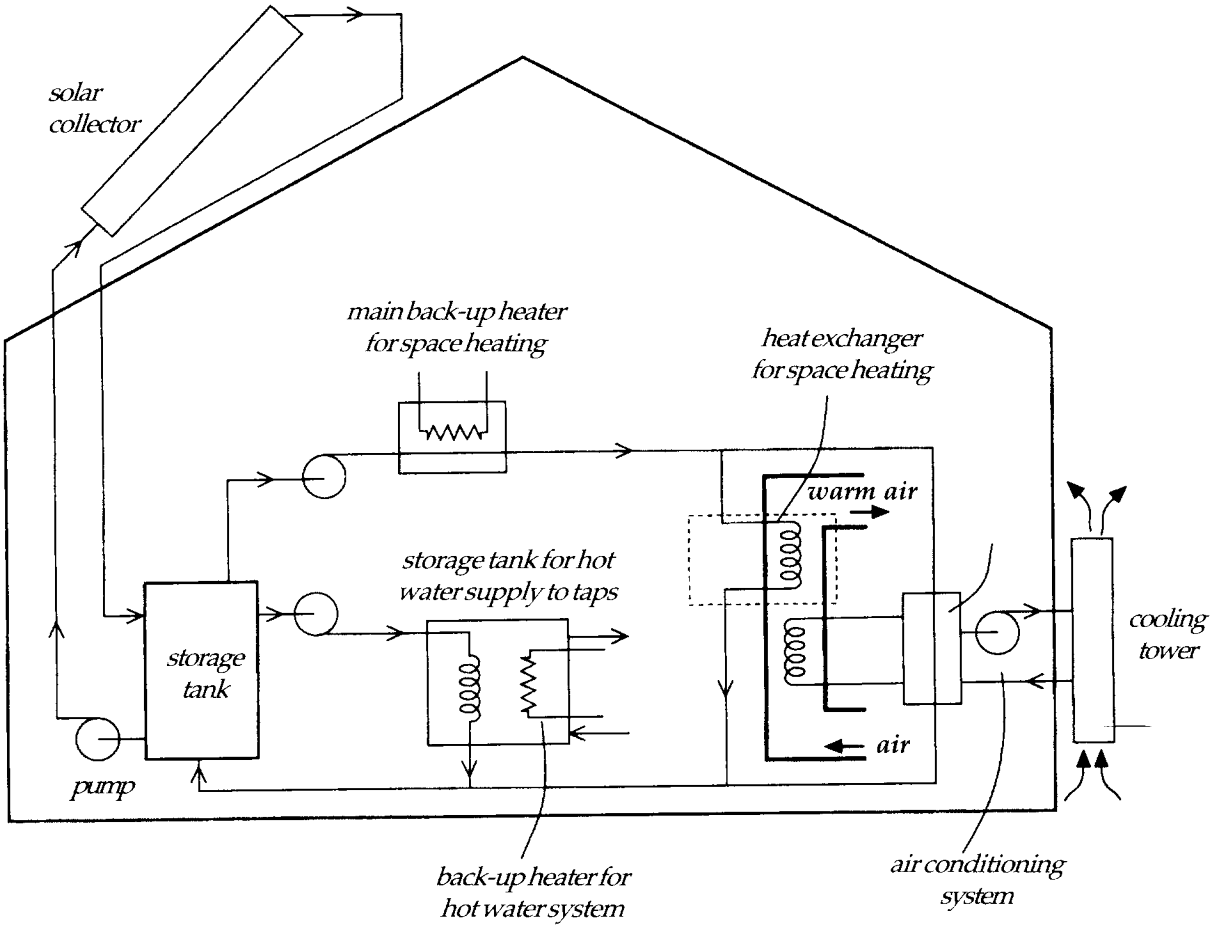
- Use the idea of conduction to explain why the pipe bringing hot water from the solar panels is made into a long coil inside the tank.
- Use the idea of convection to explain why the immersion heater is placed at the bottom of the tank.
- Explain why the tank is insulated.

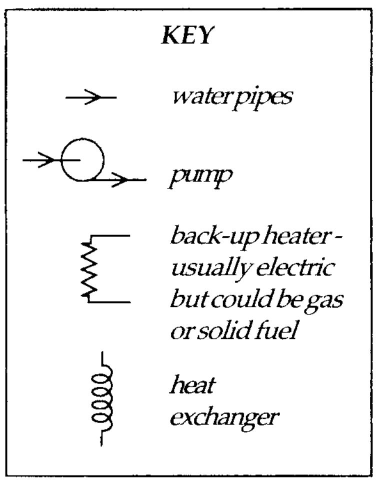
temperature of water in tank	temperature of surroundings	volume of water in tank	density of water	energy needed to raise temperature of 1 kg of water by 1°C
60°C	**20°C**	**200 m³**	**1000 kg/m³**	**4200 J**

Activity 5: Calculating energy stored

- Calculate the mass (in kg) of 200 m³ of water.
- Calculate the energy needed to raise the temperature of this water from 20°C to 60°C. Compare this answer with the amount of energy supplied by the solar panels on an average day (Activity 3). Comment on what you find.

A solar hot water and space heating system

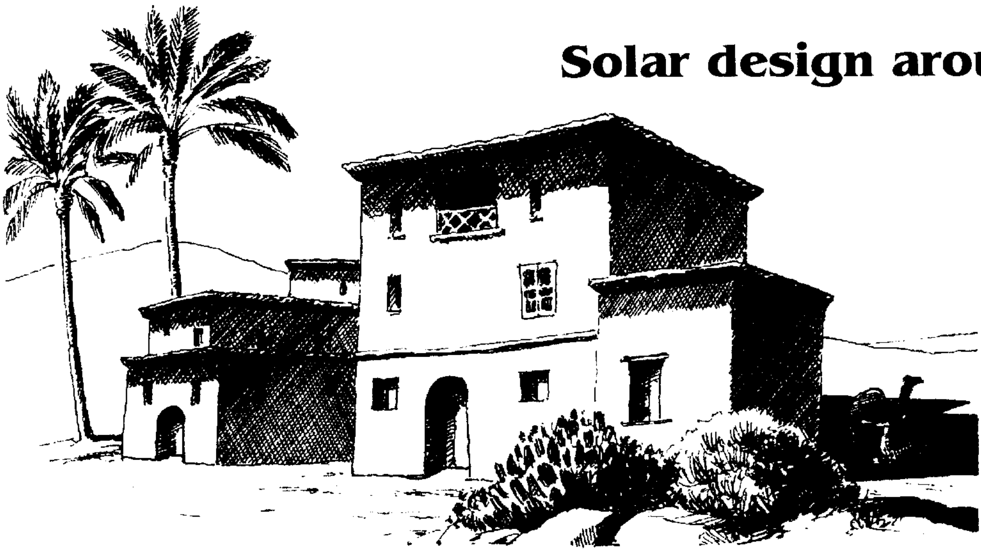




Activity 6: Interpretating a diagram

This diagram shows how a house can be heated using a solar panel on the roof; it also has an air conditioning system for use on hot days. Write down 2 or 3 sentences to explain how each of these systems works:

- the hot water supply;
- the space heating system;
- the air conditioning (cooling) system.



Solar design around the world

In tropical climes, people live in houses which are designed to stay cool. Their homes have thick walls, small windows and overhanging roofs, so that the Sun's rays do not penetrate inside, making the house too hot. They may be painted white, to reflect sunlight away. These are examples of passive solar design.

People who live in cooler parts of the world have to heat their homes when the weather is cold. This costs money, and uses up valuable resources. By making use of passive solar design, their homes, schools and offices can be more comfortable. Large windows on the sunny side of the building can capture the Sun's radiation; smaller windows on the other sides, and well-insulated walls, can keep the warmth in. This means that less fuel (such as wood, coal or gas) has to be used for heating.

We can go one step further, with active solar design. This means capturing the Sun's energy using panels or reflectors. This energy can then be used for heating water, cooking food or for generating steam. Millions of houses around the world use solar thermal collection in the form of rooftop solar water heaters. This means that they burn less fuel to heat their water.

Activity 7: Preparing a presentation

Prepare a presentation on active and passive solar design. Find some pictures to illustrate your presentation. Look for pictures of buildings from around the world. Where to look: newspapers and magazines; travel brochures; geography and history books; architecture magazines; websites. Your presentation might be in the form of a talk or a poster. Make sure that you explain how the buildings shown in your pictures:

- illustrate active and passive solar design;
- help to reduce consumption of fuels;
- are appropriate to the part of the world where they are found.

(You may also find pictures which show bad designs which are wasteful of energy.)

Solar heating – Teacher's Notes

Acknowledgements

This module is based on *Making use of Renewable Energy*, a publication of the Science with Technology project run jointly by the Association for Science Education and the Design and Technology Association (UK). Assistance in developing *Making use of Renewable Energy* was provided by The Body Shop International.

Introduction

In this module, students are asked to:

- find out about active and passive solar design;
- evaluate a commercial company's environmental policy;
- make energy estimates and calculations;
- evaluate a design for a thermal energy store;
- interpret a design for a solar energy heating system.

Scientific & technological concepts

- renewable energy;
- conduction, convection and radiation;
- energy storage and transfer;
- heat capacity

Teaching approaches

The need to reduce fuel consumption worldwide has led to an increase in the importance of solar design, both passive and active. In less developed countries, passive solar design has been an established technology for thousands of years. More developed countries have gone in for 'energy-guzzling', and efforts are now being made to reduce this.

This module could be used as part of a study of renewable energy resources. Alternatively, it could be used when students are studying thermal properties of matter (thermal energy transfer and heat capacity).

Notes on the activities

Page 1: This page introduces the idea of a heating system using solar and wind power. It focuses on a particular example, a building belonging to The Body Shop, and asks how this helps the company to meet the demands of its own environmental policy.

Page 2: Here students are asked to consider how much energy is needed for water heating, and how this can be met using solar panels. Note that calculations can only be estimates. You could point out to students that the original architects of this system would have made similar estimates when designing the building.

Page 3: Students are asked to consider a tank of hot water as a thermal energy store. They should draw on their understanding of thermal energy transfer mechanisms (conduction, convection and radiation). They must also calculate the energy needed to heat water in the tank. If they are familiar with the term specific heat capacity, you could use this here.

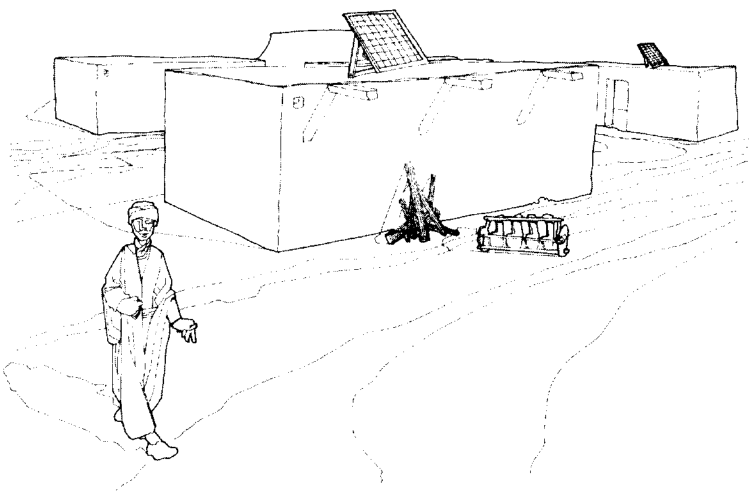
Page 4: This page shows a more complex design for a solar heating and cooling system in a house. This gives students an opportunity to use the knowledge they have gained earlier.

Page 5: Here, we outline the principles of active and passive solar design. Students are asked to find pictures of examples (good and bad) of solar design. You will have to tell the class what form of presentation you expect of them. One possibility would be to make a shared display using selected pictures from all members of the class. Pictures could be annotated to highlight the features of interest.

Photovoltaic systems

Electricity from the Sun

'Photovoltaic' (or PV for short) means turning light into electricity. Solar PV systems provide electricity from sunlight. They can provide power for a wide variety of uses. Calculators, lights, fridges, homes and even whole villages or towns can use solar electricity as their energy source.



A solar panel is made up of lots of small cells linked together. Each small cell produces a tiny electric current when the Sun shines on it. They can do this because they are made of materials called semi-conductors. Solar panels can then be linked to form a large solar PV array producing a lot of electricity.

Solar PV systems produce electricity without noise, moving parts to wear out, or pollution. One of the advantages of solar electricity is that you do not need to have a power station sending electricity to you along wires. Even in the most remote parts of the world, PV systems can supply solar electricity for all kind of uses.

Activity 1: Discussing questions

Try to answer all of these questions. Be prepared to share your answers with a partner, and with the rest of the class.

1 You may have seen a calculator powered by solar cells. (You may even have one.) Most pocket calculators are powered by batteries. What is the advantage of using solar cells to power a calculator? Are there any disadvantages?

2 Where else have you seen solar cells in use? What were they being used for? Can you suggest why they were used for this purpose?

3 What is your main source of electricity? Is it produced from sunlight, or by burning fuels, or by some other means?

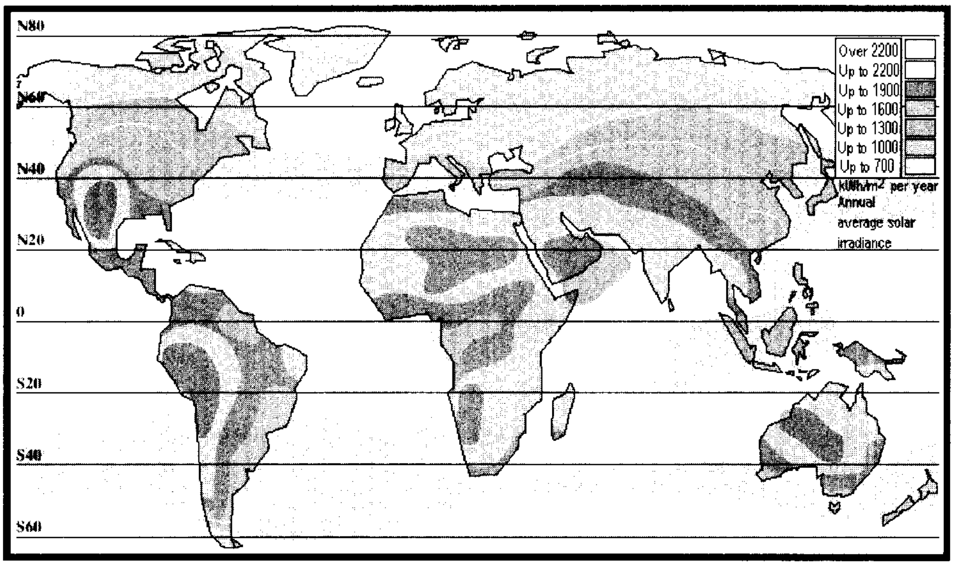
4 Think about the word **photovoltaic**. It means 'turning light into electricity'. Which part of the word means 'light'? Which part means 'electricity'? Suggest some other words which are related to each of these two parts.

Measuring the Sun's energy

We can measure the energy of the Sun at the surface of the Earth in units called 'kilowatt-hours' (or kWh for short). 1 kWh is the amount of energy used by a small electric fire in one hour, or the energy that a single hundred-watt light bulb consumes in ten hours. In fact, your electricity meter at home or school measures the electricity that you consume in the same units - kWh.

The Sun's energy that is available for collection depends on the intensity of the light, and on how long the Sun shines. Sunny summer days, when the Sun is high in the sky, give more energy than cloudy winter days. Close to the Earth's poles, the Sun does not move high in the sky, so the energy supplied by the Sun in the course of a year is greater near the Equator, and less near the Arctic and Antarctic.

To be able to compare the Sun's energy in different parts of the world, we measure how much energy falls on each square metre of land - we say kilowatt-hours per square metre (or kWh/ m^2 for short). Then we add up all the energy that arrives from the Sun in the course of a year.



Measuring the Sun's energy helps us to find out how much solar energy we can use for our own purposes. It can also tell us how big our solar panels need to be to collect enough of the Sun's energy.

Activity 2: Interpreting a map

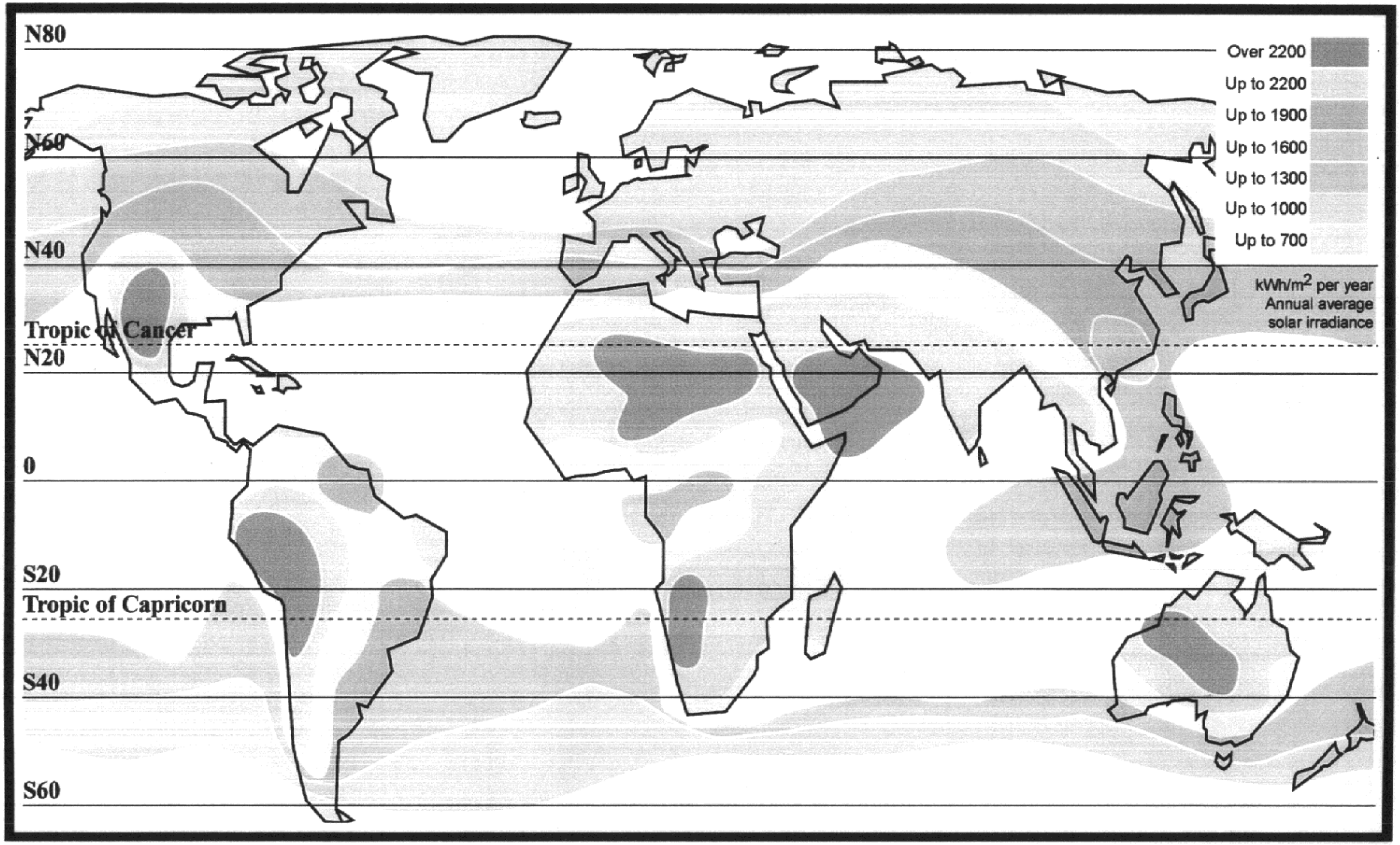
Use the world solar energy map to answer these questions:

5 Compare northern Russia and central Australia. Which one receives more solar energy each year? Can you say how much more?

6 Imagine that you are designing an emergency phone for use in remote areas. It will be powered by a solar PV system. Would you need the same size of solar collector in each country (Russia and Australia) to gather equal amounts of energy? Try to explain your answer.

7 List as many reasons as you can why some parts of the Earth receive more energy from the Sun in a year than others.

World Solar Energy Map



Monitoring the Sun's radiation

The amount of sunlight arriving varies during the day, and it varies from day to day. Here are two ways to monitor the Sun's radiation:

- Use a home-made sundial. Record the position of the end of the shadow every 30 minutes during the day.
- Use a light sensor connected to a datalogger. This will record the light level during the day, and you can then print out a graph. Alternatively, use a light meter and record readings every 30 minutes.

Once you have collected some information, you can work out the best places and times for using solar technology to harvest energy from sunlight.

Safety: Never look directly at the Sun, as this can damage your eyesight.

Activity 3: A solar log sheet

Using the results from your sundial experiment, you can fill in a solar log sheet like the one shown here. Use a compass to work out the direction of the Sun when it reaches its highest point (when the shadow is shortest). Estimate the angle of the Sun using the length of the stick and the length of the shadow. (Hint: you can use your maths trigonometry skills for this, or draw a scale diagram.) You could plot a graph to show how the angle of the Sun above the horizon changes during the day.

date	time of sunrise	time of sunset	Sun at highest point			weather
			time	direction	angle	
11 February	07:10	17:05	12 noon	S	22°	cloudy
15 February	07:05	17:10	12 noon	S	22°	sunny

Activity 4: Datalogging the Sun's radiation

Set up your light sensor and datalogger to record how the light level changes during the course of a day. Things to think about:

- Where will you position your sensor?
- In which direction will you point your sensor?
- How can you test your equipment to check that it is running correctly?

When you have a graph to show how the Sun's radiation changed during the course of a day:

- Try to explain the shape of the graph, and any sudden changes in light level.
- Suggest how the graph would be different at different times of the year.

Thinking about the cost

In many countries, most of the energy used in homes, factories and schools comes from burning fossil fuels such as coal, oil and gas. This has three main drawbacks.

Firstly, the process of taking fossil fuels out of the ground can cause damage to the environment. This can include damage caused by the extraction machinery and by the pollution that is a by-product of extraction.

Secondly, fossil fuels give off gases when they are burned. Some of these gases can cause environmental problems, such as acid rain. Others, such as carbon dioxide (CO_2) may be causing a change in the global climate - you may have heard the terms "Greenhouse Effect" or "Global Warming".

Thirdly, fossil fuels are not free. They cost money to bring out of the ground. This means that as fossil fuels run out, their price will increase.

At present, in most countries the cost of electricity from fossil fuels does not include the cost of the damage they cause to the environment. This is called the "external" costs. If these were included, the price of this type of electricity would be higher.

The table below compares the costs of electricity from various sources. When there is a main electricity grid nearby, electricity from solar PV is still expensive compared to electricity from fossil fuels, and it will take some years before PV is competitive in grid-connected situations. However, many technologies that were once expensive are now much cheaper. These include things like calculators, digital watches, and personal computers. This is the same with solar PV technologies.

In remote areas of the world it can be cheaper to use a solar electric PV system rather than building new pylons and wires. In these places, we say that it is more *cost-effective* to use PV.

	external (environmental)	financial	total
coal	2.5 - 16	4 - 9	6.5 - 25
clean coal	1.2 - 4	4 - 9	5.2 - 13
natural gas	0.6 - 1.2	6.3	6.9 - 7.5
nuclear	2.5	3.8 - 7.5	6.3 - 10
oil	2.5 - 7.5	7.5	10 - 15
solar PV	0 - 0.3	54 74	54 - 75
wind	0 - 0.1	5 - 14	5 - 14

Figures are for grid supplies in US cents. Figures in Euros are similar at publication date.

Activity 5: Comparing costs

i) Find out how much your family (or someone you know) pays for a kilowatt-hour (kWh) of electricity at home or at school.

ii) How does this compare with the *total* costs per kWh of electricity in the table? You may have to find out how to convert between currencies.

iii) If you have a supplier of PV systems nearby, find out how much electricity from their technology costs. Compare this with the costs shown in the table. You may include this data in the "additional information" section of the exchange form if you wish.

Solar electricity - projects around the world

For over 150 years, people have been developing the technology that turns sunlight directly into electricity. We call this PV (photovoltaic) technology. Recent developments in PV technology could change our lives in the twenty-first century by supplying clean, quiet and renewable energy.

Until recently, most electricity for a grid has come from burning fossil fuels such as coal, oil and gas, or from nuclear power stations. Now we can use sustainable energy from the sun. Sustainable energy means energy that is produced without using up valuable resources and without harming the environment.

In the pages which follow, you will find examples of the use of PV technology from around the world. PV systems have been developed for many purposes, including:

- power for a satellite dish for telephone calls or TV pictures;
- power for a fridge to keep food or medicines fresh;
- power for oilfields or natural gas fields, even if they are in the middle of the sea;
- power to protect pipelines from corrosion;
- power to pump water from the ground;
- power for schools or homes in remote communities.

If there is a regional electricity grid nearby, then solar PV can generate power for the grid. This means that solar PV can be part of a large electricity network. These PV systems are called grid-connected systems. They do have one advantage. When it is light, the PV panels supply power to the grid. When it is dark, electricity can be taken from the grid, so that you are never without electricity.

In many parts of the world, there is no grid nearby to supply electricity. Solar PV can be used to supply electricity to remote areas. But there is a problem. The Sun does not shine at night, so we need to be able to store some of the energy. One way is to use rechargeable batteries that can release electrical power when the Sun is not shining. Another way is to combine solar PV with another form of energy generation. This might be windpower from a wind turbine or even a diesel generator.

Activity 6: Studying PV projects from around the world

Study the briefing sheets about six PV projects. Each tells you:

- where in the world the project is operating;
- why the project is important;
- what the system can do;
- technical and financial details of the system.

When you have read about the six projects, answer the questions on the next page.

Questions about PV projects from around the world

1 Read about the six PV projects from around the world. If you are not sure about where any of them are, locate them on a map.

Now look back to the solar energy map on page 1. Find the approximate location of each project on the map. Which of the six locations gets the most energy per square metre from the Sun in the course of a year? Approximately how much energy does this location receive per year?

2 Which of the six projects, which show how PV technology:

- can be used to bring power to a remote rural area?
- can play a part in a grid-based electricity supply system?
- can provide an electricity supply for specialist uses?

3 For the system used in the Indian school:
Explain how the system can supply energy even when the Sun is not shining.

4 For the system used by health centres in Zambia:
Explain how the system allows more people to be treated each day.

5 For the system in the Olympic village at Sydney:
Explain how this system will help to promote the use of PV technology around the world.

6 For the system used in the Spanish school:
Explain what happens to the electricity generated by the system when there are no pupils at the school (at weekends and in the holidays).

7 For the system used in the Australian oilfield:
Explain what makes a PV system especially suitable for use in this situation.

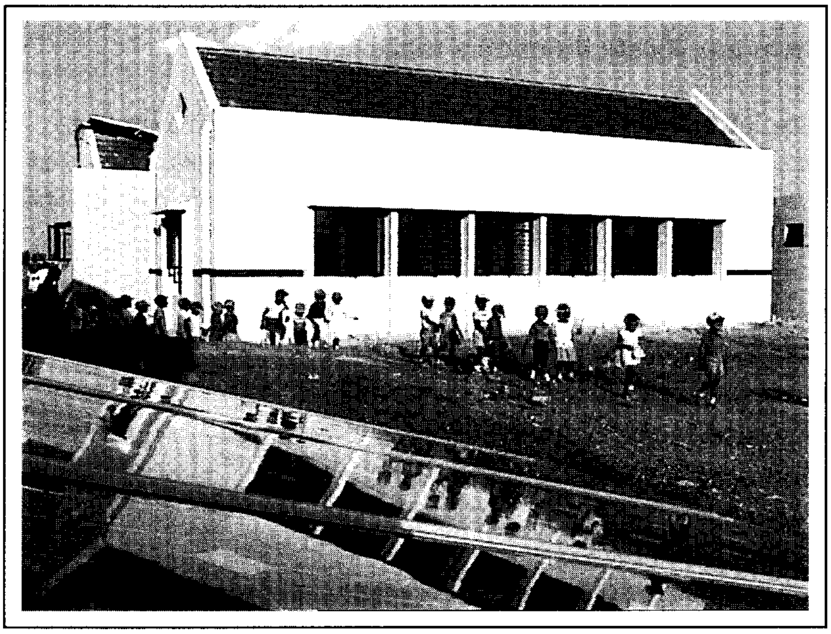
8 For the system used for communications in Vietnam:
Explain how it is helping the country's economic development.

9 More and more countries around the world are interested in conserving the world's resources whilst allowing people to have a better life. This is what we mean by **sustainable development**. Choose one of the six projects, and explain:

- how it shows that PV technology can help a country to develop its economy and improve the standard of living of its people;
- how the use of PV technology reduces damage to the environment, helping to make the development sustainable.

Which of the six projects *best* shows how PV technology can contribute to sustainable development?

Solar power for a school in the Indian countryside



Where in the world?

India - the Shanti Bhavan Boarding School, in the Damapuri district of Tamil Nadu.

Why is it important?

In remote parts of the countryside there may be no electricity grid to deliver power. This school helps underprivileged children aged from 4 to 10 years old. With solar electricity, the school can offer facilities that are equal to the best in the world. This helps the school improve its quality of education.

This school is a model for the future, where electricity is generated in a sustainable way. When they leave the school, students will understand how it is important to care for their environment.

What is the system like?

The solar electric PV system can provide power for lighting, water heating and educational equipment. It also drives water pumps, which maintain the school's water supply.

Technical and financial summary

The system uses 66 x 75watt BP solar PV modules. It stores energy using 12V batteries. The system can provide power for 3-5 days without sunlight.
Finance was provided jointly by the charitable George Foundation and Wipro Finance Ltd of Bangalore.

Refrigeration for medical vaccines and solar lighting in Zambia

Where in the world?

Zambia, Africa, where there are 200 health centres out in the countryside.

Why is it important?

In many parts of the world, people who live in the countryside do not have access to good medical services.

The 200 health centres in the Zambian countryside need a reliable electricity supply. The power keeps vaccines cool so that they stay fresh longer.

Once the Sun sets in rural health centres, the lack of light limits the work that can be done. The solar electric systems also supply power for lighting so that medical staff can continue their work after sunset.

What is the system like?

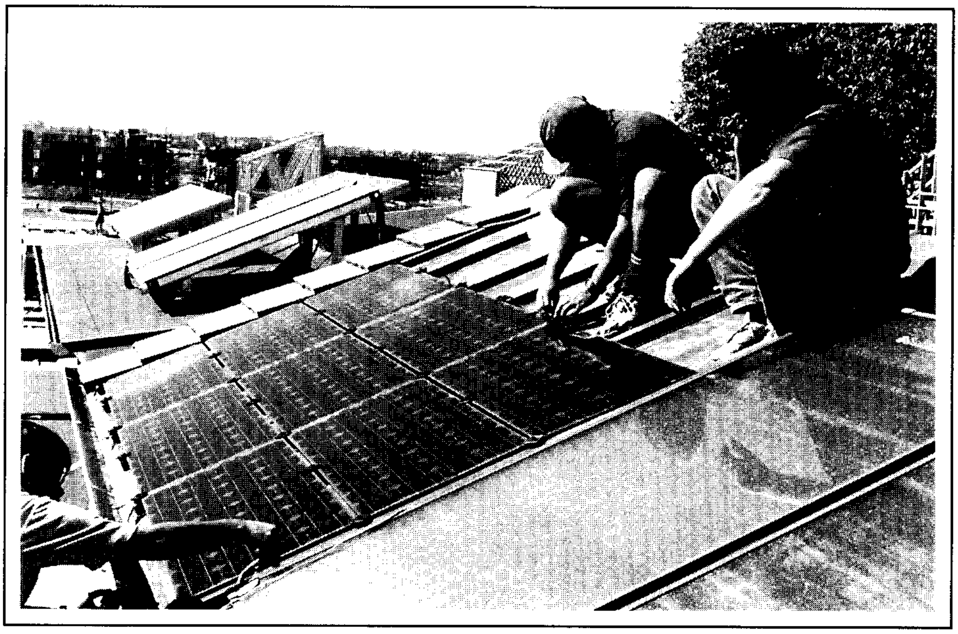
The solar electric PV system provides the electricity needed to run special vaccine refrigerators. These medical fridges were designed to meet the standards of the World Health Organisation (WHO). Batteries also allow electricity to be stored for lighting in the evenings.

Technical and financial summary

Each refrigeration system uses a 75 watt PV module and battery storage. Each lighting system uses a 50 watt module and battery storage to power 5 x 8 watt lights.

The finance for this important development in rural healthcare came from the European Development Fund. The total cost was £850 000.

Solar power for the Sydney Olympic Games



Where in the world?

Australia - the athletes' village for the Sydney 2000 Games.

Why is it important?

Athletes from all over the world will be in Sydney for the Olympic Games in September, 2000. Their village will generate its own solar electricity, a message they will take back to their home countries. The Olympic Village will become housing for ordinary citizens once the Games are over. These houses will continue to generate electricity for years to come. This is one of the largest housing developments in the world to use solar electric power.

What is the system like?

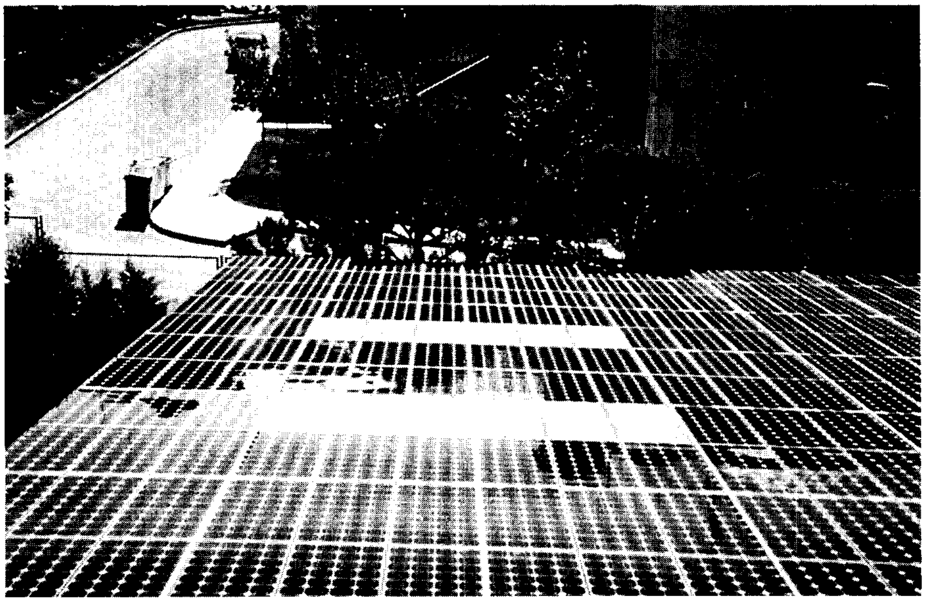
The homes were all designed using passive solar principles and have photovoltaic (PV) cells built into the roof. By using PV designs that turn sunlight efficiently into electricity, the village will demonstrate how effective renewable solar energy can be. There will be more than 500 solar electric power systems in the completed village.

Technical and financial summary

Each system uses 12 x 85 watt BP Solar Saturn panels, which give a maximum power output of 1 kW. The total energy generated by all the systems will average 1000 MWh (1000 000 kWh) per year.

Finance was provided by the Sustainable Energy Development Corporation. The total cost was £2 million.

Solar powered sport at a Spanish school



Where in the world?

Spain, at the Nueve Horizonte School in Madrid.

Why is it important?

Schools use large amounts of electricity and this project shows how renewable solar power can make a major contribution.

The experience gained at this Spanish school can be applied in schools all over the world.

Since children use the building, the system had to be especially safe and reliable.

What is the system like?

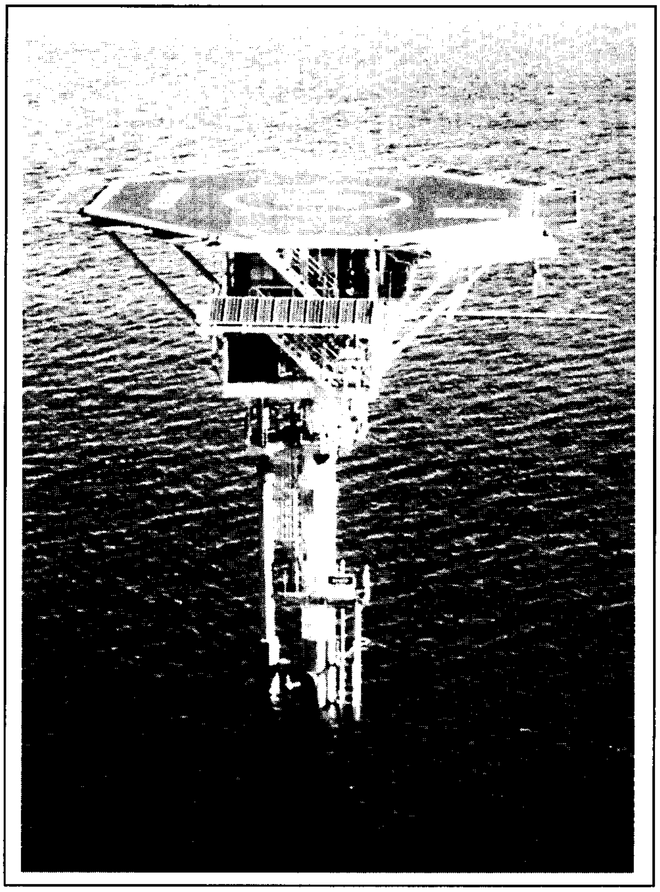
This is the largest school photovoltaic (PV) system in Spain. It is connected to the local electricity grid so that any spare electricity becomes available for others to use. The roof of the basketball pitch contains a mixture of high efficiency PV modules and clear glazing to let in the daylight. One of the benefits to the school is that its electricity bill is much less now that some electricity is generated on site.

Technical and financial summary

The system has 630 BP Solar Saturn PV panels, with a maximum power output of 54 kW. The average energy generated per year is 62 MWh (62 000 kWh) each year.

Finance was provided by the European Union, BP Solar and the Spanish government. The total cost was £620 000.

Power for offshore oil and gas fields in Australia



Where in the world?

Australia, on the North West Shelf oilfield.

Why is it important?

Every platform needs its own independent power supply to operate.

Once an offshore oilfield has been developed, some of the oil production can be controlled automatically. These are called un-manned offshore platforms.

Solar electricity is generated by photovoltaic (PV) cells and this is an ideal power source in Australian waters where sunlight is freely available.

To produce oil and gas safely it is essential that electricity is always available. Electricity is needed to operate the control systems and to monitor how the oilfield is working.

Production platforms on their own in the sea need good warning lights for passing ships.

What is the system like?

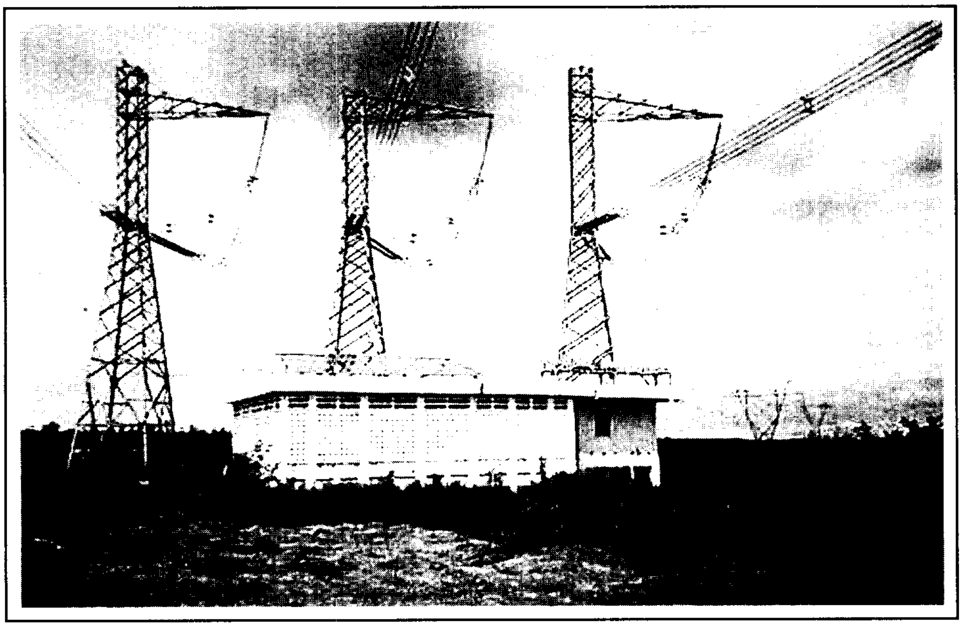
The offshore platform has four solar power systems. These produce the power needed to operate all the safety and monitoring devices onboard. The solar powered navigation lights are strong enough to be seen up to 10 nautical miles away. Solar electricity is stored in batteries for use at night when there is no sunlight.

Technical and financial summary

Each system uses 20 special BP Solar panels, designed for use at sea. Energy is stored in a 24V battery bank.

Finance for this project came from Western Australian Petroleum. The total cost was £200 000.

An optical fibre link for Vietnam's twin capital cities



Where in the world?

Vietnam, the twin capital cities of Ho Chi Minh and Hanoi.

Why is it important?

Vietnam is unusual in having two capital cities, one in the north and the other in the south of the country. The two capitals are 700km apart.

Every year more and more information is being exchanged between these cities. Eventually, engineers found that a new communication link was needed to carry the extra information.

Optical fibres can carry enormous amounts of information between places but they need a reliable power supply.

Much of Vietnam is rural and there is not always a suitable power supply nearby.

What is the system like?

Solar electricity generated from photovoltaic (PV) cells is used to power the communication link. In many places mains electricity could be used but it is at the wrong voltage for this system. Many expensive transformers would be needed to change to the correct voltage. By using a combination of PV solar electricity and batteries, the whole communication link can operate effectively. The batteries store electricity during the day and release it at night.

Technical and financial summary

Each system generates about 3000 kWh of energy per year. This comes from 44 x 75 watt BP Solar panels, which can produce 3.3 kW maximum power. Energy is stored in a bank of 48 batteries.

Finance was provided by the Vietnam National Post and Telecoms Company. The total cost was £500 000.

Photovoltaic systems – Teacher's Notes

Acknowledgements

This module is based on a unit on photovoltaic systems developed by Paul Rowley for Science Across the World, a project run by the Association for Science Education (UK). For more about Science Across the World, see their website (http://www.bp.com/saw/). The technical data on photovoltaic systems around the world (pages 7-12) were generously provided by BP.

Introduction

In this module, students are asked to:

- consider the uses of photovoltaic systems;
- find out about the worldwide availability of solar radiation;
- monitor the position and brightness of the Sun;
- study and interpret information about photovoltaic projects from around the world;
- calculate the cost of electricity supplied by photovoltaic systems.

Scientific & technological concepts

- electricity generation;
- electricity distribution grid;
- photovoltaic cells;
- solar radiation;
- kilowatt-hours;
- sustainable development.

Teaching approaches

Photovoltaic (PV) cells are finding increasing uses. As the technology develops, their cost decreases. At the same time, pressure for cuts in polluting methods of electricity generation has enhanced the desirability of PV systems. This module is intended to help students to understand the technology and its applications.

The module could be used when students are studying energy technologies. A group of students might study this module, while others were studying other technologies. Then each group could prepare a report on their findings, for presentation to the rest of the class.

Notes on the activities

Page 1: This page sets the scene, ensuring that students understand the meaning of the term photovoltaic, and are familiar with some uses of PV cells. If you have access to simple PV cells for demonstration purposes, show these now.

Page 2: Here we consider the availability of solar radiation around the world. The text also explains the units (kWh) used for measuring solar energy.

Page 3: Students are asked to monitor the Sun and its radiation. This could be an extended piece of work, in which students make measurements over several days or weeks. Alternatively, they could make observations on a single day, and discuss how their results would have been different on other days (because of weather changes, seasonal variation etc.).

For the sundial experiment, note that the longer the vertical stick used, the more sensitive the technique and the more accurately can the Sun's elevation be determined. If you do not have access to datalogging equipment, sketch a graph to show how the light level due to the Sun varies during the day, and ask pupils to sketch graphs to show how this would change through the year. If you have PV cells which can be connected to an ammeter, you could use this to monitor the changing light level.

Page 4, 5: These pages introduce some of the uses of PV systems, and provide questions relating to the case studies presented on pages 7-12.

Page 6: This page explains how to calculate the cost of electricity generated by PV systems, using one of the case study systems as an example. Pupils can calculate costs for two other case study systems.

Page 7 - 12: These pages present six case studies of the use of PV systems from a variety of situations around the world.

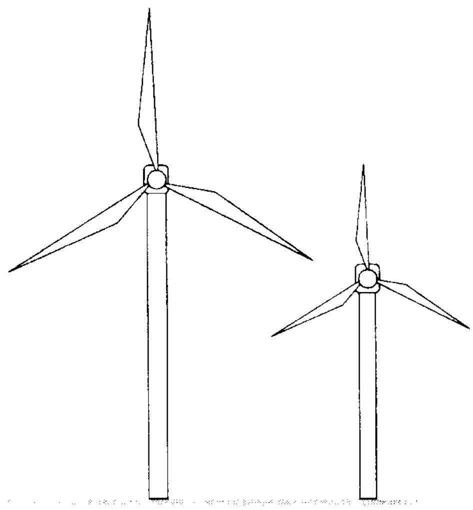
Answers to questions

1. Solar cells don't run down. However, the calculator can only be used in daylight, or under artificial lights.
2. Eg for roadside telephones, for garden fountains, for powering spacecraft etc.
3. (Students may need help with this.)
4. Photo = light (photograph, photosynthesis, photon, etc.) Volt = electricity (volt, voltage, voltmeter etc.)
5. Central Australia.
6. Bigger collector in northern Russia, to collect the same amount of energy.
7. Rays oblique nearer poles; clouds and dust in atmosphere absorb energy.

Answers to questions about PV projects from around the world

1. Look at values on map.
2. Rural power: India, Zambia; grid-based: Sydney, Spain; specialist: Australian oilfield, Vietnam.
3. Battery storage.
4. Working after dark; medication stored for longer, so more readily available.
5. Good publicity.
6. Diverted to grid.
7. Robust and reliable, so can work unattended.
8. Improved communications help business.
9. (Students need to show both development and sustainability.)

Using wind power



Longley Farm is in the north of England. It stands on a windy site, high in the Pennine Hills. It was inherited in 1948 by two brothers, Joseph and Edgar Dickinson; at that time, it had a herd of just ten cows. Today it is one of the largest independent dairies in Britain and an internationally renowned business using 'state of the art' equipment, some designed by the brothers themselves. It has a worldwide market, sending cream to Japan, Saudi Arabia and Egypt, and cottage cheese to France.

The Dickinson brothers are firmly committed to conservation and they have applied this to the business. In 1986, they installed their first wind turbine. This generates electricity to run the refrigerated storage units for cream and yoghurt. This turbine supplies 10% of the electricity needs at the dairy.

Activity 1: Calculating the cost

The Dickinson brothers felt that it was better for the environment to use wind power, rather than electricity generated by burning fossil fuels. But did it also make economic sense? Did they save money by using wind power? Here are some pieces of technical information which will help you decide.

- The capital cost of building the turbine and putting in the cable in 1986 was £50 000.
- This capital cost was spread over five years.
- Maintenance costs are about £200 per year.
- In an average year, the turbine supplies 240 000 units of electricity (1 unit = 1 kilowatt-hour).

1 Use this information to calculate the total cost of the setting up and running the turbine for 5 years.

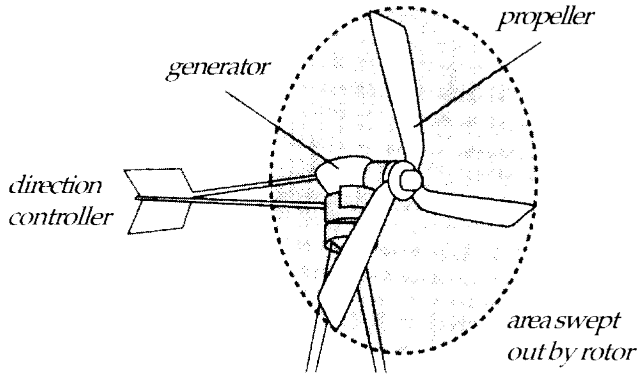
2 Calculate the amount of electricity supplied by the turbine in 5 years.

3 Calculate the cost of each unit of electricity.

4 Compare your answer with the cost of buying electricity from the local electricity supply company, £0.054 per unit (at 1986 prices). Is the turbine good value for money?

5 In fact, the projected working life of the turbine is 13 years. Calculate the average cost of each unit of electricity supplied by the turbine over this period.

Generating electricity

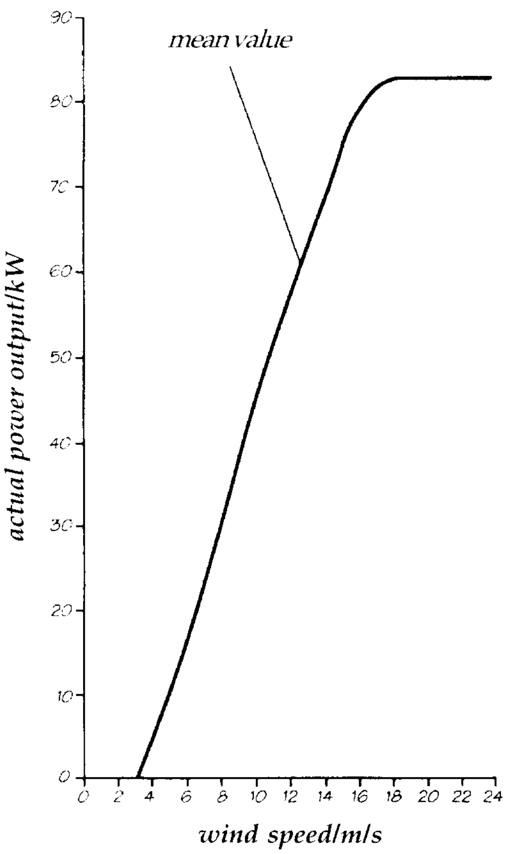


A wind turbine collects energy from moving air. The wind spins the rotor blades round, and this turns the generator. Cables carry the electricity produced by the generator down to the ground. The turbine at Longley Farm has an on-board computer which senses the wind speed and direction. It turns the turbine as the wind direction changes. High winds could damage the turbine, so when the wind speed is more than 23 m/s it rotates the turbine until it is at 90° to the wind direction and applies the brakes. This avoids damage to the turbine. Wind speeds below 3 m/s are too slow to turn the turbine. There are about 43 days in the year when the turbine cannot be operated. This is because there is not enough wind, or it is too windy.

Average monthly wind speeds (in m/s) at Longley Farm

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8.96	11.75	9.08	5.48	3.98	4.80	6.89	7.55	8.25	7.16	6.02	11.45

Activity 2: Interpreting data



Study the data shown in the table and the graph, and answer these questions:

6 Plot a graph to show how the average wind speed varies month-by-month through the year. Are there any months when it looks as though the turbine could not be used on some days during the month?

7 The average output of the turbine is about 25 kW. What is the average wind speed at Longley Farm?

8 The graph was provided by the company who supplied the turbine. They gave the power output of the turbine as 75 kW. What wind speed would give this output?

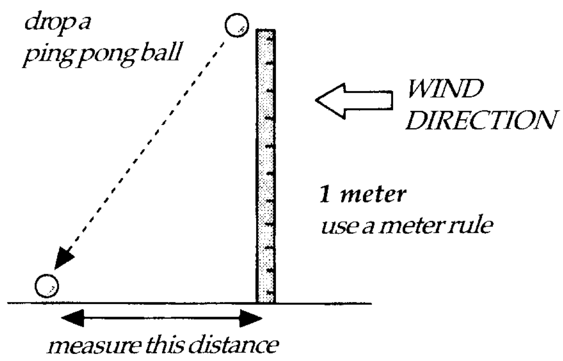
9 Suggest why the average power output of the turbine at Longley Farm is much less than that suggested by the company who supplied it.

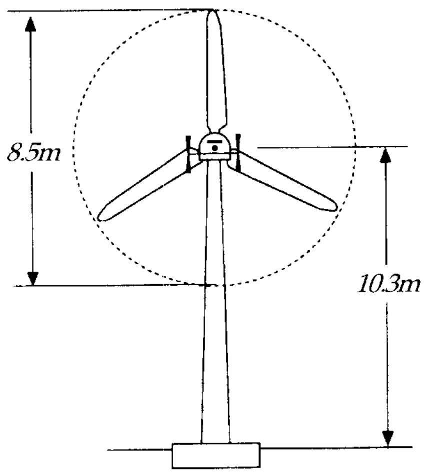
How much wind energy?

Wind turbines need to be sited in windy places. The greater the wind speed, the more energy it has. In fact, twice the wind speed means eight times as much energy. That's because fast-moving air has more kinetic energy, and more air passes every second. When deciding where to site a wind turbine, you need to know what the typical wind speed will be. Your local Meteorological Office will be able to provide records for your area.

Activity 3: Measuring wind speed

You can measure wind speed using an anemometer. Alternatively, use the simple method shown in the diagram. Measure the distance (in m) from the foot of the rule to the point where the ball lands. To calculate the wind speed (in m/s), multiply this distance by 9.





The amount of energy which a turbine can collect from the wind depends on the wind speed. It also depends on the length of the turbine blades. Long blades sweep out a larger area, and collect more energy. Available power $P = A \times d \times v^3$ where A = area swept out by blades, d = density of air, v = wind speed.

Activity 4: Calculating power

10 The turbine at Longley Farm has blades 8.5 m long. Calculate the area *A* they sweep out.

11 Calculate the power available for a wind speed *v* of 15 m/s. (The density of air $d = 1.2\ kg/m^3$.) A wind turbine cannot extract all of the energy available in the wind. An efficient turbine may extract about 40% of the energy. From the graph on page 2 you can see that the Longley Farm turbine provides 75 kW (75 000 W) of power when the wind speed is 15 m/s.

12 What fraction of the energy available in the wind is this? (This tells you the efficiency of the turbine.)

Siting a wind turbine

Activity 5: Decision making

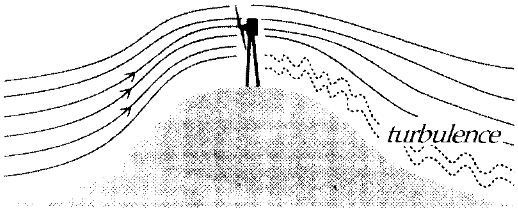
When deciding where to site a wind turbine, you need to think about two things:

- Where would be a good place to catch a lot of energy from the wind?
- What will be the environmental impact of the wind turbine?

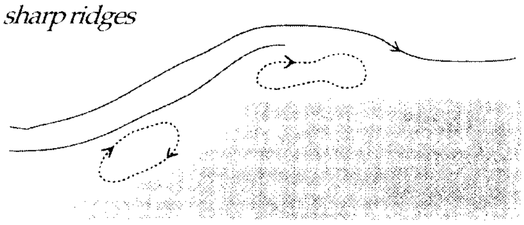
The diagrams on this page and the next page will help you to understand how to choose a good site. Look at each of the diagrams and discuss with a partner what they tell you about siting a wind turbine.

Using all of these ideas, decide where you might position a wind turbine in your own locality. If you think this would be completely impossible, explain why.

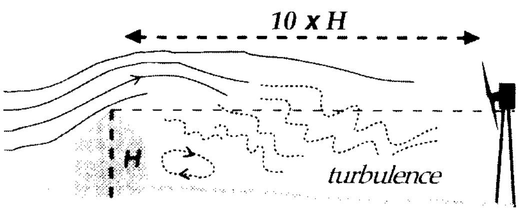
GOOD SITES
speed up effect over smooth hills

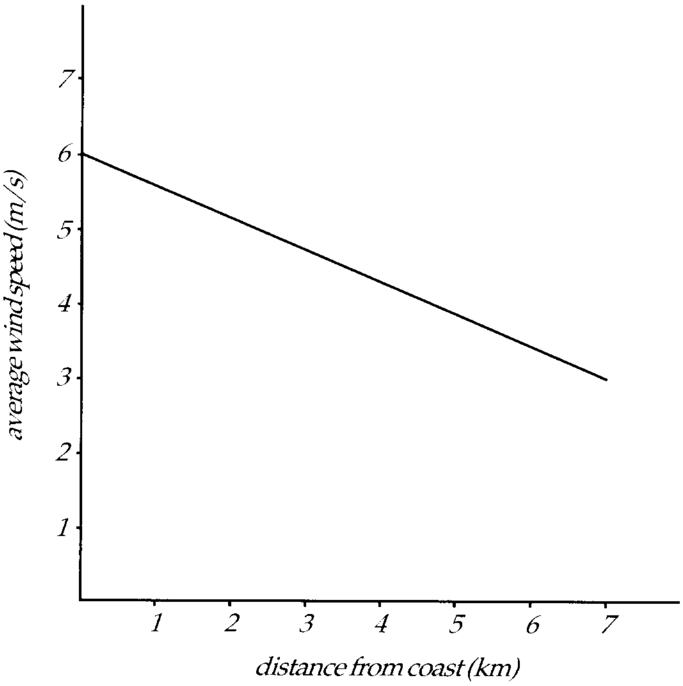


BAD SITES
turbulence at top and bottom of cliffs or sharp ridges



OBSTACLES
keep clear of obstacles by at least **10 times height of obstruction** *or use a tall tower*



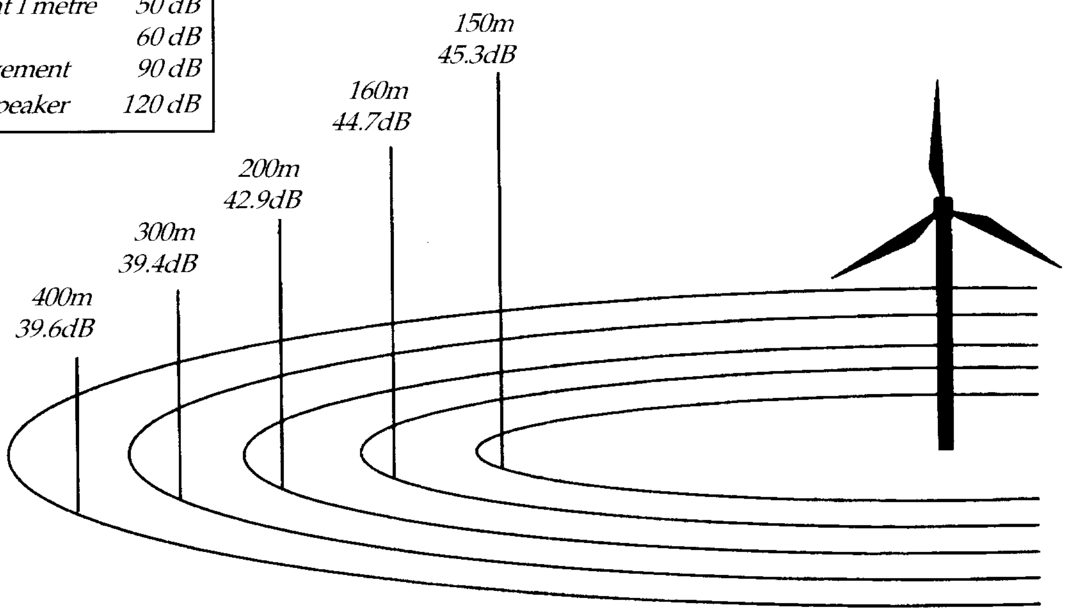


Environmental impact of wind turbines

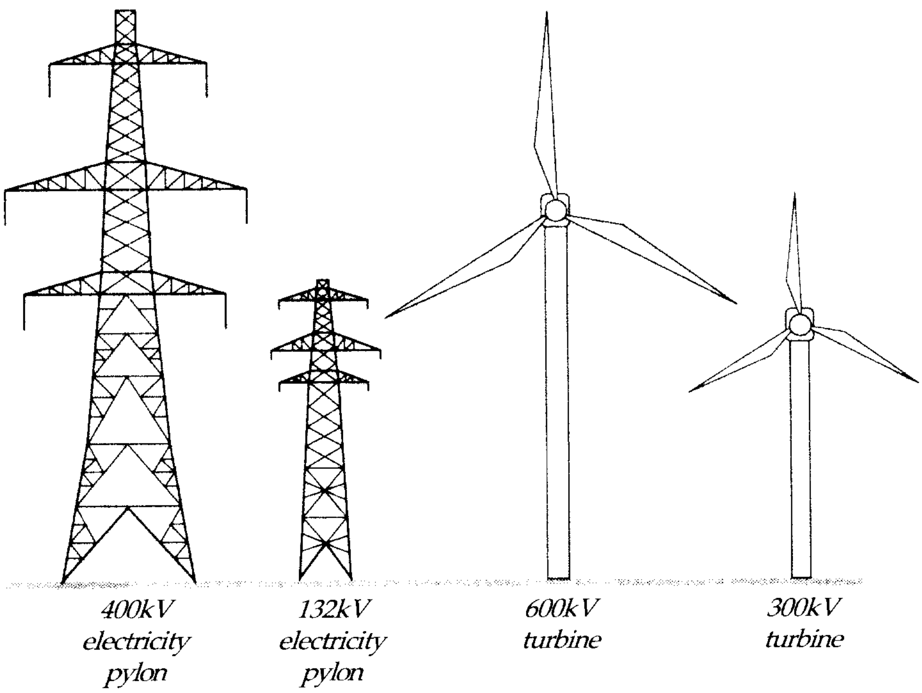
Noise levels

When running at full speed, a typical 300 kW turbine could produce about 40 dB at 100m; a car travelling at 60 kph produces the same noise level at this distance. For a wind farm of thirty 300 kW turbines, a noise level of 45 dB at a distance of 500m from the nearest machine would be typical.

threshold of hearing	*0 dB*
whisper	*20 dB*
normal conversation at 1 metre	*50 dB*
busy classroom	*60 dB*
heavy truck - from pavement	*90 dB*
disco - 1 m from loudspeaker	*120 dB*



Visual impact



Using wind power – Teacher's Notes

Acknowledgements

This module is based on Making use of Renewable Energy, a publication of the Science with Technology project run jointly by the Association for Science Education and the Design and Technology Association (UK). Assistance in developing Making use of Renewable Energy was provided by Longley Farm, West Yorkshire, UK.

Introduction

In this module, students are asked to:

- find out about wind turbines and where they are best sited;
- make power estimates and calculations;
- make cost effectiveness calculations;
- make measurements of wind speeds;
- suggest a suitable site for a wind turbine;
- evaluate the environmental impact of a proposed wind turbine.

Scientific & technological concepts

- renewable energy;
- wind energy;
- power;
- kinetic energy;
- energy efficiency;
- environmental impact;
- noise levels and decibels.

Teaching approaches

Wind power is a renewable resource, and is readily available in many parts of the world. Traditionally, it has been used for operating mills and pumps; today, it is finding new aplications in electricity generation.

This module could be used as part of a study of renewable energy resources. It provides opportunities for students to consider the appropriateness of wind power in their local situation.

Notes on the activities

Page 1: This page introduces a specific application of wind power, on an English farm. The farmers' motivation was both environmental and economic, and this page asks students to consider the economics of the installation. (You may wish to convert the costs quoted to a more familiar currency.)

Page 2: Here students learn how a wind turbine is controlled, and about the variability of its output.

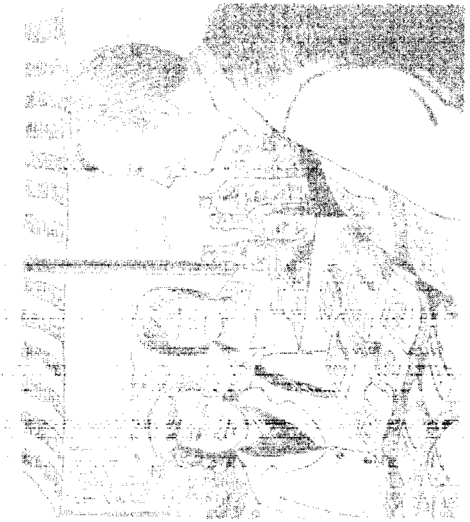
Page 3: Students can measure the wind speed; you might provide information about the average wind speed in your own locality. This can be obtained from the local Meteorological Office, whom students might contact. There is also some technical information about how to calculate the power available in wind. A turbine cannot extract all of the kinetic energy of the wind, since this would leave the air stationary. Efficiencies are typically 30-40%.

Page 4,5: Here, students are asked to identify a suitable site for a wind turbine in their own locality. They should use the ideas about suitable sites on page 4, and about environmental impact on page 5. It may be that no suitable site can be identified; students should be able to say why none is possible. If wind turbines already exist in the neighbourhood, students could examine their sites in terms of the criteria identified on these two pages.

Answers to questions

1 £51 000.
2 1.2 million units.
3 £0.0425 (= 4.25 pence).
4 The turbine is good value, provided it keeps running.
5 £0.0169 (= 1.69 pence) - very good value.
6 The months with lowest wind speeds are April, May and June.
7 From the graph: about 7 m/s.
8 From the graph: about 15 m/s.
9 The turbine was designed to work in higher wind speeds.
10 Area A = 227 m^2.
11 920 kW.
12 8%.

Nutrition



Alcohol in your body

All over the world, people drink alcoholic drinks. They drink them to have a good time, to celebrate, to forget their worries and their cares. Alcohol is a drug, and so its use is usually controlled. Children may not be allowed to buy alcohol, or to drink it. In some countries, alcoholic drinks are banned all together. Governments put tax on alcohol to make it more expensive and so reduce consumption.

The effects of alcohol

When you drink an alcoholic drink, the alcohol gets into your blood stream. The table shows the effect of different concentrations of alcohol. (The concentration is shown as the number of milligrams of alcohol in every 100 millilitres of blood.)

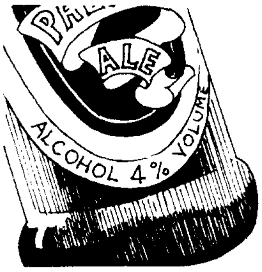
concentration of alcohol (mg/100 ml)	approximate effect
20	sense of relaxation and well-being
40	less inhibited, talkative, increased sense of well-being, greater likelihood of accidents
60	ability to make decisions impaired
80	physical co-ordination diminishes
100	deterioration in physical and social control; obviously drunk
140	staggering, double vision, vomiting
400 - 500	death

Activity 1: Questions for discussion

- At what age are you allowed to drink alcohol in your country?
- At what age can you buy alcoholic drinks?
- Should parents impose stricter rules on their children, as far as drinking alcohol is concerned? Should parents introduce their children to alcohol gradually?
- Do you know of any other countries or societies where the rules are stricter, or more lax?

How much alcohol?

The container of an alcoholic drink is usually labelled to show how much alcohol there is in it. Beer is much weaker than whisky: beer might contain only 4% alcohol, but whisky might contain 40%. The table shows some typical values, as well as the volume of alcohol in a standard drink. These are the standard sizes of drink served in Scotland and Ireland.



beverage	volume of standard drink	concentration of alcohol	volume of alcohol in standard drink
beer	1 pint (= 550 ml)	4%	22 ml
wine	1 glass (= 125 ml)	12%	15 ml
sherry	1 glass (= 125 ml)	20%	25 ml
whisky	1 single (= 35 ml)	40%	14 ml

The volume of alcohol in a pint of beer is worked out like this:

Volume of alcohol = volume of standard drink x concentration of alcohol
= 550 ml x 4 ÷ 100 = 22 ml

Some olde units

In most parts of Europe, the volume of a drink is given in millilitres (ml), but the table shows some older measurements, such as the pint, that are still used today.

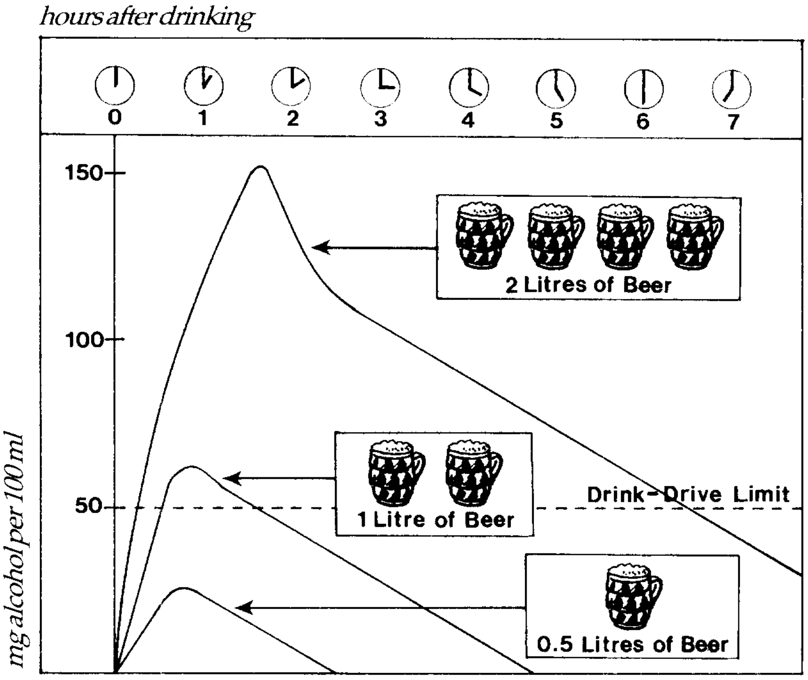
An old-fashioned way of describing the strength of an alcoholic drink was known as 'proof'. A 70% proof spirit such as whisky contains 40% alcohol. In Scotland, some beers are labelled as '40 shilling ale' (40/- ale). This was the amount of tax paid on a barrel of the beer; the stronger the beer, the more the tax.

Activity 2: How much alcohol? – Some calculations

1. If one pint of beer contains 22 ml of alcohol, how much alcohol is there in a half pint?
2. A can of Scottish beer is labelled '80/- Scotch ale', volume of 440 ml, alcohol 6% by volume. How much alcohol does it contain?
3. In France, it is recommended that you should not drive after consuming more than about 30 ml of alcohol. How many glasses of wine contain this much alcohol?

Burning up alcohol

Alcohol is absorbed into the bloodstream from the stomach. Eventually it is broken down in the liver. Scientists have measured how long the alcohol stays in someone's blood, after they have been drinking. The graph shows their results.



Activity 3: Data analysis

Look at the graph:

- Which line is for the person who has consumed most beer?
- The alcohol in a drink doesn't take full effect until some time after it has been drunk. How can you tell this from the graph?
- The liver breaks down alcohol at a steady rate. How can you tell this from the graph?
- What is the drink-driving limit, in mg of alcohol per 100 ml of blood, as shown on the graph?
- If you drink two litres of beer, how long should you wait before you are likely to be below the drink-driving limit?

Activity 4: Devising a publicity campaign

- In some countries, the drink-driving limit is 50 mg/100 ml; in others it is 80. What is it where you live?
- Do you think people stick to the limit? Are younger drivers more or less careful than older ones?
- Look back to the table on page 1. What do you think would be a safe limit?
- How much beer could someone drink and still drive safely?
- How could you use the graph on this page to help people understand the dangers of driving under the influence of alcohol?
- Devise a poster, a talk or a TV commercial to show your ideas in a convincing way.

Enzymes at work

The chemical name for the alcohol in alcoholic drinks is ethanol. It is a compound of carbon, hydrogen and oxygen; its chemical formula is C_2H_5OH. In the liver, ethanol is oxidised – it combines with oxygen, like burning. In the end, it becomes ethanoic acid, the same acid that is found in vinegar.

$$C_2H_5OH + O_2 \longrightarrow CH_3COOH$$

ethanol + oxygen ⟶ ethanoic acid + water

To make the oxidation happen, an enzyme called LAD has to be present. LAD is 'liver alcohol dehydrogenase', and it is found in the liver. People who drink too much may damage their liver; then they don't have enough LAD to burn up the alcohol quickly, so it stays around in their blood stream for much longer.

A genetic effect

In the Far East, people tend to avoid alcohol. If they do drink some, their faces go bright red and they feel very ill. This is because they do not have the LAD in their liver which is needed to burn up the alcohol. The alcohol is simply turned into ethanal, which is a poisonous substance that makes you feel very ill.

ethanol/ethanal

To make LAD, liver cells must contain a gene to make the enzyme. It's not just most Far Eastern people who don't have this gene. A few European people don't have it, as well as many people in eastern countries including India and China. Geneticists don't understand why this gene is missing, but perhaps it helps to explain why drinking alcohol is frowned on in so many of these countries.

A cure for alcoholism

Some people become addicted to alcohol. This addiction is known as alcoholism. Some alcoholics are helped by taking a drug called antabuse. Originally, antabuse was designed as a drug to kill parasitic worms which sometimes get into people's guts. Then it was noticed that, if the patient had been drinking alcohol, the antabuse made them feel very sick. Antabuse stops LAD doing its work so the patient's body fills up with ethanal. This makes them feel so ill that they soon learn to avoid drinking alcohol.

Activity 5: Discussion

- Young people tend to drink different alcoholic drinks than those chosen by older people.
- What alcoholic drinks are advertised to young people in magazines and in cinemas? What techniques are used to sell these drinks?
- Do you know of any alcoholic drinks which are specifically designed to appeal to young people? Is it fair to try to sell these drinks to young people, given the dangers of alcohol?

Alcohol in your body – Teacher's Notes

Acknowledgement

This module is based on ideas and information from *Organic Chemicals in Everyday Life*, published by the Irish Science Teachers' Association.

Introduction

In this module, students are asked to:

- consider the social context of alcohol consumption;
- calculate the alcohol content of a variety of drinks;
- analyse data relating to the metabolism of alcohol in the body;
- apply their knowledge to devise publicity in favour of responsible alcohol use.

Scientific & technological concepts

- concentration of substances;
- metabolism;
- oxidation;
- enzymes;
- genetic characteristics.

Teaching approaches

The consumption of alcohol is a sensitive topic. Some students may already be users of alcohol; others may come from backgrounds where alcohol is not used; some may have cases of abuse in their families. Some caution will be needed in opening up this topic.

The module shows how some basic ideas from chemistry can be applied in a Health Education topic. You might start by having a brief discussion of the effects of alcohol on the body, as shown in the table on page 1. It is likely that students will take the opportunity to tell of their own experiences (first or second-hand). This can cause amusement; however, it is advisable to let this run its course before making the point that alcohol use and abuse is a serious topic. All societies where adults use alcohol as a social drug have rules about alcohol consumption, and ways of inducting children into sensible use. This is the focus of the discussion on page 1. Thereafter, the unit deals with various aspects in a fairly straightforward way.

Notes on the activities, answers to questions

Page 1: As mentioned above, this page introduces the idea of alcohol as a social drug in many societies. The discussion questions deal with some factual points; the answers to these will depend on the country where you live. Students may well know of the situations in other countries, and this is an opportunity to consider whether the rules in your own country might be changed. You might wish to point out that the descriptions of the effects of alcohol on the body are only approximate. Different people react differently; this is discussed further on page 4. Everyone needs to discover their own level of alcohol tolerance.

Page 2: This page shows students how to calculate the quantity of alcohol in a standard drink. It also takes the opportunity to point out some unusual units in which the strength and volume of drinks may be measured; you may be able to provide other examples of such units. Students could discuss the merits or otherwise of 'rationalising' weights and measures.

1 11 ml of alcohol
2 26.4 ml of alcohol
3 2 glasses of wine

Page 3: The graph on this page shows the results of an experiment in which people were given various amounts of beer to drink; their blood was sampled at intervals. Students could be asked how they thought this graphical information was obtained. Then they could devise a protocol for this experiment.

1 The top line.
2 The graph takes a while to reach its peak.
3 The graph slopes down in a straight line.
4 50 mg/100ml
5 Approximately 6 hours.

All three lines slope downwards with the same gradient. It is interesting to note the reason for this. The liver has to oxidise the alcohol using the enzyme LAD (see page 4). At these concentrations of alcohol, the liver is working at top speed; all the available LAD reaction sites are in use. It is comparable to a petrol station with a long queue of customers. All the pumps are working continuously, and the queue decreases at a fixed, maximum rate.

In the activity to devise a publicity campaign, students should bring together all of the ideas which they have looked at so far in this unit. This could simply be a homework project, or you could allow more time for students to gather additional information. You will need to decide how much time to allow for this, whether they should work as groups, and so on. For students who are going on to look at page 4, you could delay this activity until the unit is completed.

Page 4: This page considers aspects of the metabolism of ethanol. You may need to explain that an enzyme is a biological catalyst. Students could be asked to write balanced equations for the two reactions shown at the top of the page. Only one major problem associated with alcohol consumption is mentioned: that of poisoning by ethanal (acetaldehyde), arising from LAD defficiency. This may have a genetic basis, or it may result from a damaged liver caused by alcohol abuse. Liver damage also results in defective protein production in the body, and many other problems. Alcohol affects the brain in a variety of ways, too: it causes dehydration (by osmosis), and can flush out vitamins, particularly vitamin B.

The final discussion provides an opportunity to consider the commercial pressures to which young people are exposed, to encourage them to drink alcohol.

Testing the quality of food

When we buy food from a shop or market stall, we expect it to be of good quality. From time to time, food suppliers may adulterate the food – they may cheat us by adding some cheaper substance to the food. For example, they may dilute milk with water, or add mud to mustard seeds. They may mix grit with rice, or mix inferior oil with cooking oil. They may even dye vegetables.

Sometimes people die when they consume an adulterated food. Hundreds of people died in Spain after cooking with adulterated cooking oil, and many others went blind.

Activity 1: Interpreting a newspaper report

Look at the newspaper report on Page 2. It was published in newspapers in Kathmandu, Nepal, in October 1998.

1 Read the first paragraph.

- Make a list of all the foodstuffs mentioned in this paragraph.
- Make a second list of all the substances used to adulterate foodstuffs.

2 Read the second paragraph. When milk is pasteurised, it is heated for a short time to kill bacteria and any other micro-organisms, some of which might make you ill.

- What disease can be caused by drinking unpasteurised milk?
- Fortunately, few Nepalese people get this disease. Why not?

3 Read the third paragraph. Ghee is clarified butter, used like oil for frying.

- Researchers say that vanaspati (vegetable) ghee should be tested. Is there a test at present?
- What organisation do the researchers work for?

4 Read the fourth paragraph.

- Why do people prefer to buy brightly coloured noodles?
- How can you avoid eating adulterated noodles?

5 Read the last paragraph. The CFIC prosecutes people who sell adulterated food. They find the process is very slow.

- Why is the process of prosecuting offenders slow?
- Why is it important to prosecute offenders as quickly as possible?

PRESS RELEASE Kathmandu, October 1998

Food Products Widely Adulterated!

Do you go by bright colours while choosing vegetables and sweets? If yes, think twice. Researchers at the Central Food Investigation Centre (CFIC) warn that attractive sweets, vegetables and other food products may cost you your health. Reason: Farmers spray pesticides to save vegetables from decaying and use colours to make food products look bright. According to researchers at CFIC, powdered brick is mixed in chilli powder, sawdust in cumin and coriander powders and other hazardous powders in turmeric.

Milk samples tested in the capital are found to be highly adulterated and of low quality. Especially milk is found to be heavily thinned with water and powdered milk added liberally to thicken it. A CFIC spokesman says that the 'pasteurised milk' available in the market is often not pasteurised. If Nepali people did not have the practice of boiling their milk, gastroenteritis would have reached epidemic proportions. Many dairies are in court for selling low quality milk. In CFIC sample tests of food products, milk is usually the second most commonly adulterated item.

Vanaspati ghee is also found to be heavily adulterated in the country. Researchers believe there is a need to test vanaspati ghee in the same way that edible oil is being tested at present. It is expected that a standard for vanaspati ghee will be introduced soon.

Likewise, local noodles may be adulterated with inedible products: the kind of metallic yellow used can even activate cancer. One should eat only plain, colourless noodles.

The Food Act is mostly only applied in the capital, although it could be implemented in 36 districts, including the Terai, where adulteration is a serious problem. CFIC has to go to the District Administrative Office to file a case if a food product is found to be defective and this slows down the process of prosecuting offenders.

Looking for impurities in food materials

Activity 2: Testing foods

Food inspectors use many different tests to check the quality of foods. Try out some of the tests given below, to check for adulteration.

Safety warning: Under no circumstances should you taste or eat any of the food samples provided.

1 Testing the quality of ghee

Ghee is clarified butter, made from milk and used for frying. You can also buy vegetable ghee, which is cheaper. Manufacturers sometimes sell ghee which is adulterated with vegetable ghee.

a Melt one teaspoonful of ghee in a test tube.

b Add an equal amount of concentrated hydrochloric acid and a pinch of common salt.

c Shake well for one minute and allow to stand for one minute.

d A crimson colour appearing in the lower layer shows that vegetable ghee is present.

2 Testing the purity of milk

Milk may be adulterated by adding water. This makes it more runny, and less dense.

a Put a drop of milk on a glass slide and hold the slide vertically. Pure milk stays on, flows very slowly, leaving behind a white trail.

b Use a lactometer or hydrometer to measure the specific gravity of the milk sample. When the lactometer or hydrometer is floating in pure milk, it will give a reading of at least 1.026. In diluted milk, the instrument sinks lower.

3 Testing adulterated spice powder

One of the samples of powdered spice has been adulterated; sand has been added to it.

a Think of a way of separating the sand from the spice.

b Test your method to see if you can identify the adulterated sample.

4 Testing other foods

You may like to suggest good ideas for checking other foods, or for purifying them. Discuss your ideas with your teacher and try them out.

Looking for impurities in food materials

It is important that food supplies are regularly checked. If not, the quality of food may decline. This may be because the food producers, distributors or sellers set out to cheat the customers, or it may be because they become careless about the quality of their goods.

Food inspectors have the task of collecting samples of food and testing them. They may work for the local authority or for the national government. Their work protects us all from being harmed by our food.

Activity 3: Researching

Find out about the work of food inspectors. You could write to the food inspection service, or invite an inspector for interview, or look in careers literature. Here are some things you could find out:

- Where do they work? Who employs them?
- What training do they undergo? What qualifications do they have?
- How do they collect samples of food? How do they test them?
- Do they prosecute offending producers and suppliers? What are the commonest offences?

Activity 4: Writing a play

Help people to understand the importance of the work of food inspectors by writing and performing a play. Here are some characters you might include:

- a farmer who supplies the food
- a shopkeeper or stallholder who sells it
- a customer who eats the food
- another customer who is suspicious of the food
- a food inspector who tests the food
- another inspector who sets out to find out who has committed an offence

It's up to you to decide the outcome of the play!

Testing the quality of food – Teacher's Notes

Acknowledgement

This module is based on a module developed for UNESCO at a workshop in Nepal, and edited by Dr Sharada D Maharjan and Prof Patrick A Whittle.

Introduction

In this module, students are asked to:

- interpret information about food adulteration;
- carry out simple tests on samples of adulterated foods;
- find out about the work of food inspectors;
- explain the importance of the work of food inspectors.

Scientific & technological concepts

- food quality;
- food testing;
- sampling;
- separating mixtures.

Teaching approaches

This module encourages students to think about food quality, why it may be poor, and how it may be checked. Although the module was developed for use in schools in Nepal, the same issues arise in every culture. For most people, the state provides some protection via a food inspection service.

The module starts by presenting the problem of food adulteration. Students can then carry out some simple tests on samples of adulterated foods. Then they are asked to find out about the food inspection service. Finally they can present what they have learned through a short piece of drama. (Alternatives to this are suggested below.)

Notes on the activities

Pages 1, 2: Here, the idea of food adulteration is introduced. (This is probably the most readily-appreciated way in which food quality may be reduced.) The text on page 2 is from a press release issued in Kathmandu. The questions in Activity 1 will help students to understand the ideas presented in the text.

Some of the foods mentioned in the test may be unfamiliar to students. You might like to supply some samples for them to look at and smell.

Page 3: Students can now try out some simple tests on samples of adulterated foodstuffs. It's up to you, the teacher, to adulterate them! Details of the materials needed for each test are given overleaf.

Page 4: In Activity 3, students are asked to find out about the work of the food inspection service in their area. One way to tackle this would be to invite an inspector in to the class. He or she could give a talk and answer questions, but students might be more actively involved if they were to interview the inspector using an interview schedule drawn up in advance. They could then draw on the ideas generated in Activities 1 and 2.

Finally, students are asked to write and present a short play, illustrating the problems of food adulteration and the importance of the work of food inspectors.

An alternative would be to ask students to write a story or draw a strip cartoon with the same theme.

Testing foods – Activity 2

Safety: Students should be warned that under no circumstances should they taste any of the foodstuffs or other materials used in these tests.

1 Testing the quality of ghee

Both ghee (clarified butter) and vegetable ghee are available internationally. Look for tins in shops that sell Indian produce.

- Sample A: Pure ghee
- Sample B: Ghee and vegetable ghee, mixed in equal proportions
- Concentrated hydrochloric acid
- Common salt (sodium chloride)
- Test tube
- Spatula

2 Testing the purity of milk

- Sample C: Full-cream milk and water, mixed in equal proportions
- Sample D: Full-cream milk
- Glass slide e.g. microscope slide
- Lactometer or hydrometer

3 Testing adulterated spice powder

You may need to experiment here to devise your own adulterated spice. Choose a spice such as cumin or coriander with the same colour as the sand you intend to adulterate it with. Grind the spice until it has the same coarseness as the sand. Mix them together.

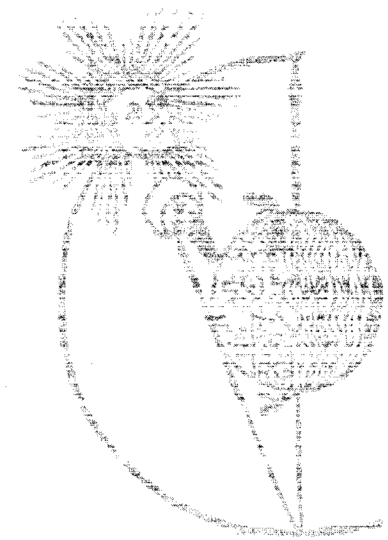
- Sample E: Unadulterated spice powder
- Sample F: Spice powder mixed with sand

An obvious way to separate the mixture would be to mix it with water in a test tube. The sand will sink more rapidly than the spice, which may float.

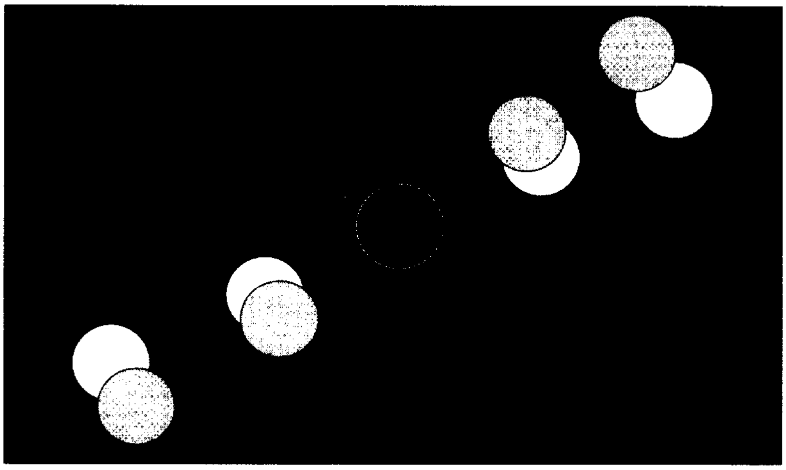
4 Testing other foods

You may like to devise some other food mixtures which students could test.

Astronomy



Understanding eclipses of the Sun



A total eclipse of the Sun is a very dramatic event. The Moon passes in front of the Sun, blocking out its light. The daylight fades and the sky overhead is dark. The temperature drops by several degrees and the wind gets up. Birds fall silent, or fly off to roost. Looking towards where you last saw the Sun, you see a black disc surrounded by a glowing, silvery cloud – the Sun's corona. After just a few minutes, the Moon starts to move clear of the Sun again. The corona disappears, and the Sun appears as a bright crescent in the sky. Daylight begins to return. Within an hour or so, things are back to normal. There is no evidence left of the spectacular astronomical event that you have just witnessed.

Today, scientists have a clear understanding of why eclipses occur. The Moon's orbit periodically takes it into a position where it blocks off the Sun, as viewed from a small strip of the Earth's surface. By coincidence, the Moon almost exactly covers the Sun's disc. This is because the Sun is about 400 times as big as the Moon, but it is also 400 times as far away, so they look the same size. Similarly, the Moon may pass into the shadow of the Earth; this is when we see an eclipse of the Moon. This module is about some of the things which people have thought about eclipses at different times in history.

Activity 1: Making a model

It is difficult to get a clear idea of the sizes of the Sun, Moon and Earth, and how far apart they are in space. The table shows these distances; it also shows the distances you could use for a scale model of these quantities. Make a model, and line up the three objects so that the Moon blocks off the Sun, as seen during an eclipse of the Sun.

diameter of Earth	13 000 km	1.30 cm
diameter of Moon	3500 km	0.35 cm
diameter of Sun	1 400 000 km	140.00 cm
Earth-Moon distance	380 000 km	38.00 cm
Earth-Sun distance	150 000 000 km	15 000.00 cm = 150 m

A scientific witness

Teresa Grafton saw an eclipse in India, in October 1995. She went on an organised visit which was accompanied by professional and amateur astronomers. She knows a lot about astronomy, and she understands why eclipses happen. Here is her account:

"The eclipse coincided with Diwali, the Hindu Festival of Lights. Whilst the astrologers made dire predictions, the gathering astronomers enjoyed fireworks by night and anticipated those nature had planned for the 24th. Our location was Fatehpur Sikri, a deserted city carved out of red sandstone, with mosques, forts, palaces and huge courtyards, dating from the sixteenth century.

"As the Sun rose, there were hundreds of us, perched along battlements, silhouetted against the lightening sky. Nearby, an American kept up a running commentary and an amateur astronomer from Cornwall quietly adjusted his equipment. The tension was extraordinary. Though surrounded by telescopes and cameras, I decided to watch my first total eclipse with my own eyes, carefully protected by a mylar filter. At around 7.30 a.m. the invisible Moon took its first bite out of the Sun.

"Over the next hour or so, the air began to chill and the light to change as the Moon gradually covered the Sun. Birds wheeled noisily overhead, increasingly restless. At totality, the birds roosted. The world around us turned grey-green beneath a purple sky, with the odd bright star and Venus low in the East. Now filters were unnecessary, and for a few precious seconds I stared at a black hole in the sky – around its edge a pearly-white fringe – the Sun's outer atmosphere or corona, streaming into space.

"There was the famous 'diamond ring' – the brilliant burst of light as the Moon slipped away from the Sun. We saw tiny crescent Suns reflected everywhere. But that black hole is the image which remains."

Activity 2: Recording eclipse memories

People find eclipses very memorable. A total eclipse of the Sun is difficult to forget.

- Find someone who has seen an eclipse of the Sun. Record what they remember of it. Show them Teresa's description of the Diwali eclipse. Do they recall seeing any of the same things? What effect did it have on them?
- Report your findings to the class. Compare them with the reports from other members of the class. What makes an eclipse so memorable?
- Some people suggest that having a scientific understanding of an eclipse would spoil it for you. It wouldn't seem so awe-inspiring. What do you think?

A Roman account

This account was written by Lucretius, a Roman poet and philosopher. He lived in the first century BC. It helps us to understand what the Romans knew about the Sun, the Moon and eclipses.

"You must understand that various causes may account for eclipses of the Sun and the Moon's occultations.

"If the Moon can cut off the sunlight from the Earth, uprearing its obstructive head between the two and planting an unseen sphere in the path of the glowing rays, why should we not picture the same effect as produced by another body that glides round forever lustreless?

"Or why should not the Sun periodically fail and dim its own fires and afterwards rekindle its light when it has passed through a stretch of atmosphere uncongenial to flame, which causes the quenching and quelling of its fire?

"And again, if the Earth in turn can rob the Moon of light by screening off the Sun that shines below while the Moon in its monthly round glides through the clear-cut cone of shadow, why should not some other body equally well pass under the Moon or glide over the solar orb so as to interrupt its stream of radiant light?

"And supposing that the Moon shines by its own lustre, why should it not grow faint in a determinate quarter of the heavens while it is passing through a region uncongenial to its particular light?"

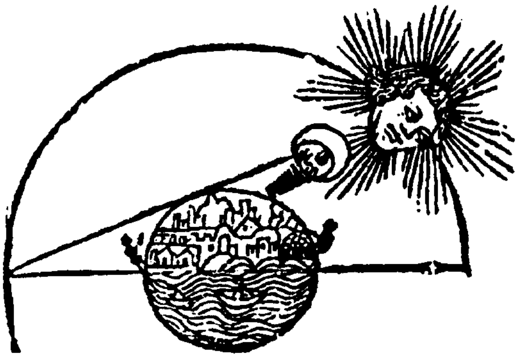
Activity 3: Examining Lucretius' ideas

Lucretius gives three different explanations of an eclipse of the Sun, and three of an eclipse of the Moon. He uses rather difficult language.

- Below, you will find some jumbled sentences which say the same things as Lucretius, but in simpler language. Put them in the same order as Lucretius' ideas.
- Do you think that, in Lucretius' time, people understood eclipses in the same way that we do today? Did they have the same ideas of the Sun and Moon as we do?

  - An eclipse of the Sun may happen because the Moon blocks its rays.
  - An eclipse of the Moon may happen because the Earth blocks the rays of the Sun.
  - Another explanation is that there might be another, invisible object that we never see which blocks the Sun.
  - Another explanation could be that another, invisible object may be blocking off the Sun's rays from the Moon.
  - Perhaps the Moon glows because it has its own source of light, and it grows dim when it goes through a region of space where it can't burn so well.
  - Perhaps the Sun goes through a region of space where there are gases which stop it from burning so well.

More eclipse ideas



This picture was drawn in the sixteenth century. It shows how an eclipse of the Sun happens when the Moon blocks off the Sun's light.

People understood eclipses over 2000 years ago, and they were able to predict when an eclipse would happen. But later, in the Middle Ages, this knowledge was forgotten. When an eclipse happened, people were taken by surprise. They thought that the gods were displeased, and that some dreadful fate was about to befall them.

In the sixteenth and seventeenth centuries, European scientists worked out the details of the planets' orbits round the Sun. They saw the planets as bodies moving with the precision of clockwork. Eclipses could be predicted to the minute and were anticipated with great excitement by astronomers and the educated people of the towns. Here is what someone wrote about the total solar eclipse of 8 April 1652:

"The country people tilling, loosed their ploughs. The birds dropped to the ground."

And here is what Francis Baily, an English astronomer, wrote in his account of the total eclipse of 1842:

"I was astounded by a tremendous burst of applause from the street below, and at the same moment was electrified at the sight of one of the most brilliant and splendid phenomena that can be imagined, for that instant the dark body of the Moon was suddenly surrounded with a corona, a kind of bright glory [a saintly halo, as painted by medieval artists] .... But the most remarkable circumstance attending the phenomenon was the appearance of three large protuberances apparently emanating from the circumference of the Moon but evidently forming a portion of the corona."

Baily had read many eyewitness accounts of eclipses, but this was the first one he had seen for himself. He had not anticipated anything so magnificent. At the same time, he declared that there was "something in its singular and wonderful appearance that was appalling."

Another astronomer, François Arago, observed the same eclipse in the south of France. A murmur of excitement built up as totality approached, to be replaced by a profound calm. As the Sun returned it was greeted with "transports of joy and frantic applause." Eclipses had become a spectacle of great public interest, and they still are today.

Activity 4: Interpreting historical evidence

1. Look at the picture at the top of the page. Identify the Sun, the Moon and the Earth. Find the Sun's rays and the shadow of the Moon. Did the artist understand why eclipses happen?

2. Find out about the Sun's corona. Today, we call the 'protuberances' which Francis Baily saw 'prominences'. What are they? Do they come from the Moon or the Sun?

3. How have people's reactions to eclipses changed in the last 2000 years?

Understanding eclipses of the Sun – Teacher's Notes

Acknowledgement

This module was written by David Sang, ASE (UK), and is based on material from *Total Eclipse of the Sun: Activities for Secondary Schools* (ASE).

Introduction

In this module, students are asked to:

- understand the origins of solar and lunar eclipses;
- appreciate the excitement of a total solar eclipse;
- make a model to illustrate why eclipses happen;
- collect memories of eclipses;
- interpret historical ideas, reports and other evidence.

Scientific & technological concepts

- eclipses;
- solar System;
- light rays;
- solar structure.

Teaching approach

Eclipses have been understood for over 2000 years. However, this knowledge was built up gradually, and was questioned in the same way that any scientific knowledge is debated. This module provides an opportunity for students to consider some of this debate.

It is often suggested that scientific knowledge and understanding destroy any romantic or emotional response one may have to natural events. Scientists' responses to eclipses tend to give the lie to this idea, although the responses of educated scientists and members of the public are clearly not the same as those of a medieval peasant.

Notes on the activities

Page 1: This activity will remind students of why eclipses occur. It is important to stress the point that the similar apparent size of the Sun and the Moon is purely coincidental. Making a scale model will also help to establish the large distances involved in the Solar System. (Other models are possible, including those which use light bulbs or projectors to model the Sun.) If students have already studied eclipses in depth, you could move on quickly to the rest of the module.

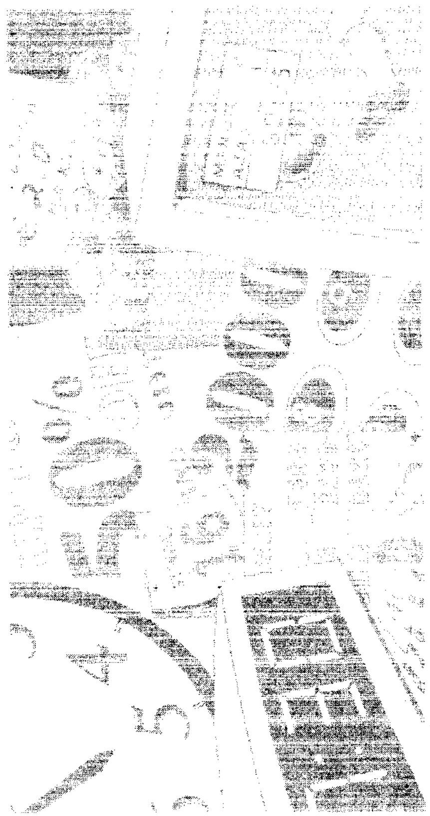
Page 2: This account can be used to emphasise the striking quality of a solar eclipse. It is unlikely that students will have seen a total eclipse, though they may well recall the eclipse of 11 August 1999, visible across Europe, western Asia and the Indian sub-continent. For people who have seen eclipses, they are a strikingly persistent memory. Students are asked to collect any such memories. This will serve to emphasise the significance they must have had for people in ealier times.

Page 3: This activity is an exercise in interpreting some text which contains ideas which are not part of the current scientific concensus. Lucretius is not simply prepared to accept the conventional explanation of eclipses, and has come up with some alternative versions. Because the text is rather difficult, students are supplied with the same ideas in more modern language, and are asked to match these up with the older text.

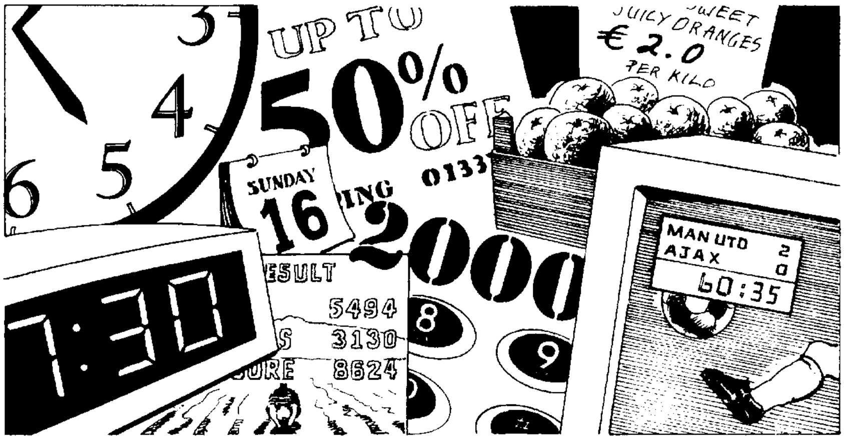
Page 4: This activity asks students to interpret further historical material, including an engraving. In the 1840s, when Francis Baily was writing, the Sun's corona had been observed but no-one knew whether it was a feature of the Sun, or part of the Moon which only showed up when it was illuminated from behind by the Sun. Similarly, they were not sure whether the prominences, only visible during an eclipse, were a solar or lunar feature. The last question asks students to consider how scientific knowledge has changed people's attitudes and reactions towards eclipses. You could extend this to a broader discussion of how scientific knowledge affects our view of nature. Students could also discuss the idea that scientific knowledge may have disappeared in the past, and may need to be re-discovered.

Further information: The history of our understanding of eclipses has been studied in detail. You will find an extensive collection of quotations at the following website: http://ds.dial.pipex.com/eclipse99page/quotes.htm

Numeracy



Working with numbers



Today we see numbers everywhere – on clocks and timetables, in books and newspapers, in important documents and forms, in computer games and on television. It's important to understand numbers, and to be able to work with them. This module will give you some ideas about useful ways to make the most of numbers.

Look at these two numbers – can you say which is bigger?

214 753 or 21 475

Here's an easy way to decide:

Write one number above the other.	
Make them match up at the right-hand side.	**214 753**
The gap before the thousands will help.	**21 475**
(It's easier with squared paper.)	

The first number has more digits, so it must be greater. Now, how about these two numbers – which is bigger?

214 753 or 213 475

Here's how to decide:

Write one number above the other.	**214 753**
Make them match up at the right-hand side.	**213 475**
Each has the same number of digits.	

Now compare the digits, starting at the left.

First digit = 2 for both.
Second digit = 1 for both.

The third digit is greater (4) for the first number than for the second (3), so the first number must be greater.

Try these:

1 Say which is bigger:

23 456	or	**23 546**
1 276 548	or	**1 726 548**
3 829	or	**3 828**
5 482 490	or	**5 482 489**

2 The table shows the diameters of the nine planets in the Solar System. Write down the names of the planets in order, from largest to smallest.

planet	diameter (in km)
Mercury	4878
Venus	12 103
Earth	12 756
Mars	6786
Jupiter	142 984
Saturn	120 536
Uranus	51 118
Neptune	49 528
Pluto	2284

3 Make up some more examples like question 1, to challenge your friends.

Making a million

The Earth is 150 million kilometres from the Sun. The population of Sweden is 8 million. And if you have a million dollars, you're a millionaire.

A million is a big number, but it's hard to appreciate just how big. Here's one way to begin to understand such a big number.

Step 1: Imagine piling up one million grains of rice on the floor. How big will the heap be? As tall as you? As tall as your teacher? Will it fill your classroom? Or the whole school?

Step 2: Collect some rice. Count out 100 grains. Put them in a small bag. Repeat with another 100 grains, until the class has filled 100 bags.

Step 3: Collect together the 100 small bags, each containing 100 grains. Put them in a bigger bag. Now you have 10 000 grains.

Step 4: Now you have to start imagining! Picture 100 of these larger bags. (It may help to imagine them arranged in a 10 x 10 grid.)

Step 5: Picture all the grains in all of these bags. That's one million grains.

Step 6: Think back to Step 1. Will the million grains fill your classroom? Did you make a good guess?

Try these:

Take a spoonful of sand. How many grains of sand are there in your spoonful? A million or more? (You could use salt as an alternative.)

Step 1: Tip the sand on to a piece of paper. Smooth it out into a circle – try to make it of an even thickness. Divide the circle into four equal parts; keep one quarter and discard the rest.

Step 2: Shape this sand into a line. Make the line of an even thickness. Divide the line into five equal parts; keep one fifth and discard the rest.

Step 3: Repeat Step 2. Now you have saved one quarter of one fifth of one fifth of the grains. That's one hundredth.

Step 4: Now you may be able to count the grains in one hundredth of the spoonful. If there are still too many to count, divide the sand again.

Step 5: Work out the number of grains in the original spoonful.

Step 6: Comment on your answer. Is it exactly the right answer, or an estimate?

Try this:

- Find some sheets of graph paper, with millimetre squares. Cut off any white border around the edge.
- Stick sheets together until you have made a piece one metre square.
- Work out how many squares there are along each side – remember, one thousand millimetres make a metre.
- How many millimetre squares fill one square metre?
- Try counting the squares – or ask a friend to count them for you.

Counting one million

How long did it take you to count 100 grains of rice? How long would it take you to count one million? Here's how to work it out:

Step 1: Suppose it took 6 minutes. To count 100 bags, each containing 100 grains, would take 600 minutes, or 10 hours.

Step 2: To count 100 of these bigger bags would take 100 times as long. Suppose you worked for 10 hours each day; it would take you 100 days.

Step 3: If you started on January first, when would you finish? Add up:
31 days of January + 28 days of February (usually!) + 31 days of March = 90 days.

Step 4: That leaves 10 days over - you will finish on April 10th.

Try this:

Suppose you could count one grain of rice each second. It would take you one million seconds to count one million grains of rice.

- There are roughly 30 million seconds in a year. What fraction of a year would it take to count one million grains of rice?
- How many days is that? (Use the fact that there are roughly 360 days in a year.)

Try these:

It is often useful to be able to estimate numbers – just like you estimated the number of grains of sand or salt, or the time to count one million grains of rice. Often, you need simply count a sample of things, and then multiply up.

Suggest how you might estimate the following:

1 The number of pedestrians or vehicles passing your home or school each day.
2 The number of leaves on a tree.
3 The number of stars visible in the night sky.

Paces and spaces

It's useful to be able to make a map or plan – perhaps to help you organise your vegetable garden, or an area for car parking. The first step is to learn a simple way to measure distances.

Try this:

Step 1: Measure the length of your pace when you are walking naturally. To do this, walk for 10 paces on flat ground in a straight line. Ask your partner to measure the distance you have covered using a metre rule or tape measure.

Step 2: Repeat Step 1 five times. Put the results in a table, like the one shown.

Distance moved in 10 paces:

1st attempt	2nd attempt	3rd attempt	4th attempt	5th attempt
8.3 m	8.1 m	8.4 m	8.3 m	8.2 m

Step 3: Look at your results. Do any of them seem wrong in some way? Discard any obviously doubtful results. (The ones in the table look fine. You would not expect to walk exactly the same distance each time, because your pace varies slightly. An answer of, say, 9.1 m might have been suspect.)

Step 4: Calculate the average length of 10 paces, and of one pace.
Average length of 10 paces = (8.3 + 8.1 + 8.4 + 8.3 + 8.2) m / 5 = 8.26 m
Average length of 1 pace = 0.826 m or 83 cm

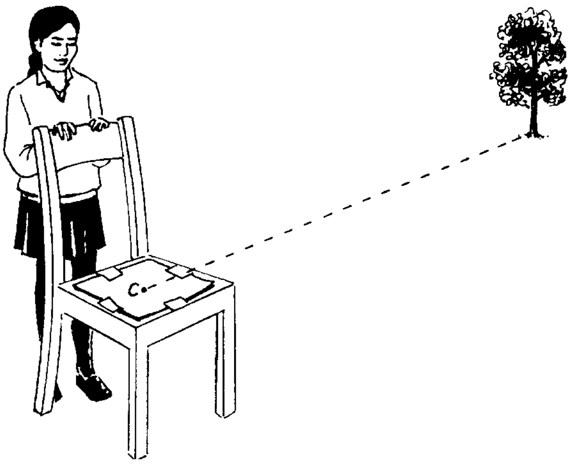
Step 5: Repeat Steps 1 - 4 to find the length of your partner's pace. Compare your answer with your partner's, and with others in the class. Do your results seem reliable?

Try this:

- Measure some distances by pacing them out. How far is it from one classroom to another? From home to the shops or to the market? Can you find the shortest route from home to the shops, or to the market, or to the school?

- Make a map. You could map your school, or your route from home to school. Indicate important features along the way, and the distances between them. Compare your map with those produced by other members of the class.

Make a map



Here's how to make a simple area map. With your partner, choose an open area of ground near your classroom. This is the area you are going to map.

Step 1: Place a stool or chair in the middle of the area. Tape a sheet of plain paper onto the seat. In the middle of the paper, mark a point to represent the chair. Label it C.

Step 2: Here's how to mark the direction of a feature of interest in the area you are mapping – for example, a gate. Place your ruler on the paper, so that it passes through point C. Move the ruler around until it points towards the gate. (It's easier if you crouch down and look along the ruler. Make sure it points directly at the gate, as well as passing through point C.) Draw a line on the paper to show the direction of the gate. This is called a sight line.

Step 3: Draw sight lines for other features of interest.

Step 4: Now, pace out the distance to each of the features. Record them in a table. Convert each measurement to metres.

Step 5: You now need to convert the distances to ones that will fit on the paper. (Which object is furthest away?) Choose a suitable scale, for example, 1 cm to represent 1 m.

Step 6: Suppose the gate is 6.5 m away. Mark the gate at a point 6.5 cm from point C on the correct sight line.

Step 7: Repeat this process for all the other measurements, always using the same scale. Now you have a complete map of the area.

Try this:

Check your map: Measure the distance from one feature to another, for example, from the gate to a tree. Does this scale to the same distance on your map?

Try this:

Scientists often survey an area to establish the different types of plants and animals which are living there. The first step is make a map and indicate the vegetation which is present.

Choose an area of interest. Make a map of the area, using the method you learned above. Now, mark areas on the map to show different types of vegetation; eg;

grass **scrubby bushes** **evergreen tree** **sandy soil without plants**

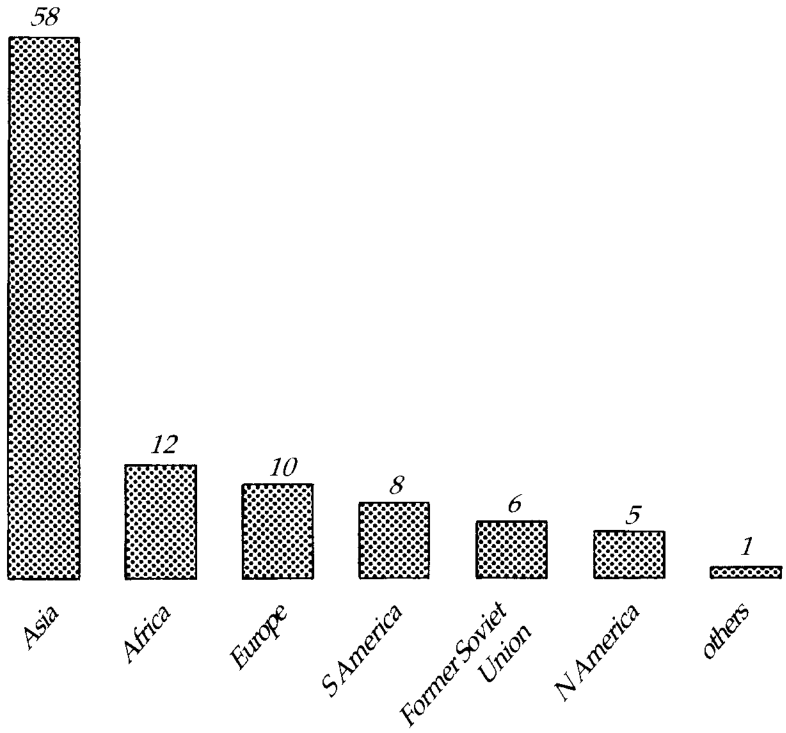
The Global Village: Population

We live in a global village. Modern communications have made it possible for us to speak to people all round the world, just as if we lived together in a village. And we all share the same environment. If we cause any damage to the environment, we may harm people in far-distant countries.

How many people live in this global village? Roughly, 6 000 000 000. That's six thousand million, or six billion. It's hard to picture so many people. Here's one way to make a picture in your mind of all these different people.

Step 1: Picture a village of just 100 people. These people will represent everyone in the world.

Step 2: The bar chart shows how many of the 100 come from each area of the world. Which group do you belong to?



Try this:

1 Of the 100 people in the village, 35 are children. Just 6 are aged over 65. The remainder are aged between 18 and 65. Draw a bar chart to represent the numbers of people in each age group.

2 Each year, in the village, there are 3 births and 1 death. Work out the population of the village next year, and the year after.

3 Now you will need to scale up from 100 people in the village to 6 000 000 000 in the world. How many people will be born in the world next year, and how many will die? By how many will the world's population increase?

The Global Village: Languages

There are more than 4000 languages spoken in the world today.

- There are about 140 languages with more than 1 000 000 speakers.
- There are at least 400 languages with fewer than 1000 speakers.
- More than 100 languages have become extinct in the last 100 years.

Let's think again about the global village of 100 people, representing the whole population of the world. The table shows how many of the 100 people speak some of the major languages.

number of people out of 100	language	number of people out of 100	language
17	Mandarin	6	Russian
9	English	4	Arabic
8	Hindi/Urdu	smaller numbers speak other languages	
6	Spanish		

Try these:

1 Is your language included in the table?

2 Of the 100 people in the village, how many are represented in the table? What can you say about those who are not represented?

3 Draw a chart to show the information from the table. You could choose a bar chart or a pie chart.

4 How many people in the village could you communicate with?

Points for discussion:

- What languages are spoken in your community? What other languages do the schools teach?
- Name some languages which are not included in the table.
- 90% of traffic on the internet is in English. Why do you think this is? How will it affect the languages spoken around the world in the future?
- Would it be sensible if everyone spoke a second common language? Should people all learn an existing language, such as English, or an invented language such as Esperanto?
- Why might it be useful for you to be able to speak another language?

Working with numbers – Teacher's Notes

Acknowledgement

This module is based on a module devised by Prof. Alan Bishop of Monash University, Australia.

The module introduces some basic ideas for teaching certain skills of numeracy. This is an approach to mathematics which stresses useful, practical mathematical methods which can be applied in everyday situations. The development of skills in numeracy can encourage the empowerment of individuals, families and communities.

Introduction

In this module, students are asked to:

- learn to compare large numbers;
- develop their understanding of large numbers, particularly one million;
- consider ways of estimating large numbers;
- learn how to produce maps and plans using simple surveying techniques;
- find out how to represent the population of the world by scaling down.

Scientific and mathematical concepts

- comparing large numbers;
- counting, sampling and estimating;
- surveying and mapping;
- using bar charts and pie charts.

Teaching approaches

As with other modules in this pack, you may wish to make a selection from the activities offered in this module, depending on the experience and numeracy skills of members of your class.

Notes on the activities

Page 1, 2: This page introduces the idea of large numbers and how to compare them. Students should know about the idea of place value, though this term is not explicitly used.

Page 3, 4: These pages are intended to give students a feel for the idea of one million. The first activity on page 3 asks students to count grains of rice. You will need 10 000, so that members of the class can count them into bags of 100. 10 000 grains of rice is less than 1 kg.

In the second activity, they will learn to estimate the number of grains in a spoonful of sand or salt. This introduces useful ideas about sampling and estimating.

Making a metre square of graph paper: this has one million millimetre squares, and this makes this large number seem more manageable.

Again, appreciating that there are 30 million seconds in a year makes one million easier to understand.

Page 5, 6:: These two pages help students to produce simple maps and plans of familiar areas, an important skill when considering land use, for example. It is also useful when carrying out ecological surveys.

Page 7, 8: The population of the world is a large number (6000 million, or 6 billion). These activities will help students to relate to this number by representing the population as a small village of 100 people. They will need to be able to scale back and forth between these two numbers.

Comment on millions and billions

Everyone agrees that a million is 1000 000. However, in the past, there have been different usages of the terms billion and trillion. Most people today follow the American usage (which is also the international scientific convention):

1 billion = 1 thousand million = 10^9
1 trillion = 1 million million = 10^{12}

Note on equipment

Students will require:

- paper, pencil, ruler;
- metre rule or tape measure;
- the activities on pages 5 - 8 require the use of calculators, particularly for scaling up and down of quantities.

Appendix 1

Project 2000+ Steering Committee

United Nations Educational, Scientific and Cultural Organisation (UNESCO)

The World Bank

United Nations Children's Fund (UNICEF)

United Nations Development Programme (UNDP)

United Nations Environmental Programme (UNEP)

Commonwealth Secretariat

International Council of Scientific Unions (ICSU)

International Council of Associations for Science Education (ICASE)

International Organisation for Science and Technology Education (IOSTE)

Gender and Science and Technology (GASAT)

World Council of Associations for Technology Education (WOCATE)

References

Holbrook, J. & Rannikmae, M. (Ed)
"Supplementary Teaching Materials Promoting Scientific & Technological Literacy"
ICASE, 1997

Maharjan, S. D.
"The Naulogaon Free Sweets Story: an Environmental Casestudy"
- unpublished workshop paper,
Kathmandu, 1998

SATIS
"SATIS Science Investigations (Video)"
ASE Science & Technology in Society (SATIS) Project,
London, 1990

UNESCO
"Science 2000+: Scientific and Technological Literacy for All
UNESCO, Paris, 1994

Whittle, P. A.
"STL, Solar Energy, and the Nepal Science Curriculum"
- unpublished workshop paper,
Kathmandu, 1998

Other publications

Maharjan, S. D. & Whittle P.A. (Ed)
"Promoting Students' Scientific & Technological Thinking "
- developing skills and attitudes concerning our environment

Holbrook, J. & Rannikmae, M. (Ed)
"Supplementary Teaching Materials Promoting Scientific
& Technological Literacy"
ICASE, 1997

UNESCO
"Science 2000+: Scientific and Technological Literacy for All
UNESCO, Paris, 1994

Science Across Europe & Science Across the World Materials
Acid Rain; Energy in the Home; Drinking Water; The Food We Eat;
Global Warming; Renewable Energy; Waste; Road Safety; Healthy Living

SATIS materials from The Association for Science Education (UK)
http://www.ase.org.uk/