From Babylon to BIOTECHNOLOGY

Science content

Fermentation, microbes, enzymes, antibiotics, penicillin, DNA, genetic engineering, enzymes in washing powder.

Science curriculum links
AT3 Processes of life
AT4 Genetics and evolution
AT7 Making new materials
AT17 The nature of science

Syllabus links
- GCSE Science, Biology, Chemistry
- Sixth-form General Studies

Cross-curricular themes
- Health Education
- Economic Awareness

Lesson time
1–2 hours

Links with other SATIS materials
102 Food from Fungus
201 Energy from Biomass
309 Microbes make Human Insulin
609 Hitting the Target
1010 Can it be done? (questions 23, 29)
1202 Mapping the Human Genome

NERIS
Search on
BIOTECHNOLOGY
and UPPER SECONDARY
Additional search terms
GENETIC ENGINEERING
ENZYMES

SUMMARY

This unit was developed from SATIS No. 710, *What is Biotechnology?*. The new unit, *From Babylon to Biotechnology,* replaces the former unit with the exception of case study 2, *Using bacteria to extract metals from ores*. This case study remains up-to-date and may be used with the new unit.

The new unit provides a similar introduction to the historical development of biotechnology and to current concerns. The emphasis has been changed, especially on pages 3 and 4 and more questions added. There is a new case study about enzyme washing powders.

STUDENT ACTIVITIES

- ☐ Reading and answering questions: the development of biotechnology.
- ☐ Case study – reading, data interpretation and questions: *Enzymes in the washing machine.*

AIMS

- ☐ To show the development of an important branch of science
- ☐ To give a simple introduction to biotechnology and illustrate its wide scope
- ☐ To illustrate how biotechnology can be used to meet some human needs
- ☐ To provide practice in comprehension and data interpretation skills

USING AND ADAPTING THE UNIT

- ☐ The unit is suitable for class or independent use.
- ☐ The unit may be used in parts and combined with case study 2 from SATIS No. 710.
- ☐ The information in the case study, *Enzymes in the washing machine,* could be used as a starting point for practical investigations. The new lipase, Novo Lipolase 100T is available from The National Centre for Biotechnology Education, Department of Microbiology, University of Reading. Tel. 0734 873743. Amongst its many activities, the Centre provides advice and publishes a newsletter for schools.

Author **Dean Madden**
Developed from SATIS No. 710, *What is Biotechnology?* (1986).

First published 1991

What is biotechnology?

Q1 *Traditional uses of biotechnology mentioned in the unit are making beer, bread, wine, vinegar, yoghurt and cheese.*

Q2 *A beer-like drink may have been made by accidental fermentation of a cereal-water mixture.*

Q3 *The microscope*

Q4 *Pasteurisation*

Q5 *Living organisms maintain temperatures around 37 °C because their enzymes function at this temperature. However, there are enzymes which can tolerate much higher temperatures and the alkaline conditions produced by washing powders.*

Q6 *(a) Antibiotic (b) Recycled from patients' urine*

Q7 *DNA (deoxyribonucleic acid).*

Q8 *6000 BC Brewing beer*
4000 BC Yeast as a raising agent
BC wine making, yoghurt, cheese
1600s Microbes discovered
1800s Pasteurisation
1897 Edward Buchner – enzymes
1928 Penicillin discovered
1940s Penicillin made in bulk
1953 DNA structure discovered
1960s Genetic code cracked
1970s Genetic engineering

Q9 *Examples of biotechnology are (b), (c), (e) and (f).*

Products containing enzymes are widely available. For example, well-known washing powders and barbecue sauces contain proteases to break down proteins (which in the case of barbecue sauce will make meat tender) and toothpastes contain enzymes also found in saliva (such as lactoperoxidase) that protect against tooth decay. The enzyme described in part B is not yet available in washing powders. It is in fact a lipase (lipolase), but its name has not been given in the student text to avoid confusing students.

Enzymes in the washing machine

1 *Using saliva*

2 *It contains enzymes (such as amylase)*

3 *'Biological' washing powders contain enzymes.*

4 *Proteases in washing powder solutions gradually break down other enzymes such as lipases. This is a particular problem with modern liquid formulations. However, it can be overcome by adding an enzyme inhibitor (boric acid) to the liquid. In the washing machine, the boric acid is diluted and so loses its inhibitory effect.*

5 *(a) The activity increases (non-linearly) with increasing pH (and nears 100% at pH 11).*
(b) pH 7
(c) More effective in alkaline solution.
(d) About 64%
(e) 9–10.5

6 *(a) The activity rises from 60% between 10 and 37 °C to peak at 100% and falls with increasing temperature thereafter.*

(b) The 40 °C setting of a washing machine. (The graph shows an optimum value of 37 °C.)

7 *(a) C*
(b) C was launched at a time of concern that enzymes might be harmful. Any skin allergies were likely to be blamed on the new powder.
(c) The number of complaints has fallen to a very low value and there is no significant difference between non-biological and biological powders A and B.
(d) No. They show no difference.

Despite many years of research, there is no evidence of allergies to enzymes occurring amongst domestic users of biological washing powders. (The same is not true of the other components of washing powders.) Most of the complaints seem to be inspired by fears aroused by the media. Workers in detergent manufacturing plants did suffer when enzymes were first introduced, but this problem was quickly overcome by the introduction of stringent safety regulations and the development of effective encapsulation techniques to prevent the formation of airborne enzyme dust.

Acknowledgements
We wish to thank the National Centre for Biotechnology Education for their help in producing this unit.
Illustrations by Joyce Curtis
Figure 3 supplied by J Sainsbury Plc.

From Babylon to BIOTECHNOLOGY

Part A – What is biotechnology?

Part A Information and questions.

Part B Case study of a washing powder enzyme.

Biology is the study of living things. Technology is about solving problems to provide the things we need. So biotechnology uses living things to make and do the things we need.

More precisely, **biotechnology is the use of biological processes to provide goods and services.** These goods include chemicals, foods, fuels and medicines. Services which depend on biotechnology include waste treatment and pollution control.

Biotechnology uses living cells or chemicals such as enzymes made by them. The cells may come from familiar plants or animals or be microbes, like yeast.

Milestones in biotechnology

6000 BC: the first beer is brewed

Traditional biotechnology started before 6000 BC when the Babylonians brewed the first beer. Brewing uses yeast cells to turn sugar to alcohol. About 4000 BC, the Egyptians learnt to use yeast in bread-making. Wine is made by fermenting grapes and is mentioned in the Old Testament of the Bible.

Beer, bread and wine all depend on the fact that yeast cells can live without oxygen. They produce carbon dioxide and alcohol in a process called **anaerobic fermentation.**

Another ancient fermentation process uses bacteria to turn alcohol to acetic acid in the manufacture of vinegar. Yoghurt is also made by fermentation. Bacteria which make lactic acid are added to milk. Many types of bacteria and moulds are used to convert milk into different cheeses.

All this traditional biotechnology was an art, rather than a science. People did not understand what was going on when they made beer, bread or cheese. Before biotechnology could really take off, scientists had to find out more by carrying out careful investigations.

Figure 1 The Babylonians were some of the earliest people to use biotechnology

Q1 Give three examples of traditional uses of biotechnology.

Q2 How do you think the Babylonians discovered beer making?

Seventeenth century: microbes discovered

Microbes were used in making food and drink for thousands of years before they were identified. It was not until the seventeenth century that Anton van Leeuwenhoek reported seeing microbes with one of the first microscopes.

At the time many people thought that living things could grow of their own accord from non-living things. In the nineteenth century Louis Pasteur disproved this idea which was called the theory of spontaneous generation. He showed that microbes could only come from other microbes. Later, Pasteur used his ideas to prevent wine turning to vinegar and milk from going sour. His method is still used today, and is called pasteurisation.

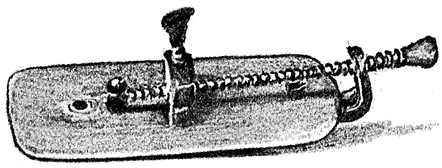


Figure 2 Leeuwenhoek's microscope

> *Q3 What invention was vital before microbes could be discovered?*
>
> *Q4 Milk for sale to the public has been heat treated and rapidly cooled which kills most of the microbes that may be in it. What is the process called?*

1897: enzymes are discovered

In 1897 Edward Buchner showed that you do not need whole yeast cells to make alcohol. Parts of the cells will do the job. We now know these are the parts which contain enzymes.

Enzymes are biological catalysts. They are made by cells to speed up and control biological reactions. Enzymes are present inside the cells of all living things. They control all life processes. Since 1897 many useful enzymes have been obtained from the cells of microbes, plants and animals.

Enzymes are used in industry and in the home in things as different as biological washing powders and barbecue sauce.

Figure 3 Biological washing powders contain enzymes which break down protein stains

> *Q5 Suggest why a lot of living things have body temperatures around 37 °C*

1928: penicillin – biotechnology makes the wonder drug

In the early years of this century a scratch or cut which went septic could spell death. People born in 1930 could on average expect to live until they were 54. Today, our life expectancy is much greater. At least ten years of this extra life span are due to the use of antibiotics.

In 1928, Alexander Fleming, a doctor at a London hospital, made an interesting observation. He noticed that a certain mould, *Penicillium*, stopped bacteria from growing. Some years later, scientists in Oxford extracted a chemical from the mould, and used it to fight bacterial infection. This chemical was called penicillin.

Penicillin was at first made in large amounts by growing the mould on nutrient broth in thousands of milk bottles. Technologists in America then developed better ways of culturing the mould inside large fermenters.

Penicillin saved many Allied lives during the Second World War. In fact the drug was so precious that urine from treated patients was collected. The penicillin excreted in it was separated out and used to treat others. The Nazis did not have penicillin, and had to rely upon older, less effective drugs.

Since then, many more antibiotics have been discovered. Most are made using some form of biotechnology.

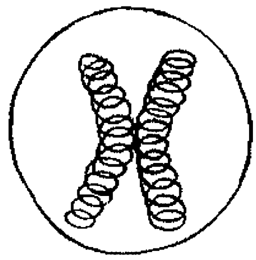
1953: DNA – the code of life

Why do people look like their parents? Why is it that cats give birth to little cats, and not to dogs or rabbits? Questions like this have puzzled scientists for hundreds of years.

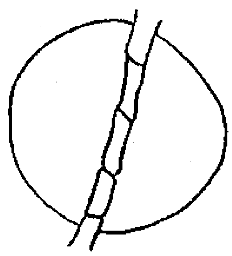
In 1953, scientists in England called Rosalind Franklin, Maurice Wilkins, James Watson and Francis Crick put together the evidence and provided part of the answer. The molecule they were working on was deoxyribonucleic acid, known as DNA. Rosalind Franklin discovered it had a spiral shape and with the help of a home-made model, Watson and Crick worked out the structure.

DNA is found in the chromosomes within the cells of all living things. It controls the cells' activities. DNA is carried in sperm and eggs, and so is passed on from one generation to the next. Copies of it go into each new cell when the cell divides. This explains why we look like our parents.

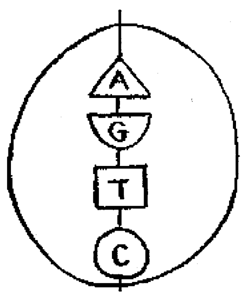
The DNA acts as a set of coded instructions for the cell. Instructions for making proteins are called **genes.** Once the structure of DNA was known, people began trying to crack the genetic code. By the early 1960s, they had succeeded. The genetic code turned out to be the same in all living things. This meant, in theory, that you could take instructions from one cell and stick them into another – even if the cells came from completely different organisms. This process of 'cutting and pasting' DNA is called **genetic engineering**.



A chromosome



Genes on a chromosome



DNA

Figure 4 Chromosomes and DNA

Q6 *(a) What sort of drug can be used to fight an infection caused by bacteria?*
(b) How was penicillin recycled during the Second World War?

Q7 *Name the molecule that contains the genetic code.*

1970s: genetic engineering is developed

In genetic engineering, scientists move DNA instructions from one type of cell to another. This can prompt cells to make useful products.

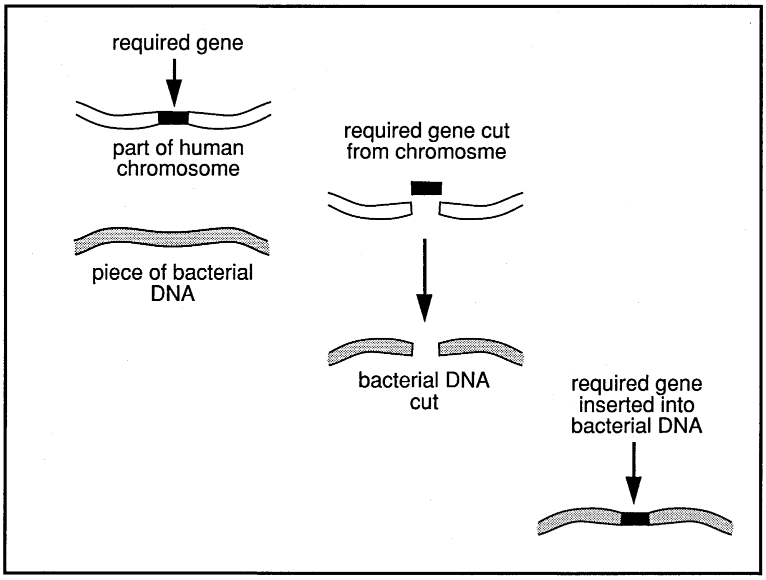
A child who does not produce enough growth hormone remains relatively short. Nowadays this can be prevented by treating the child with human growth hormone. Before genetic engineering, the hormone had to be extracted from dead bodies. It took 20 000 bodies a year to get enough hormone to treat all the people in Britain who needed it. Now DNA from human cells is put into microbes. In a fermenter the size of a dustbin the microbes make the same amount of hormone in 12 hours.

Other products of genetic engineering include insulin, which is needed by people with diabetes and vegetarian rennet for making cheese. Vegetarian rennet is used instead of rennet taken from calves.

Q8 Make a time chart listing the important events in the development of biotechnology described in this unit.

Q9 Which are examples of biotechnology?
- *(a) Extracting human growth hormone from dead bodies*
- *(b) Making human growth hormone by fermentation*
- *(c) Producing compost from rotting plant matter*
- *(d) Refining oil to make petrol, diesel fuel, fuel oil, etc.*
- *(e) Using bacteria to turn glucose to fructose (a very sweet sugar)*
- *(f) Making biogas from decomposing household and farm waste*
- *(g) Making steel from iron*

Figure 5 Genetic engineering – the basic method



Who are the biotechnologists?

The biotechnology industry needs all sorts of people working together as a team. Microbiologists, biochemists, computer scientists and engineers use scientific discoveries to produce new or better goods and services. Biotechnology companies also need lawyers, accountants and sales staff who understand something about the science behind the business.

Biotechnology could help to solve many of the world's problems, such as disease, hunger and pollution. However, it also raises many difficult and controversial issues. It is important that we all know about biotechnology so that we can help to decide what should and should not be done.

Part B – Enzymes in the washing machine

In 1821 the US Army Regulations told soldiers to clean their uniforms in an unusual way:

> "... spots of dirt or grease, or stains (on the uniform), will be taken out by ... saliva"

Saliva contains enzymes such as salivary amylase which normally help us to digest our food. Proteins, fats and starch are common in the stains found on clothes. These substances can also act as a kind of glue, sticking dirt to the fabric. Enzymes help to break down these stains in the same way that enzymes break down food in our bodies.

Enzymes are not themselves alive, but come from living things. The enzymes in washing powders come from harmless microbes. The idea of putting enzymes into washing powders didn't catch on until a method of growing large numbers of microbes in fermenters was developed. Washing powders containing enzymes are often called 'biological'.

When biological powders were first introduced, manufacturers received many complaints. People blamed enzymes for skin rashes and itching. They believed that protein-digesting enzymes (proteases) in the powders were responsible. However, after years of careful research there is no scientific evidence for this.

Because enzymes usually work at low temperatures they can help to shift stains without the need for very hot water or harmful chemicals. Enzymes are biodegradable – once they are washed down the drain they break up within a few hours.

Most biological powders contain proteases – protein digesting enzymes. But proteins aren't the only stains on clothes. Danish biotechnologists have now made a new enzyme for washing powders, using the techniques of genetic engineering. The new enzyme breaks down fats, which make the worst kind of stains. Scientists took the gene for a fat-digesting enzyme (a lipase) from one fungus and put it into another fungus called *Aspergillus*. They chose *Aspergillus* because they already have a lot of experience of growing it in fermenters.

The new lipase enzyme can break down grease and oils. It will remove marks like shoe polish, lipstick and chip fat from fabric.

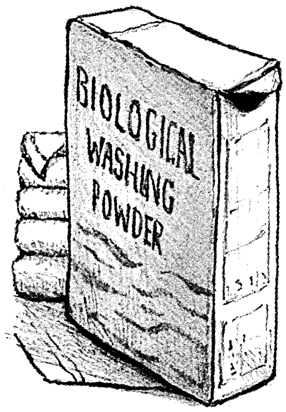


Figure 6 Instead of washing clothes in very hot water, biological washing powders will help to break down stains in low temperature washing programs

1 How were US soldiers ordered to get spots of dirt off their uniform in 1821?

2 Why did the method work?

3 Why are some washing powders described as 'biological'?

4 Enzymes are proteins. What might happen if washing powder manufacturers put a mixture of proteases (protein-digesting enzymes) and lipases (fat-digesting enzymes) into the same product?

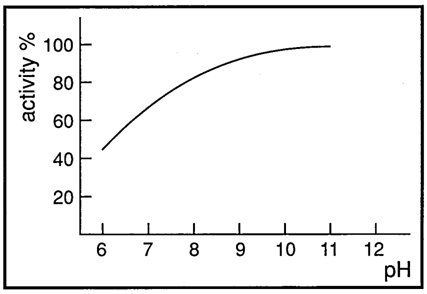


Figure 7 Activity of the new lipase enzyme at different pH values

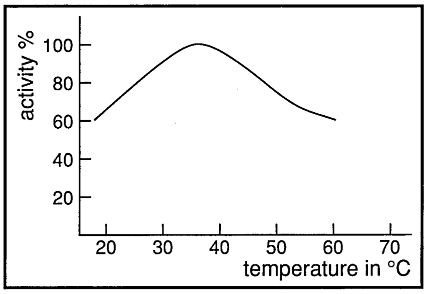


Figure 8 Activity of the new lipase enzyme at different temperatures

The graphs in figures 7 and 8 show how the *activity* of a new lipase enzyme depends on pH and temperature.

5 Look at figure 7.

(a) Describe how the activity of the enzyme varies with pH.

(b) What is the pH of a neutral solution?

(c) Is the new enzyme more effective in acid or alkaline solutions?

(d) Use the graph to find the activity of the new enzyme in a neutral solution.

(e) Strong acids and alkalis are corrosive. What pH would you recommend for a washing powder that contains this enzyme?

6 Look at figure 8.

(a) Describe how the activity of the new enzyme varies with temperature.

(b) What temperature would you advise for washing clothes in a washing powder containing the new enzyme?

The graphs in figure 9 show the number of complaints received after three new washing powders, A, B and C, were introduced. (Most complaints were about allergies like skin rashes and itching.)

Washing powder A was non-biological; washing powder B was biological; washing powder C was biological and similar to B, but was launched when newspapers announced that enzymes might be harmful.

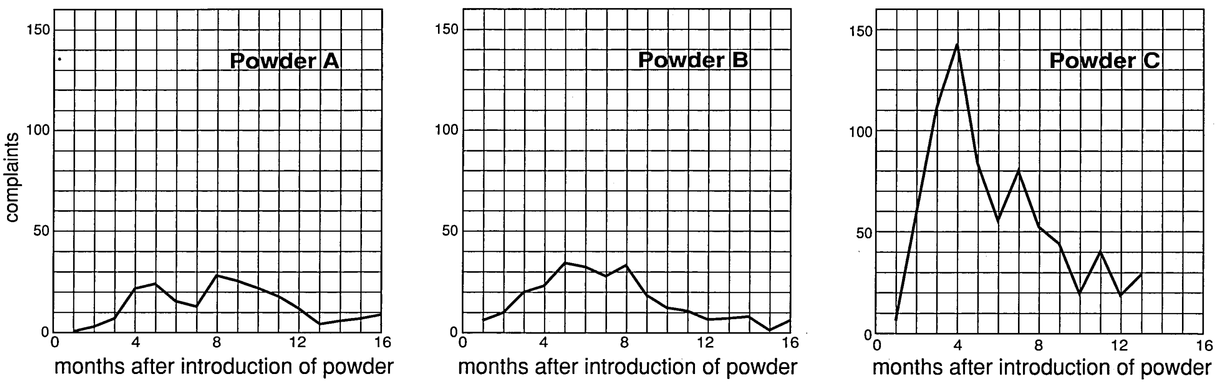


Figure 9 The number of complaints received after three new washing powders, A, B and C, were introduced

7 Look at figure 9.

(a) Which powder received the most complaints?

(b) Powders B and C are very similar. Suggest why one received more complaints than the other.

(c) What can you say about the number of complaints after the powders had been on sale for more than a year?

(d) Do these graphs give evidence that enzyme washing powders cause skin rashes and itching?

Answers to the questions are given in the *Teachers' Notes.*

EARTHQUAKES in Britain?

Science content
Earthquakes, Richter scale, Mercalli scale, seismograph, seismogram, speed, time, vibration.

Science curriculum links
AT 1 Exploration of science
AT 9 Earth and atmosphere

Syllabus links
- GCSE Science
- Geography

Cross-curricular themes
- Environment

Lesson time
1–2 hours
and homework

Links with other SATIS materials
1107 The Eruption of Mount St Helens

NERIS
Search on
EARTHQUAKES and UPPER SECONDARY

SUMMARY

Part A is based around an earthquake that occurred in North Wales in July 1984. It describes the experiences of people who felt it and relates them to the Mercalli scale. Students may then determine the location and time of the earthquake. Part B deals with seismographs and part C is an earthquake hazard survey of the home.

STUDENT ACTIVITIES

☐ Introductory reading: Richter and Mercalli scales

☐ Questions relating observations to the Mercalli scale

☐ Plotting an isoseismal map

☐ Interpreting seismograms

☐ Making an earthquake detector

☐ Questions for group discussion – civil emergencies

☐ Home survey – preparedness for an earthquake emergency

AIMS

☐ To link with work on plate tectonics and earthquakes

☐ To consider the precautions that individuals can take to prepare for a natural disaster

☐ To provide opportunities for assessing evidence and interpreting seismic data

☐ To provide an opportunity to design, make and evaluate a seismograph

USING AND ADAPTING THE UNIT

☐ Part A is suitable for independent work or for homework. 'When did the earthquake occur?' might be omitted by students who find the mathematics too challenging.

☐ Worksheets are provided for use with parts A and C.

☐ The apparatus for part B, 'Can you make an earthquake detector?' should include a variety of items such as: hacksaw blades, G cramps, masses, springs (as used for Hooke's Law experiments), pendulums, retort stands, wooden blocks, thread, card, paper, Sellotape, plasticine, fibre-tipped pens.

Authors **Peter Whitehead**
Dave Pierson

First published 1991

Teaching notes

The unit is divided into parts so that teachers may select those most appropriate to their class.

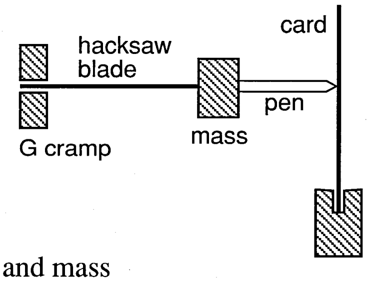
There is no direct correlation between the Mercalli and Richter scales. Values for earthquake intensity on the Mercalli scale are a little higher than on the Richter scale. The Richter scale is logarithmic – like the decibel scale for the intensity of sound.

Part B 'Can you make an earthquake detector?'

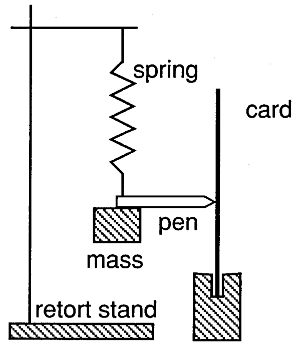
A seismograph has a part that moves with the Earth's vibration and a part that stays still.

- It is suggested that students are told what apparatus is available and that they may select what they need.
- A suitable time limit is 30 minutes.
- Typical student designs are

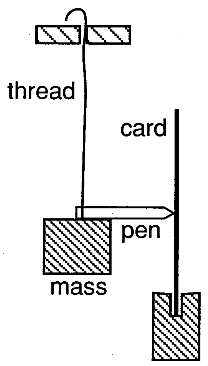
(i) cantilevered beam



(ii) spring and mass



(iii) pendulum



After students have completed their seismographs, it is important that the class reviews their designs to evaluate:

- whether their devices measure horizontal or vertical vibrations,
- their sensitivity to vibrations,
- the reliability of their detectors,
- the validity of their measurements,
- the connection between the external vibration (the independent variable) and the device's response (the dependent variable), the device's response being a trade-off between springiness and inertia.

Acknowledgements

Dennis Curry of University College, London, read and commented on the trial version.

The material on the 1984 North Wales earthquake has been developed from an article by Peter Whitehead which appeared in *Geology Teaching*. The data was supplied by the Department of Earth Sciences at Leeds University.

Figure 2 is reproduced by permission of the *Shropshire Star*.

Figures 3 and 7 by Joyce Curtis.

Answers to the questions

Q1 *Between 3 and 4 on the Mercalli scale.*

Q2 *(a) Hanging objects swing – lamp over bunk, picture on wall, plant on wardrobe would shake, curtains swing; the vibration will be more noticeable in the upper bunk. Cat will wake up.*

(b) Vase and books may fall off the shelf, so will items on the chest of drawers, bedside table, plant on wardrobe, picture and mirror on the wall: standard lamp may fall over: bunk beds shake; weak plaster in walls may crack and so may the window glass.

(c) The wardrobe and bunk beds might topple over, other furniture would move, books and ornaments would be thrown to floor. There would be damage to the plaster on the walls.

Q3 *4*

Q4 *Possibly little higher.*

Q5 *Caernarfon and Pwllheli*

Q6 *Oxenhope*

Q7 *1.8 s approximately*

Q8 *5.5 km/s*

Q9 *210 km*

Q10 *38 s*

Q11 *(a) 6:56:43, (b) 6:56:41*

Q12 *6:56:03*

Questions for group discussion

- *(a) radio – in the probable event of power being cut off, to receive information, for example on location of emergency medical centres, roads closed, arrangements for water supplies etc.;*

  (b) water purification tablets – water mains are often fractured by earthquakes; water supplies may become contaminated giving rise to outbreaks of disease;

  (c) heavy gloves – for lifting rubble to rescue people trapped underneath;

  (d) map – used to the help find routes to emergency centres should the usual routes be blocked.
- *Scores will depend on individual preferences.*
- *(a) Floods, damage by gales, inundation by the sea in coastal areas, forest fires, etc. (b) The items on the list are useful for any civil emergency.*

EARTHQUAKES in Britain?

Part A – Do earthquakes occur in Britain?

What does an earthquake feel like? Here are descriptions by two schoolchildren of an earthquake that happened in Britain in 1984.

> 'I was sitting on the toilet and thought the seat was moving.'

> 'My Mum told me to stop jumping on my bed and I said it wasn't me.'

Occasionally there are earthquakes whose effects are more serious. In 1580 an earthquake centred around the Straits of Dover destroyed buildings and set the church bells ringing all over Kent. In 1884 a church in Colchester, Essex, was wrecked and more than a thousand buildings damaged. An earthquake in 1990 damaged buildings in Shropshire.

When an earthquake occurs a lot of energy is released and the ground shakes. Two scales are used for measuring earthquakes: the Richter scale and the Mercalli scale.

The **Richter scale** is related to the amount of energy released. It is used when the earthquake has been detected by **seismographs**.

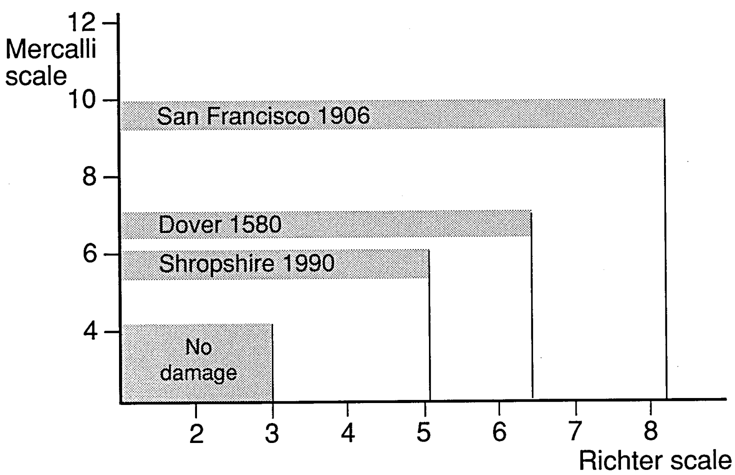
The **Mercalli scale** is used to estimate the size of earthquakes which have not been recorded by seismographs. This scale is based on what people notice when the earthquake occurs and by the damage it does. There is a simplified version on the next page. The two scales are compared below.

Part A Earthquake intensity, relating observations to the Mercalli scale, plotting an isoseismal map, interpreting seismograms. (Students will need worksheets 1 and 2.)

Part B Seismographs; build an earthquake detector.

Part C Discussion questions; survey of earthquake hazards in the home. (Students will need worksheet 3.)

Figure 1 A comparison of the Richter and Mercalli scales



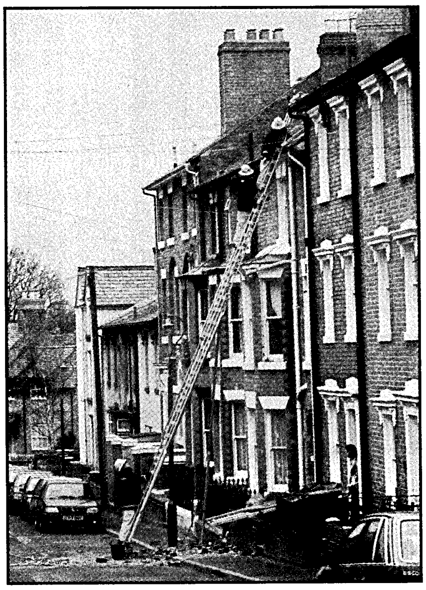


Figure 2 Firemen making safe a chimney stack in Shrewsbury after an earthquake in Shropshire in 1990. Its magnitude was put at 5.1 on the Richter scale

Earthquake 1984

The earthquake which occurred in Britain in 1984 happened at about eight o'clock in the morning.

A questionnaire about the earthquake was sent to schools in the Walsall area. Of the 350 people who replied, 212 had felt nothing because they had been asleep or on a bus at the time. One hundred and thirty-eight people reported feeling the quake. Of these, 50 people reported that animals had behaved strangely, either before or during the quake.

The Mercalli scale

1 People don't feel it. The shock is recorded by seismographs only. Some animals feel uneasy. Delicately hung objects swing.

2 Only people at rest indoors feel it, especially upstairs in buildings.

3 It seems like the vibrations of a passing lorry. Many people do not recognise it as an earthquake. Hanging objects swing.

4 Many people indoors can feel it and a few people out of doors. It may awaken some people at night. Walls make a creaking noise. The sensation is like a heavy lorry hitting the building. Standing cars rock noticeably.

5 Nearly everyone feels it. Some dishes and windows are broken, doors swing, some plaster cracks.

6 Everybody feels it. Many people are frightened and run outdoors. Books and ornaments fall off shelves. Trees and bushes shake. Small church bells ring, some plaster falls down and chimneys are damaged.

7 It is difficult to stand up. People in vehicles notice it. Furniture breaks, weak chimneys break at the roof line. You can see waves on ponds and pond water becomes clouded with mud from the bottom.

8 Buildings start to collapse. It is difficult to steer a car.

9 General panic; ground cracks, buildings shift off foundations, reservoirs damaged.

10 Landslides, most brick buildings destroyed. Wooden buildings damaged.

11 Few buildings left standing. Bridges destroyed, underground pipes broken.

12 Damage total: waves on the ground; objects thrown up into the air.

Earthquake 1984: what did people in Walsall notice?

'A lot of birds were flying around – don't usually see them.'

'Most of the dogs were barking.'

'Dog ran under the bed the night before and would not come out – this was most unusual.'

'I was asleep and heard a bang. It woke me up.'

'The bed shook, doors closed and rattled.'

'The room began to move as if someone was hitting the walls with a large hammer, accompanied by a rumbling sound.'

'It was like a lorry passing, hardly noticeable.'

'The bed began to shake and the jars in my bedroom shook and clanked together.'

'I was in bed and the bed shook. I thought I was going dizzy so I sat up and it carried on for two more seconds. I went downstairs and no-one said anything about it so I thought I had imagined it.'

'It was like a lorry driving at high speed directly outside the house.'

'There were two tremors, each lasting about eleven seconds with the same effects.'

'Cupboards and wardrobes shook. Outside the TV aerials swayed.'

The effects of the earthquake in other parts of the country varied. Near the **epicentre** – where the earthquake occurred – some buildings were slightly damaged.

Q1 Read the comments of people in the Walsall area. What number on the Mercalli scale would you give to the effects of this earthquake in Walsall?

Q2 Suppose you were sleeping in the bedroom in figure 3. Describe what might happen during an earthquake of strengths: (a) 3, (b) 5 and (c) 7 on the Mercalli scale.

Earthquakes usually last for a minute or so. They are caused by a sudden release of energy in the Earth's crust or upper mantle producing seismic waves.

A **seismograph** is an instrument that detects and records earthquakes.

The **epicentre** is the place on the surface of the Earth directly above the **focus** of an earthquake. Earthquakes which occur less than 70 km under the surface of the Earth are the most destructive to buildings. These are known are 'shallow-focus' earthquakes.

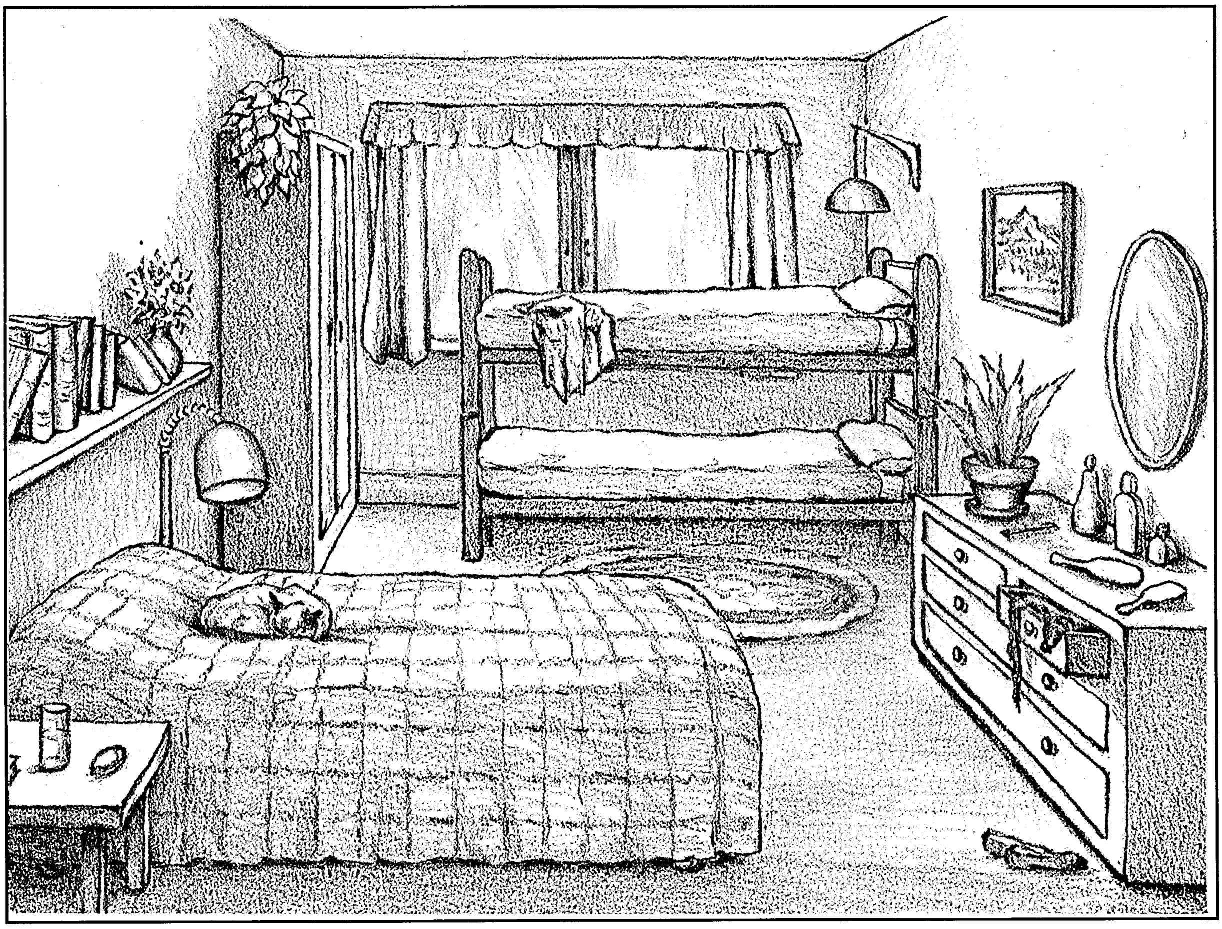


Figure 3 Would you be safe in this room during an earthquake? See question Q2

Where did the earthquake occur?

The intensity of the 1984 earthquake in different parts of Britain is given in table 1.

Table 1 The intensity (Mercalli scale) of the 1984 earthquake in towns and cities across Britain

Town	Intensity
Glasgow	3
Newcastle	3
Belfast	4
Londonderry	3
Lancaster	4
Leeds	4
Grimsby	3
Holyhead	5
Caernarfon	6
Waterford	4
Cork	3
Pwllheli	6
Coventry	4
Cambridge	3
Barmouth	5
Cardiff	4
London	3
Plymouth	3
Southampton	3

Activity *(Use worksheet 1)*

1 Worksheet 1 is a copy of the map of Britain, shown in figure 4. Write the intensity values from table 1 beside the dot marking each town on the map. For example, put a '3' beside Glasgow on the map.

2 Join all the dots that have the same value. Make smooth curves. (These curves should not cross each other.)

This is an **isoseismal map** of the earthquake.

Q3 *What according to the isoseismal map, was the intensity of the earthquake in Walsall?*

Q4 *How does this value compare with the evidence provided by the Walsall school survey?*

Q5 *Which two towns on the map appear to lie closest to the epicentre?*

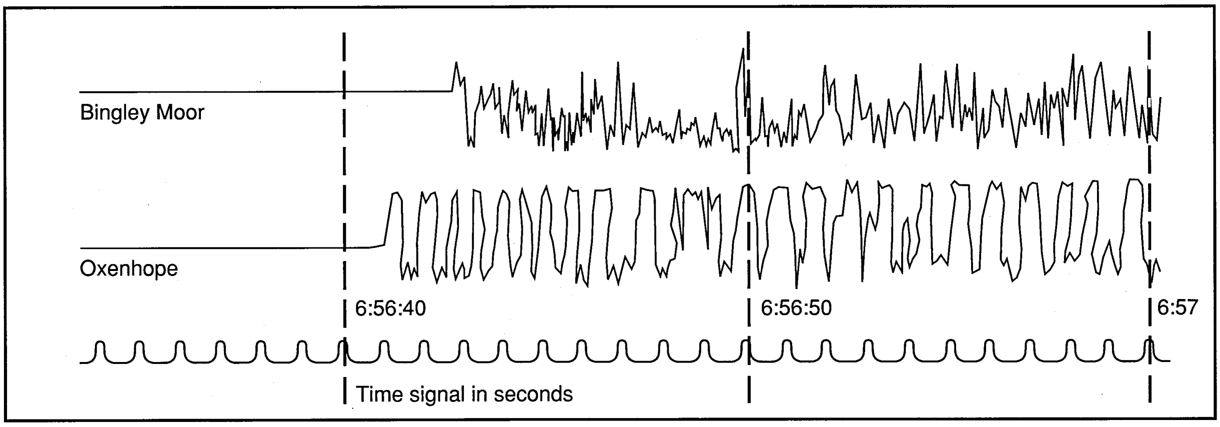
Figure 4 Map of the British Isles showing the position of the towns and cities in table 1. Use the copy of this map on worksheet 1.

When did the earthquake occur?

The traces in figure 5 show shock waves from the 1984 earthquake arriving at seismographs at Bingley Moor and Oxenhope. These earthquake monitoring stations are situated near Leeds and are 10 km apart. By chance, they were exactly in line with the epicentre of the earthquake. The third trace shows the time in seconds and reads in Greenwich Mean Time.

The traces were made just before 7:00:00 GMT (in other words, just before 8.00 a.m. British Summer Time).

Figure 5 Seismograms of the 1984 earthquake as shown on worksheet 2



Work from the map and traces on worksheet 2. Assume the earthquake occurred at the surface.

Q6 *Which station did the shock wave reach first?*

Q7 *Use the timescale on worksheet 2 to find the time-lag between the first arrival of the shock wave at the two stations.*

Q8 *The recording stations are 10 km apart. How fast was the wave travelling?*

Q9 *Mark on the map the position of the epicentre of the earthquake. Use the scale of the map to estimate how far it was from Oxenhope.*

Q10 *How long would the wave take to travel this distance?*

Q11 *At what time (to the nearest second) did the first arrival occur at (a) Bingley Moor, (b) Oxenhope?*

Q12 *At what time GMT did the earthquake begin?*

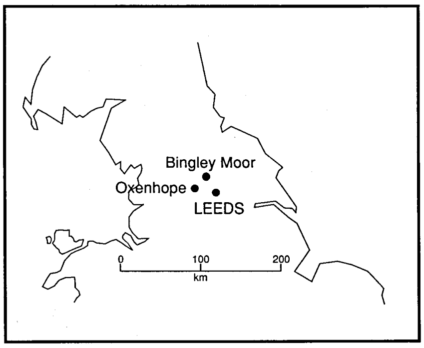


Figure 6 The location of the earthquake monitoring stations, Bingley Moor and Oxenhope

Part B – Detecting earthquakes

When an earthquake occurs, its strength and position are calculated using readings from many seismographs.

The Chinese invented the first earthquake detectors. They looked like large pots. When an earthquake occurred, dragons near the top of the pots spat balls into the mouths of the frogs below. Information about which balls had fallen from several detectors told them where the earthquake had happened.

Geologists now use seismographs to measure either vertical or horizontal movements of the ground. The motion is magnified electronically and a trace recorded on a rotating drum. Modern seismographs are so sensitive they can measure ground movements as small as 0.000 000 000 1 m.

The problem in measuring vibrations is to have a steady point when the ground moves. In figure 8, this is the pen. It remains steady when the ground moves because it is attached to a large mass. (A large mass has a property called inertia – it does not like to change its position.)

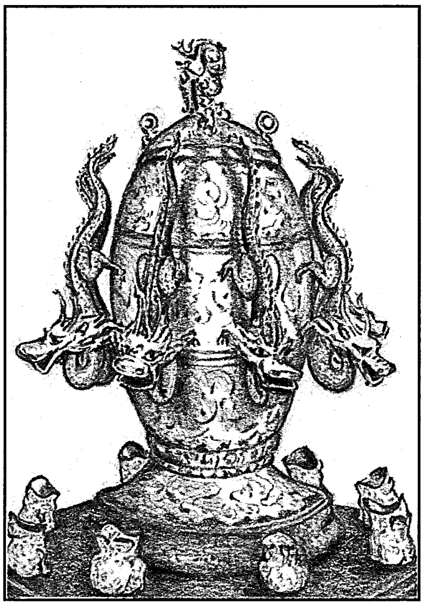


Figure 7 A Chinese earthquake detector invented in 132 AD

Can you make an earthquake detector?

Using the apparatus available to you design, build and test an earthquake detector. It should detect and record the vibrations caused by someone hitting the bench on which it stands.

A good device should have a measuring scale somewhere to show the difference between a light and heavy bang.

1 *Draw a diagram to show how your apparatus worked.*

2 *Explain how it detected the bang – which bits moved and which did not.*

3 *Was the apparatus reliable? Say if it worked every time.*

4 *Suggest how it could be improved.*

5 *Did it detect the difference between a light and a heavy bang?*

6 *Were you able to calibrate it?*

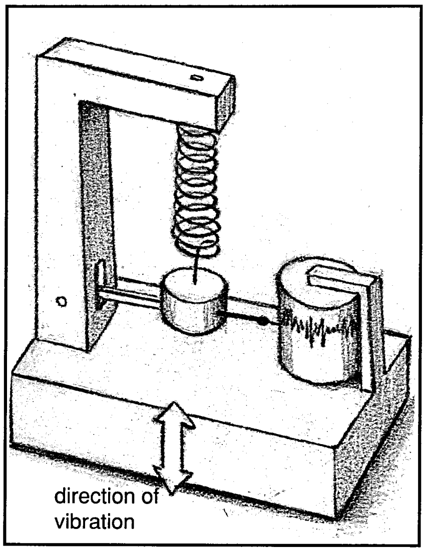


Figure 8 A simple seismograph

Part C – A big British quake?

Most earthquakes happen where two of the Earth's tectonic plates rub together.

Earthquakes can also occur within plates due to the release of stresses locked up in ancient faults. Although Britain is far from any plate margin, there have been several earthquakes with an intensity of 6 on the Mercalli scale (about 5 on the Richter scale) in the last hundred years. Geologists believe that even stronger earthquakes could occur at any time.

In Japan and California, USA, where strong earthquakes are expected, people make preparations for such emergencies. School children practise earthquake drill. Families keep emergency supplies such as those in the list on the right which comes from California.

Earthquake emergency list

Do you know where to find the following?

Radio (battery powered)
Torch
Extra batteries
Fire extinguisher
First aid supplies
Prescription medicines
Water purification supplies
Stored water
Gas main stop cock
Water main stop cock
Electricity mains switch
Food
Sturdy shoes
Heavy gloves
Blankets
Map showing location of local hospitals and emergency relief centres

Questions for group discussion

You may use worksheet 3 for your answers.

☐ *Consider the items on the 'Earthquake emergency list'.*

☐ *Why might you need (a) the radio, (b) water purification supplies, (c) heavy gloves, (d) the map?*

☐ *Decide how useful each item would be in an earthquake emergency. Rate them for usefulness as follows:*

3 = essential, 2 = very useful, 1 = useful.

(You may record your 'usefulness score' in the table on worksheet 3.)

☐ *An earthquake is a natural disaster, known in law as an 'act of God'. (a) Suggest other examples of disasters which could happen to your home or neighbourhood. (b) Would the same items on the earthquake emergency list be useful? Can you think of any items to add to the list?*

Homework activity *(Use worksheet 3)*

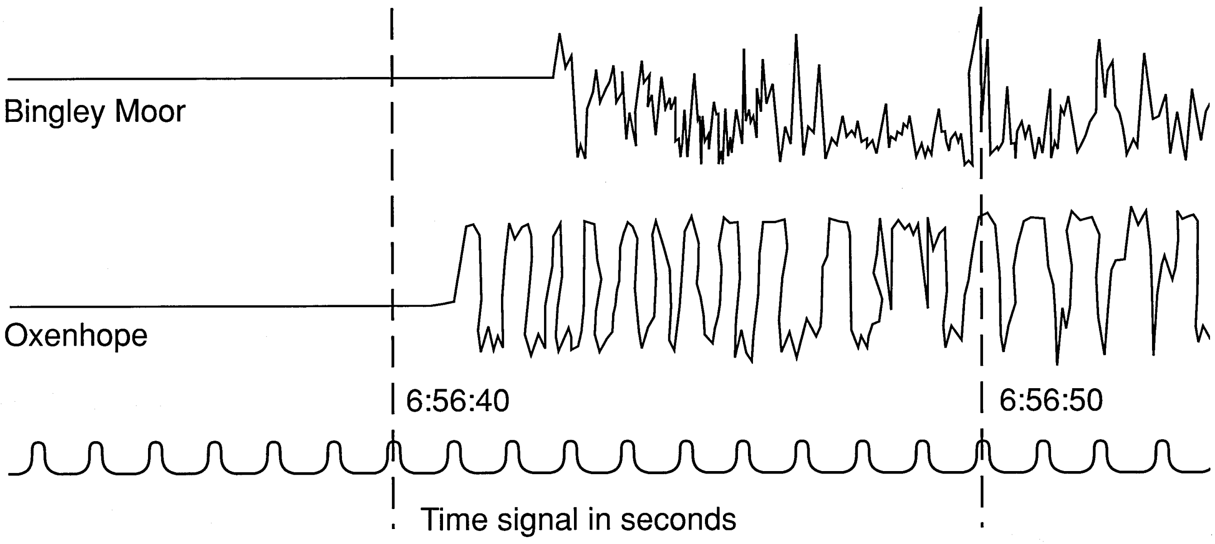
How would you cope with an earthquake?

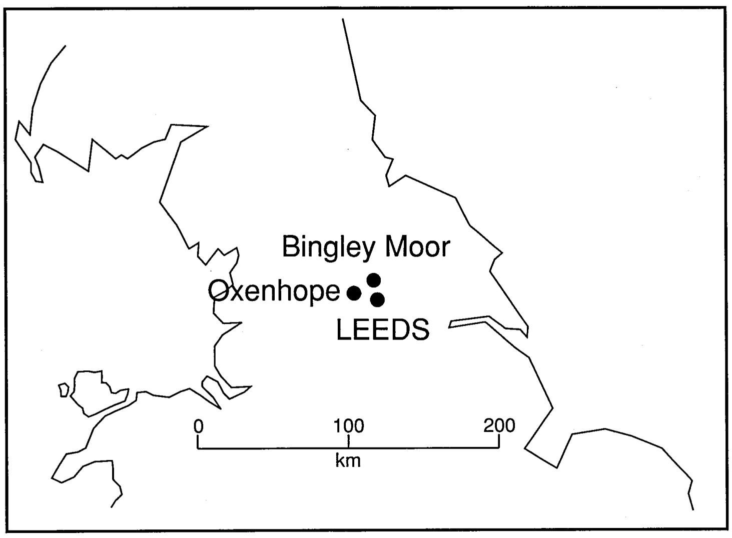
☐ Can you find the items on the 'emergency list' in your home? Fill in the checklist on worksheet 3.

☐ Survey your kitchen, bedroom and living room for earthquake hazards. Make a list of those you find.

Answers to the questions are given in the *Teachers' Notes*.

Map of the British Isles for drawing isoseismals





Seismograms of the 1984 earthquake

Part C

Name

____

Earthquake emergency list

Although you are unlikely to experience a strong earthquake in Britain, it is possible for one to occur. In the event of an emergency, do you know where to find the following things?

	Usefulness score	**Do you have it?**	**Where to find it in your home**
Radio (battery powered)			
Torch			
Extra batteries			
Fire extinguisher			
First aid supplies			
Prescription medicines			
Water purification supplies			
Stored water			
Gas main stop cock			
Water main stop cock			
Electricity mains switch			
Food			
Sturdy shoes			
Heavy gloves			
Blankets			
Map showing location of local hospitals and other buildings which might be used as emergency relief centres			
Total score			

THE GREENHOUSE EFFECT

Science content

Greenhouse effect, greenhouse gases, global warming, climate, biosphere.

Science curriculum links
AT 1 Exploration of science
AT 5 Human influences on the Earth
AT 9 Earth and atmosphere
AT17 The nature of science

Syllabus links
- GCSE Science, Biology, Chemistry, Physics,
- Geography
- Sixth-form General Studies

Cross-curricular themes
- Environment

Lesson time
1–3 hours
(homework possible)

Links with other SATIS materials
301 Air Pollution - where does it come from?

SATIS 16–19
69 Living in a greenhouse

NERIS
Search on
GREENHOUSE EFFECT

SUMMARY

The unit explains the factors that contribute to the greenhouse effect and its potential for global warming. Students are invited to draw their own conclusions.

STUDENT ACTIVITIES

- ☐ Parts A and B Reading information, interpreting data in the form of graphs, tables, maps and diagrams.
- ☐ Part C Considering evidence.
- ☐ Quiz to accompany the information.
- ☐ Small group discussion (or questions for written answers).
- ☐ Role-play simulation involving the whole class.

AIMS

- ☐ To link with work on the environment, harnessing energy and weather systems
- ☐ To develop skills in evaluating evidence
- ☐ To develop communication skills through role-play
- ☐ To heighten awareness of the impact of human activities on global warming and the life-threatening changes that may result

USING AND ADAPTING THE UNIT

- ☐ Activities (quiz, small group discussion and role-play) are provided for students of different abilities.
- ☐ Parts A, B and C used with the quiz are suitable for independent work or homework.
- ☐ The quiz may be used to revise prior work on the greenhouse effect before reading the unit.
- ☐ The role-play simulation may be used separately.

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First published 1991

Teaching notes

The unit provides a range of activities to accompany the text.

Parts A, B and C consist of data and reading material which may be used with the quiz or the discussion questions. Alternatively, they may be used to support students preparing for the role-play.

The quiz and questions may be used as discussion activities.

The interactions between various global cycles and the probable effects of global warming are not well understood at the moment. Students and teachers may wish to follow the development of ideas over a period of time, keeping a file or scrapbook of information from the media. The *New Scientist* and the quality press give frequent updates on research into this area.

A useful book for teachers on the greenhouse effect is *Hothouse Earth* by John Gribbin, Bantam Press 1990, (ISBN 0593 017951).

Simulated TV programme

Does it matter? is a role-play which may be used separately or to follow-up the main part of this unit. The scenario, a TV discussion programme, is about the impact on individuals of measures to limit global warming.

Role-play cards are provided to help students get into role. However, students may prefer to invent their own names and roles. Simple props like a hat are very effective. There is an optional page with 26 named roles for the audience.

Time needed

preparation	1/2 hour of lesson time plus homework
role-play	1/2 hour for TV show
debriefing and discussion	1/4–1/2 hour

Requirements

The following number of copies are needed.

page 10 (and page 14, if used)	class set
page 11 host and researcher(s)	2 to 5 copies
pages 12 and 13	1 copy of each

Allocating the roles

- The role of 'programme host' is demanding. She/he will need to prepare a set of questions or a script for the programme. This may be done as a group activity with the researchers. (Spare copies of the host's role card will be useful for the researcher(s).)
- The role of 'researcher(s)' is optional. The researcher's task is to provide support for the host in planning the programme.
- The four guests.
- Audience roles.

Suggested procedure

The SATIS General Guide for Teachers and the preliminary pages of Update 91 contain suggestions for running role-plays. The BBC Radio programme, 'The Coal Mine Project', from SATIS Topics 14–16, also provides a useful insight into preparation for a similar role-play.

- Allow time at the beginning of the lesson for students to finalise their roles. Check that members of the audience each have a question to put to the panel.
- Arrange the 'studio' seating.
- Ensure that all understand the format of the programme and that those in the audience may be invited to speak after the four guests.
- After the role-play, encourage students who have had to support a viewpoint which they do not hold to 'come out of role' and explain their own ideas on the issue.

Teachers may wish students to write a report of the 'programme' afterwards.

Acknowledgements

Figure 1,3 adapted from the IPCC's report summary 1990

Table 1 adapted from *The Independent* 17 April 1990

Figure 4 Based on data from William C. Clark, *Scientific American*, September 1989

Figure 5 reproduced by permission of R. F. Saunders Meteorological Office Photo Library

Figure 6 Based on data from U S National Academy of Sciences

Figure 7 and 11 Based on data from John Mitchell, 'Greenhouse Physics', *Physics World* June 1990

Figure 10 Based on data from British Antarctic Survey

Figure 12 Based on data from James Hansen/GISS

Figure 13 Based on data from Vostok core

Figure 14 Based on data from Charles Keeling/Carbon Dioxide Information Analysis Center

Ross Reynolds and Dr Keith Shine of the Department of Meteorology, University of Reading, read and commented on the original draft.

Answers to the quiz

The quiz is designed to provoke thought and discussion rather than lead to 'correct' answers. Opinions may vary and the answers below are for guidance only.

1 A

2 D/B

3 C

4 B/A

5 A

6 C

7 B/C Farmers may change to crops now grown in warmer climates. Crops may grow better in the north of the country.

8 A

9 D Methane, CFCs, N_2O, water vapour are also greenhouse gases.

10 B/A

11 D

12 A Methane

13 D They have a very high global warming potential.

14 B Cloud cover is thought likely to increase over the colder parts of the globe.

15 A

16 D Abandoning internal combustion engines would not reduce the emission of CO_2 sufficiently to halt global warming. As most electricity is generated from fossil fuel, using electric cars would not in fact help.

17 B More true to say that hurricanes may be more common as a result of global warming.

18 D Air trapped in polar ice 150 000 years ago is being analysed by scientists today.

19 B The impact of such feedback is thought to be slight.

20 A

Answers to the questions

A1 *Carbon dioxide, methane, water vapour and dinitrogen oxide.*

A2 *Ice sheet reflects the Sun's energy into space. Forests remove* CO_2 *from the atmosphere.*

Q1 *(a) Remains at the same temperature.*

(b) Temperature rises.

Q2 *The large amount of carbon dioxide emitted makes it the major cause for concern. An indication of the global warming effect from emissions of each gas can be found by multiplying the first and final columns of table 1 together.*

Carbon dioxide 26 000, methane 6300, CFCs 6000, dinitrogen oxide 1740.

Q3 *Increased temperature of sea water will cause its volume to increase (like the expansion of liquid in a thermometer). If the polar icecaps melt, the sea level will rise further.*

Q4 *If the emission of greenhouse gases is severely reduced, the model predicts that global warming will continue more slowly. The reason is that the onset of global warming will trigger many positive feedback loops. For example, water vapour is a greenhouse gas. More water vapour in the air may cause the temperature to rise further. Melting of the icecaps will make more of the Earth's surface dark and therefore more of the Sun's energy will be absorbed.*

Q5 *This is very much a matter of opinion.*
(a) Figures 6 (9) and 10
(b) Figures (9), 11 and 12 may be interpreted by some as showing a slight rise.

Q6 *(a) (i)* CO_2. *Prevent destruction of the forests, plant new forests, restrict the burning of fossil fuels (possibly by a tax).*
(ii) Methane. Reduce number of livestock (cattle, sheep etc.). Reduce refuse tipping.
(iii) Reduce the use of foam containers (e.g. for fast foods) find substitute chemicals for CFCs in fridges, foams, solvents etc.
(iv) Reduce the combustion of wood and fossil fuels, use of fertilisers.

THE GREENHOUSE EFFECT

Part A and B: information, interpreting data

Part C: evidence

Quiz: for use before or after reading the unit.

Questions: for discussion or individual answers.

Role-play (optional): involving the whole class in a discussion programme.

Many scientists predict that the world will become warmer. They say this is due to more carbon dioxide in the atmosphere and the **greenhouse effect**.

Part A – What is the greenhouse effect?

Life on Earth depends on energy. Energy from the Sun reaches the atmosphere and warms it up. Some of the Sun's energy warms the land and the oceans too. And some of the energy the Earth receives, it reflects and radiates back into space.

The Earth's atmosphere traps the Sun's energy and keeps the surface about 35 °C warmer than it otherwise would be. This is due to its greenhouse effect. Without it, life as we know it would be impossible.

The atmosphere contains very little **carbon dioxide,** but the amount is rising rapidly, as figure 1 shows. Carbon dioxide captures some of the Sun's energy, in the same way that a greenhouse becomes warm on a sunny day. That is why carbon dioxide is called a **greenhouse gas**. With *more* carbon dioxide in the atmosphere, the Earth traps more energy than it radiates back into space.

It is easy to see that if the Earth takes in more energy than it loses, it will gradually get hotter. Most scientists forecast **global warming**.

Absorption and emission of infrared energy

You can feel this happen on a sunny day in summer. The tarmac surfaces of playgrounds and roads get much hotter because, being dark, they are good absorbers of the Sun's radiant energy.

If you hold your hand above them, you can feel that they also radiate heat away.

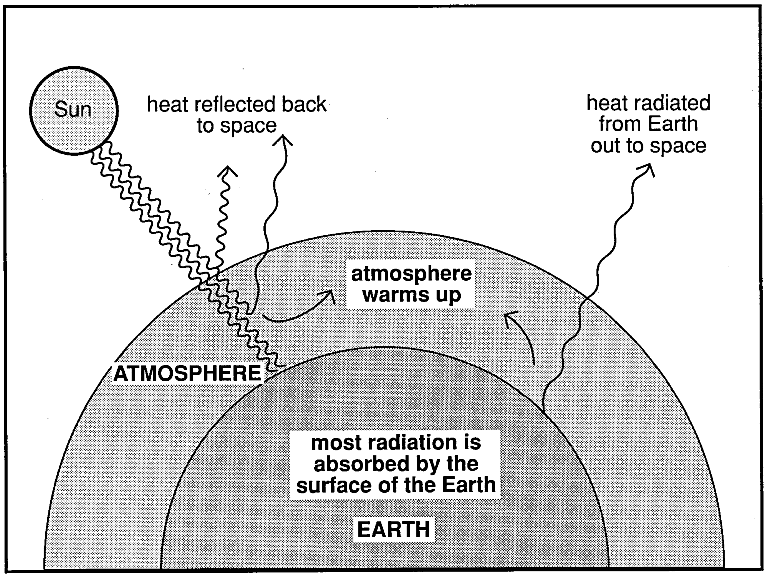


Figure 2 How the greenhouse effect works – how the Earth's atmosphere traps energy from the Sun

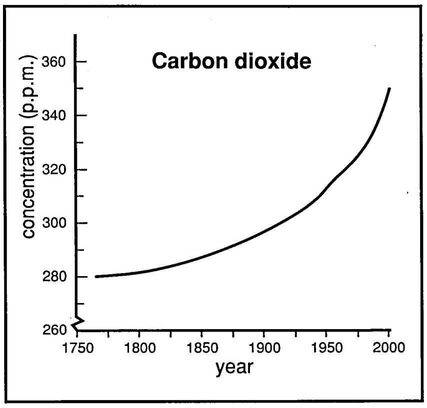


Figure 1 The concentration of carbon dioxide in the atmosphere since 1750

Carbon dioxide is not the only greenhouse gas. Water vapour is too, and it has a greater effect. Methane, chlorofluorcarbons (CFCs) used in aerosols and refrigerators, dinitrogen oxide* and ozone also trap the Sun's radiation and can lead to global warming.

Like carbon dioxide, the levels of these gases in the atmosphere are rising. The increases are due to human activities such as harnessing energy, felling forests, growing crops and keeping cattle.

**Dinitrogen oxide is commonly known as nitrous oxide*

Figure 3 The changing concentration of methane, CFCs and dinitrogen oxide in the atmosphere since 1750

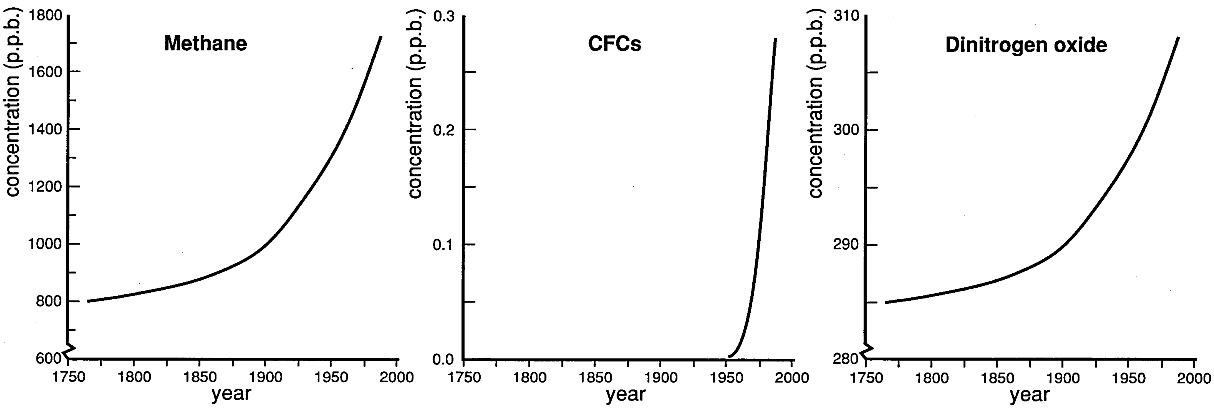


Table 1 The increase in greenhouse gases. The global warming effect shows how much warming one tonne of the gas causes in a century, compared with the warming produced by one tonne of carbon dioxide

Gas and sources	Emissions in 1990 (10^6 tonnes)	Concentration (parts per million in atmosphere)	Yearly increase %	Global warming effect
carbon dioxide burning fossil fuels and forests	26 000	354	0.5	1
methane swamps, bogs, paddy fields, animal dung, natural gas leakage, rubbish tips	300	1.72	0.9	21
CFCs fridges, foams, solvents aerosol sprays	1	0.001	4	6 000
dinitrogen oxide burning forests and fossil fuels	6	0.31	0.25	290

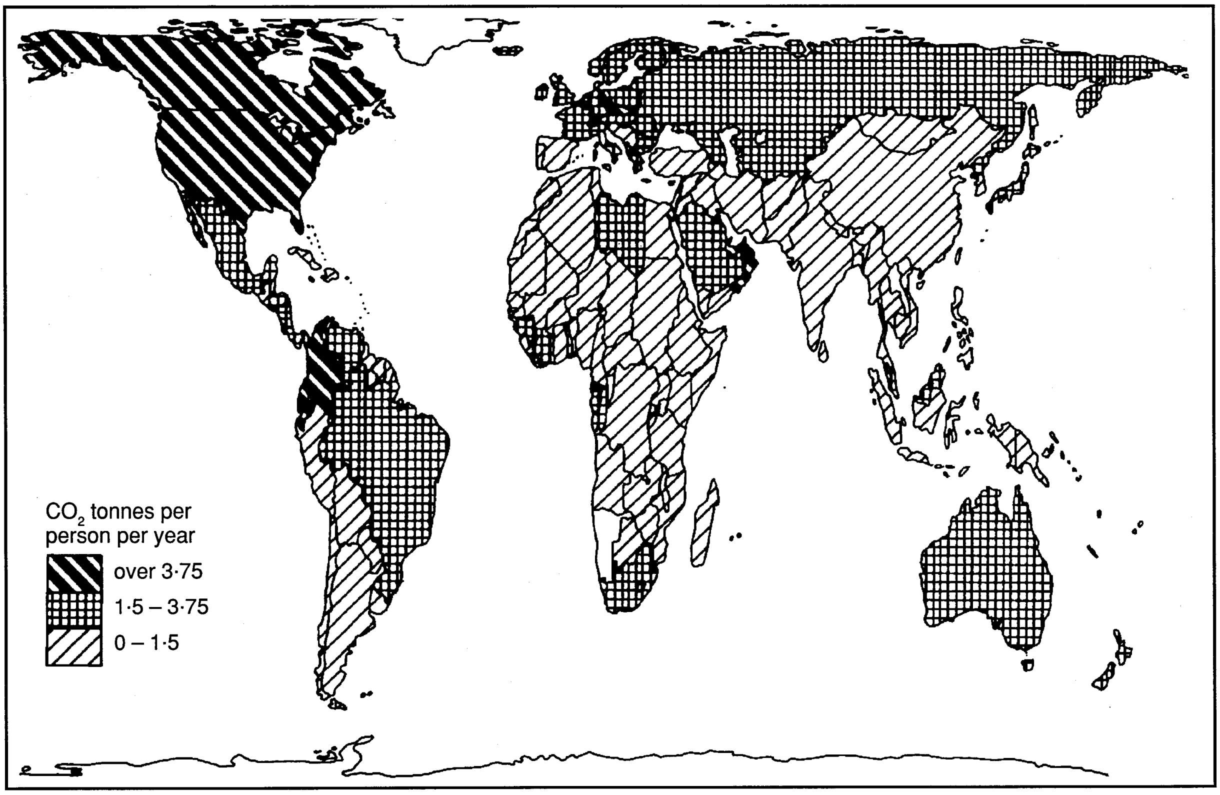


Figure 4 Carbon dioxide emissions from using energy. The map shows the number of tonnes per person per year

Part B – Global warming

What would global warming mean in practice?

The atmosphere, the Earth's surface and the oceans would become hotter. Sea levels would rise – mainly because water in the oceans expands as its temperature rises.

A warmer atmosphere would evaporate more water from the oceans. Certainly the climate would be different.

Scientists who study climate are modelling weather patterns with computers. They predict that global warming would not affect all parts of the Earth equally. There would be more rain and snow near the poles and droughts elsewhere.

Global warming may force people to flee from drought and famine to more temperate lands further north. Rising sea levels would threaten the homes and livelihood of millions of people, for example, in parts of Bangladesh, Britain and Holland.

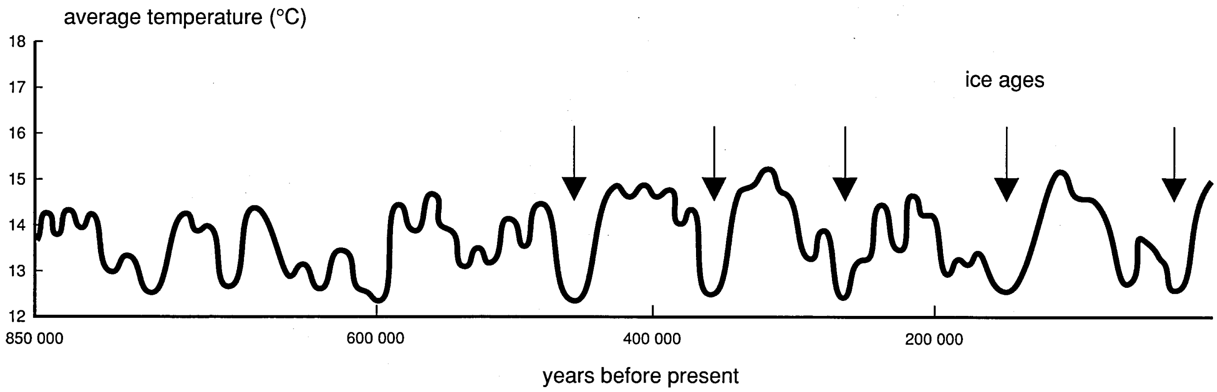
The balance of nature would alter as climate zones change. Britain in the 21st century may be too warm for many of its native trees or for the conifers planted by foresters. Insect pests normally killed by cold winters could thrive. Plants and trees may flower early and remain unpollinated through lack of insects.

Figure 5 Clouds form part of the water cycle. Global warming predictions suggest that cloud cover may increase in some areas

Will global warming happen?

The climate has changed many times since the Earth was formed 4500 million years ago. So has the mixture of gases in the atmosphere. We live in a warm period, but ice ages have been common in the Earth's past. The cold winters of the 1960s and 70s caused some people to predict the beginning of a new ice age.

Figure 6 Changes in the average temperature of the Earth over the past 850 000 years. The peaks represent warm periods, the troughs are ice ages



The computer models of the Earth's climate system predict that once global warming starts it will continue at an ever increasing rate. By 2030, the climate could be warming over 50 times faster than it did after the last ice age.

The curves in figure 7 below predict the temperature of the Earth. Curve (a) shows what would happen if the amount of carbon dioxide in the atmosphere continues to rise as it has done in the past. Curve (b) shows what would happen if there were strict measures to reduce the rise in greenhouse gases.

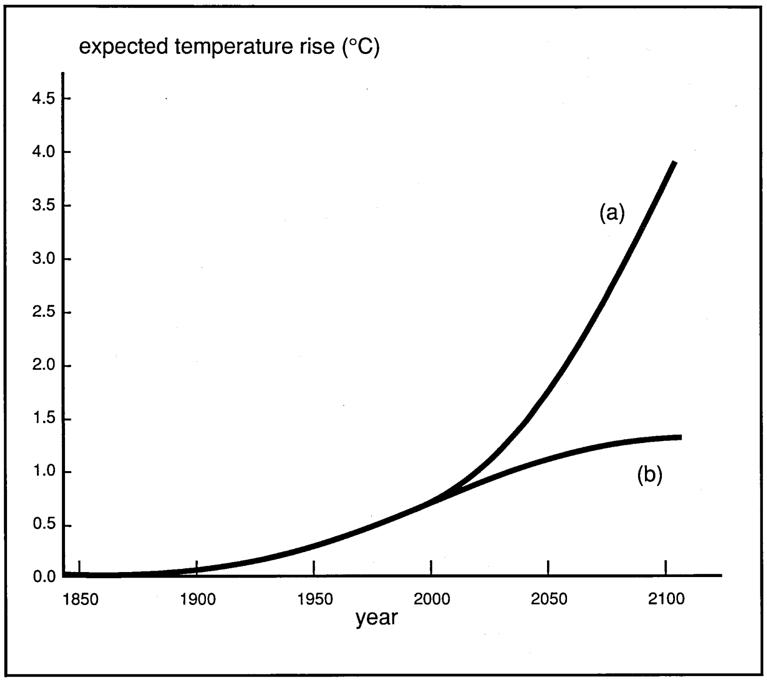


Figure 7 The temperature of the Earth if CO_2 levels (a) continue to rise and (b) are cut back as much as possible.

Most scientists agree that global warming will occur. But they are unsure about how soon or what the effects will be. They say we understand too little of the systems that regulate our planet.

The links between animals, atmosphere, plants, oceans and rocks are not fully understood. There are too many factors that affect the climate to be sure of any predictions.

Look at figure 8.

A1 *Which greenhouse gases are being added to the atmosphere?*

A2 *Which features in the landscape help to prevent global warming?*

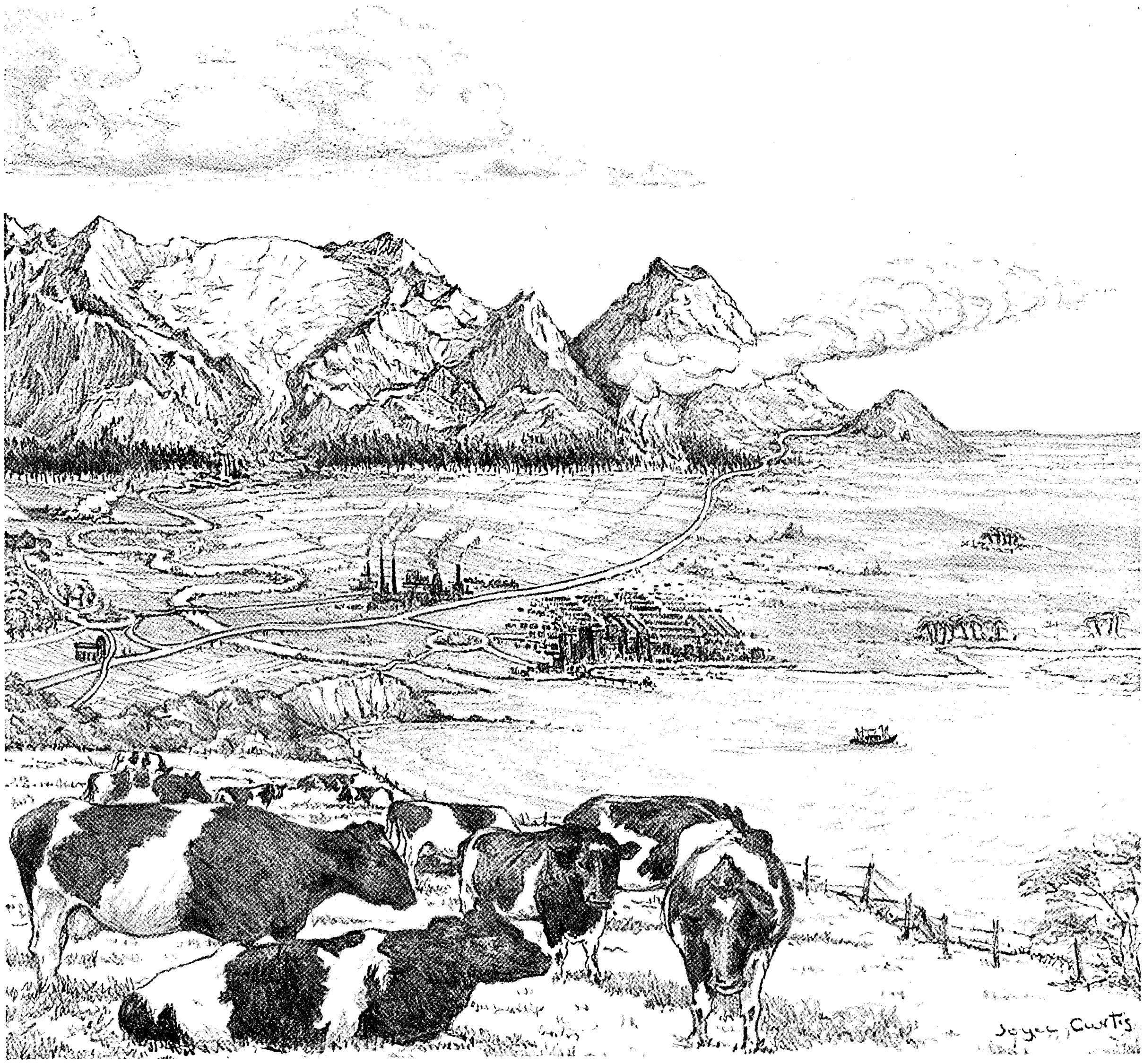


Figure 8 Human activity and the biosphere

Part C – Is the world getting warmer?

Detecting global warming is not easy. Some say the evidence is already here and that global warming has begun.

The next two pages contain data for you to consider the evidence for yourself.

Figure 9 The extremes of Britain's weather through the ages

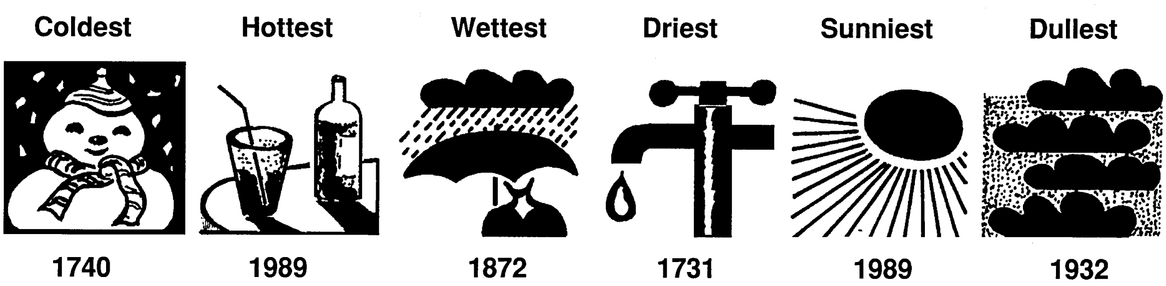


Figure 10 The changes in the annual average temperature of the Antarctic

The Antarctic is far from where people live. If the Earth's temperature is rising it should show up as a rise in the average temperature of the Antarctic. Some people think the graph shows an increase, but it is not 'statistically significant'.

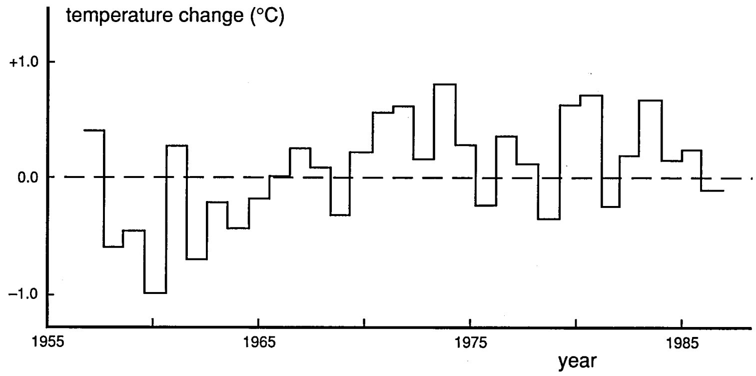


Figure 11 Are the oceans getting warmer? The map compares the average sea temperatures between 1903 and 1912 with those between 1978 and 1987

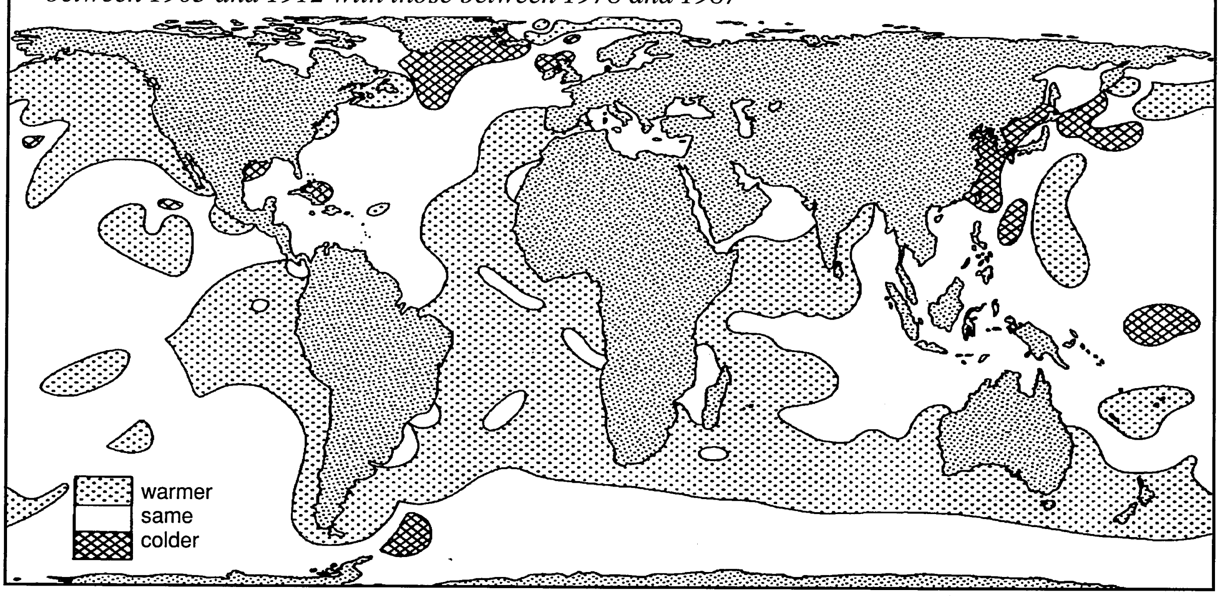


Figure 12 How average sea level has changed over recent years

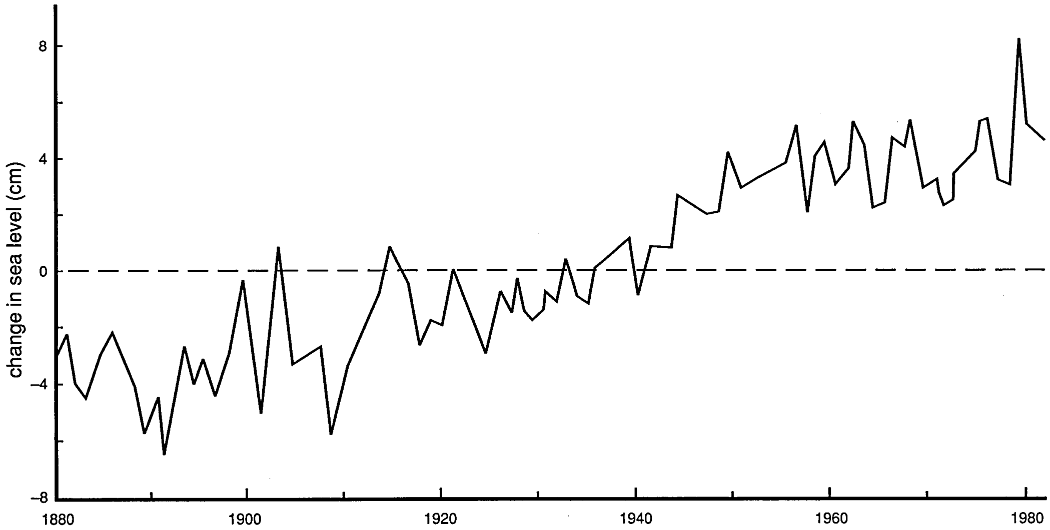
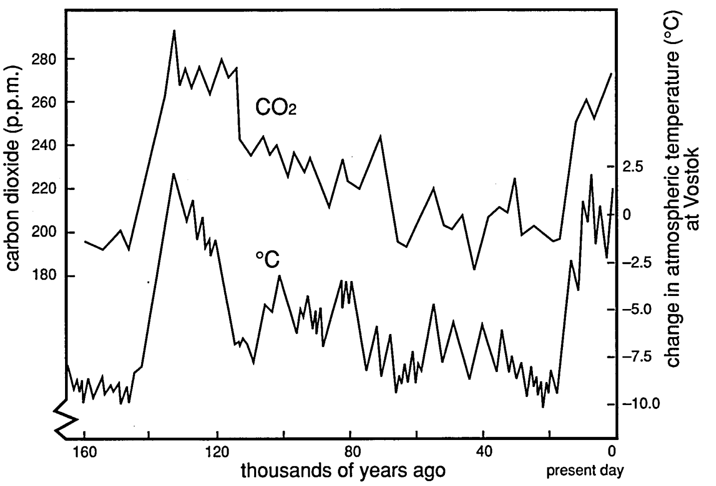
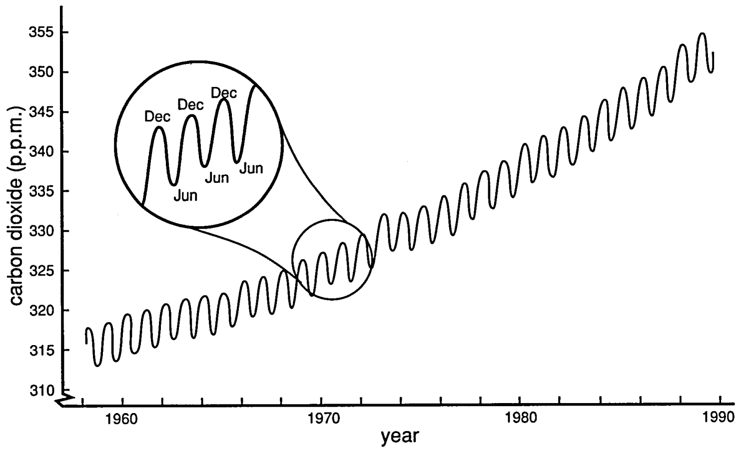


Figure 13 How the carbon dioxide content of the atmosphere and the global temperature have changed over the last 160 000 years



Scientists obtained the data for the carbon dioxide content of the atmosphere in the past from air bubbles in the ice covering Greenland and Antarctica. The bubbles deep down contained air trapped long ago.

Figure 14 The global carbon dioxide content of the atmosphere measured at the observatory at Mauna Loa in Hawaii



Hawaii is in the middle of the Pacific Ocean more than 2500 km from the nearest mainland. The observatory is on the top of a mountain, at a height of over 3000 m.

The global level of carbon dioxide varies during the year. This is due to photosynthesis. It is highest in December and lowest in June because there is more land and therefore plants to take up carbon dioxide in the northern hemisphere.

Quiz

What do you know about the greenhouse effect and global warming?

Here are some statements. Decide if they are

A	**true**
B	**can't be sure**
C	**unlikely**
D	**false**

1 There is more carbon dioxide in the atmosphere than there was 100 years ago.

2 If summer temperatures in Britain reach record highs next year, you can be sure that the global warming has started.

3 Global warming will not happen for another 100 years.

4 The greenhouse effect will cause global warming.

5 Global warming will cause sea levels to rise.

6 All ski resorts will have to close by the year 2010 because of global warming.

7 Global warming will make crops grow better in Britain.

8 Carbon dioxide in the atmosphere helps to trap the Sun's energy.

9 Carbon dioxide is the only gas with a 'greenhouse effect'.

10 Felling the forests and burning fossil fuels leads to global warming.

11 On a warmer Earth, people will need to burn less fuel to keep themselves warm, so global warming will slow down and stop.

12 Cows release gases which add to global warming.

13 CFCs damage the ozone layer but do not contribute to the greenhouse effect.

14 If the Earth's temperature rises there will be more clouds in the sky because more water will evaporate into the atmosphere.

15 Water vapour in the atmosphere traps the Sun's heat and adds to the greenhouse effect.

16 If the global warming starts we can stop it by using electric cars instead of burning petrol.

17 Hurricane force winds are caused by global warming.

18 Scientists cannot tell how much carbon dioxide was in the atmosphere 150 000 years ago because nobody made any measurements then.

19 Global warming will increase the rate of photosynthesis in plants. This will help to lower carbon dioxide levels.

20 If the Earth's temperature rises, it will radiate more energy back into space. The temperature of the Earth will settle at a new higher level.

Questions

These questions are for discussing in a group or for answering by yourself.

Q1 The Earth loses some of the energy it receives from the Sun by radiating and reflecting it out to space.

What would happen to the temperature of the Earth if it absorbs

(a) as much energy as it loses,

(b) more energy than it loses?

Q2 Explain why carbon dioxide is the major cause of concern in global warming although other gases (see table 1 on page 2) have a greater global warming effect.

Q3 Explain how global warming could cause sea levels to rise.

Q4 What does figure 7 predict will happen to global temperatures if emissions of greenhouse gases are much reduced? Suggest why this may be so.

Q5 What information can you find in this unit that suggests:

(a) there is no clear evidence of global warming taking place

(b) global warming has already begun?

Q6 (a) What could be done to stop the increase in the following greenhouse gases in the atmosphere

(i) carbon dioxide,

(ii) methane,

(iii) CFCs,

(iv) dinitrogen oxide?

(b) Who do you think should be responsible for reducing greenhouse gases: individuals, local communities or governments?

Discussing questions in a small group

- Appoint someone to chair the group.
- Arrange your seats so that everyone in the group can hear and see each other.
- Make sure that everybody has a chance to contribute.
- Make a note of your group's answers and ideas.
- Nominate someone to report the main points of your discussion to the class, if asked to do so.

Answers to the questions are given in the *Teachers' Notes*.

THE GREENHOUSE EFFECT ▫ *Does it matter?*

A role-play simulation of a TV discussion programme.

Does it matter?

This is about an imaginary TV programme, 'Does it matter?', in which you will take part with your class. It is a weekly programme which looks at issues involving science. Four guests, scientists and non-scientists, will air their views before a specially invited audience.

The topic of this week's programme is 'The Greenhouse Effect – does it matter?'

Everybody in the class will have a role to play as:

- a member of the specially invited audience,
- the programme's host (who may be assisted by researcher[s])
- one of the four invited guests.

To prepare for your role

- *Find out all you can about the greenhouse effect.*
- *What is the point of view of the person you will be playing?*
- *What will be the viewpoints of people in the other roles?*
- *If you are a member of the audience, what question would you like to ask the panel?*

8.30 p.m. **Does it matter?**

The TV chat show about science issues is hosted by Alexis Alexander.

The topic for today's guests will be *the greenhouse effect.*

As usual four people with a wide range of interests will take part in a discussion before an invited studio audience.

Ann Ellis is a scientist who has worked for the British Antarctic Survey for over thirty years and is an expert on the possible causes of changes in climate.

Juan Vaqueiro owns one of the largest cattle ranches in South America. He created it from virgin rainforest 40 years ago. The land has lost its fertility and his sons continue the task of felling trees to provide more grazing land.

Paula Watt is a director of a new electricity generating company. Her company has bought old power stations to recondition them to run on cheap imported coal.

Arthur Plank is a Midlands manufacturer of high class furniture. Most of his hardwoods come from tropical countries. His raw materials, hardwoods, are becoming scarcer and more expensive.

You need 3 to 5 copies of these role cards.

Role card

Host, Alexis Alexander

You will introduce the show, ensure that the conversation runs smoothly and, if there is time, invite people from the audience to make a point or to question the guests.

1 Welcome the viewers and audience to the show. Announce this week's topic, 'The greenhouse effect – does it matter?'. Introduce the specially invited guests (as described in the TV paper).

2 Give some background information:

The amount of carbon dioxide in the atmosphere is increasing. Nobody is sure what the effects will be but many scientists believe that the world is getting warmer.

They blame:

(i) the increase in burning of fossil fuels, such as coal, gas, oil, as well as wood,

(ii) the felling of forests, especially the tropical rainforests.

3 Ask a different question of each of your guests to invite them to express their point of view.

4 Ask members of the audience if they have a question to put to the panel or a point to make.

5 Finish the programme by:

(i) summing up the points made in the programme,

(ii) thanking the guests and the invited studio audience.

Optional role card

Researcher

Your task is to ensure that the host and guests have interesting ideas to contribute to the discussion.

Help the host to plan the interviews with the guests and check that the guests will have good answers.

You will need one copy of these role cards

Role card

The cattle rancher, Juan Vaqueiro

You and your wife Maria have a large family and live in large ranch house. The land you ranch was once forest and is now infertile. You have cleared half the land but the grazing is poor and the cattle need more land.

You need to sell more beef cattle for export. Your country is very poor and has large debts to the richer countries. This has caused a high level of inflation, the goods in shops become dearer each day.

Many of your workers have already left the countryside and moved into the slums in the cities. Here the death rate is high, especially for babies. If you clear more forest you can continue to employ a large workforce and provide them with houses and medical care. If you cannot expand your grazing area you will have to sack many workers.

Role card

Electricity company director, Paula Watt

You help to run a new electricity company formed after the privatisation of the electricity supply industry.

Your company is buying old power stations and reconditioning them. This is much cheaper than building new ones although they are less efficient to run. Your company believes it can keep the price of electricity low by using cheap imported coal.

You should be able to undercut the prices charged by other companies to the benefit of the consumer. You want people to use more electricity so that your company can grow fast.

You will need one copy of these role cards.

Role card

Furniture manufacturer, Arthur Plank

Your furniture manufacturing business has been in the family for three generations.

You make tables and chairs from hardwoods which come from the tropical rainforests. Your agent buys large areas of forest cheaply from ranchers who want to clear their land.

You could buy hardwood from a producer in Indonesia who replants the areas of forest which have been felled. This would cost more. Your profit margins are so small that using a more expensive supplier might cause your firm to become bankrupt. Families which have been employed by your firm for generations could lose their livelihood.

Role card

Scientist, Ann Ellis

You have worked for the British Antarctic Survey for 30 years. In your research you have found a strong link between carbon dioxide levels in the atmosphere and the temperature of the Antarctic.

You have been studying bubbles of air trapped in the snow over the last 160 000 years. Your figures show that in the past, the temperature of the atmosphere rose when carbon dioxide levels were high.

You have investigated the worst thing that global warming could cause. This would be the melting of the icecaps at the poles. If this happens, sea levels will rise by 5 metres, according to your calculations. The ordinary person in the street is unaware of the seriousness of the problem. Much of the world's low-lying land will be below sea level. Pacific atolls will be flooded as well as many cities and much of the world's most fertile land. You have agreed to take part in the programme to try to convince people of the possible consequences of global warming.

Audience roles (female)

A: You are **Doris Old**, pensioner.

B: You are **Gabrielle Green**, a prominent member of Friends of the Earth.

C: You are **Winifred Winney**, mother of five and member of the Women's Institute.

D: You are **Mary Mawani**, an overseas student from a coral island in the Pacific Ocean. The highest point of your homeland is only 5 metres above sea level.

E: You are **Gloria Slim**, American fashion model.

F: You are **Tessa Helps**, Mr Plank's secretary.

G: You are **Ann Word**, science editor of a national newspaper.

H: You are **Rosa Medina**, a doctor working in the slums of a South American city.

I: You are **Freda Storm**, a climatologist from the University of East Anglia. Your research involves predicting how the Earth's climate will change.

J: You are **Katy Carr**, a sales and marketing executive for the Acme Motor Company.

K: You are **Sarah Smith**, a biologist working for the World Wide Fund for Nature. You are making a special study of the animals of the tropical rainforest.

L: You are **Caroline Cooper-Jones,** city stockbroker and financial analyst.

M: You are **Samantha Storr**, the founder of a chain of furniture superstores, recently voted business woman of the year.

Audience roles (male)

N: You are **Nigel Nuke**, a worker in a nuclear power station. Nuclear power does not add to the greenhouse effect.

O: You are **Ivan Acre**. You farm low lying land near the Wash. Last year 10 hectares of your land was flooded by sea water when spring high-tides coincided with heavy storms.

P: You are **Terence Tube**, chairman of the London Underground.

Q: You are **Hans Schulz**, a German scientist. You have discovered that methane gas from decomposing cow dung is contributing to the greenhouse effect.

R: You are **Mr Lee**, a timber merchant from Indonesia.

S: You are **Nasim Khan**, from Bangladesh. Most of the land of your country is low lying and would be flooded if the sea level rose.

T: You are **Joseph Joiner**, employed in Mr Plank's furniture factory for 30 years. Your son has just joined the firm.

U: You are **Robert Rump**, owner of an American chain of steak houses called the Roasted Rib.

V: You are **Marcel Leblanc**, chef at one of London's smartest restaurants.

W: You are **Randy Gold**, multi-millionaire pop star.

X: You are **Father Patrick O'Neal**. You run a mission in the slums of a South American city.

Y: You are **Pedro Rodriguez,** a ranch hand from Brazil.

Z: You are **Sven Borg**, a Swedish ecologist.