SCIENCE & TECHNOLOGY IN SOCIETY

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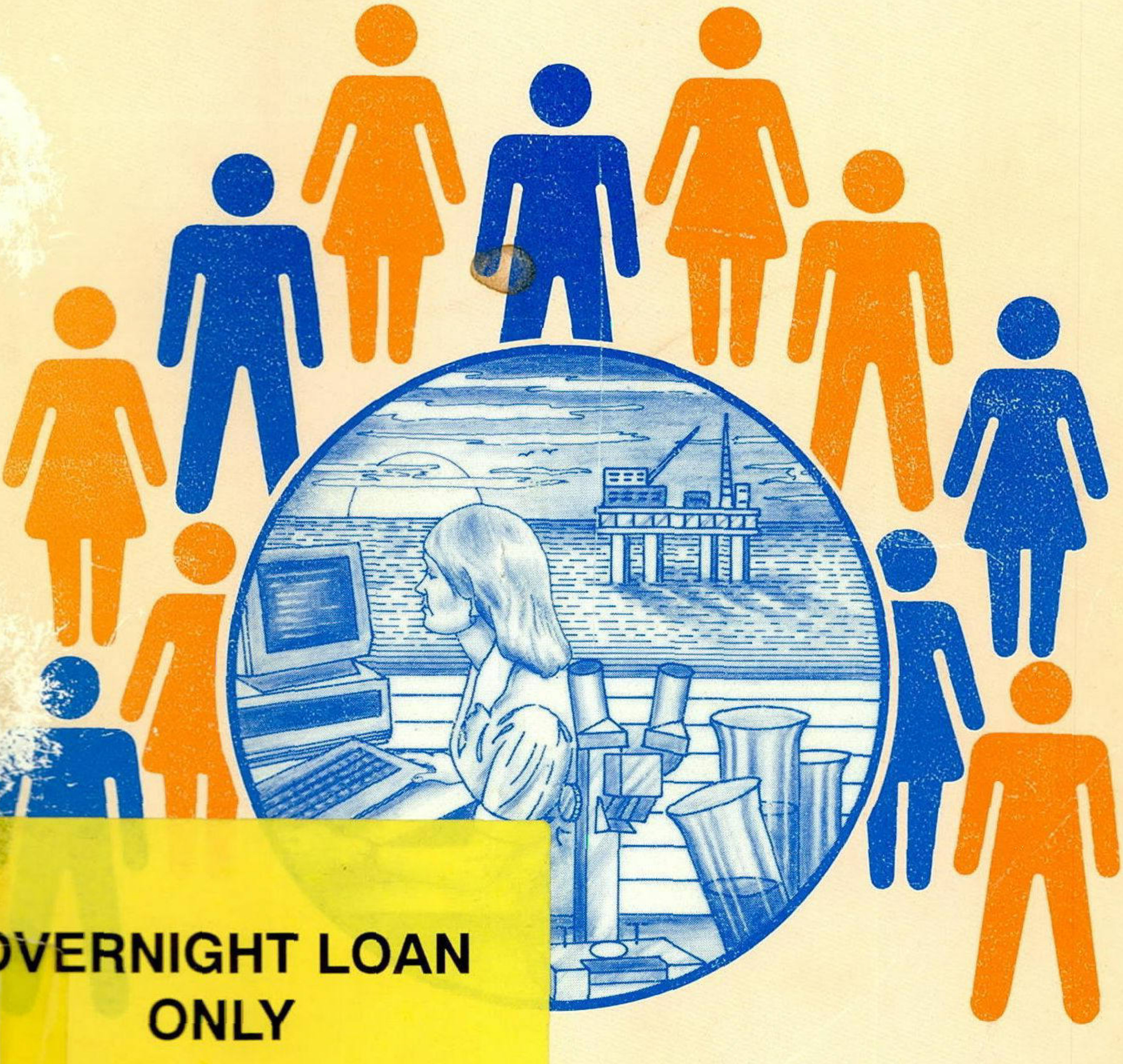

SATIS

ABOUT SATIS

Science and Technology in Society units are designed to be used in conjunction with conventional science courses, particularly those leading to GCSE examinations. Each unit has links to major science topics as well as exploring important social and technological applications and issues.

The units are self-contained and generally require about 2 periods (around 75 minutes) of classroom time. Each unit comprises Teachers' Notes (blue sheets) and Students' materials (white sheets). Full guidance on use is given in the Teachers' Notes accompanying each unit, which also include background information and suggest further resources.

Each SATIS book contains ten units. The units are numbered in a system giving the number of the book followed by the number of the unit within that book. Thus the first unit in the first SATIS book is numbered 101.

In addition to the SATIS books, a general Teacher's Guide to the project is available, giving guidance on some of the teaching techniques involved as well as ideas for further activities.

Many people from schools, universities, industry and the professions have contributed to the writing, development and trials of the SATIS project. A full list of contributors appears in the Teachers' Guide.

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SATIS 4
List of units in this book

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102 Food from Fungus
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106 The Design Game
107 Ashton Island — a problem in renewable energy
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The evacuees

During the Second World War many children from South Shields on Tyneside were evacuated to the Lake District to avoid the danger of bombs. While they were there the school dentist noticed that their teeth were remarkably good. He told this to a visiting Ministry of Education dentist named Weaver, who inspected them and was also impressed. Weaver asked for an analysis of the South Shields water supply. He found it contained 1.4mg of fluoride per litre.

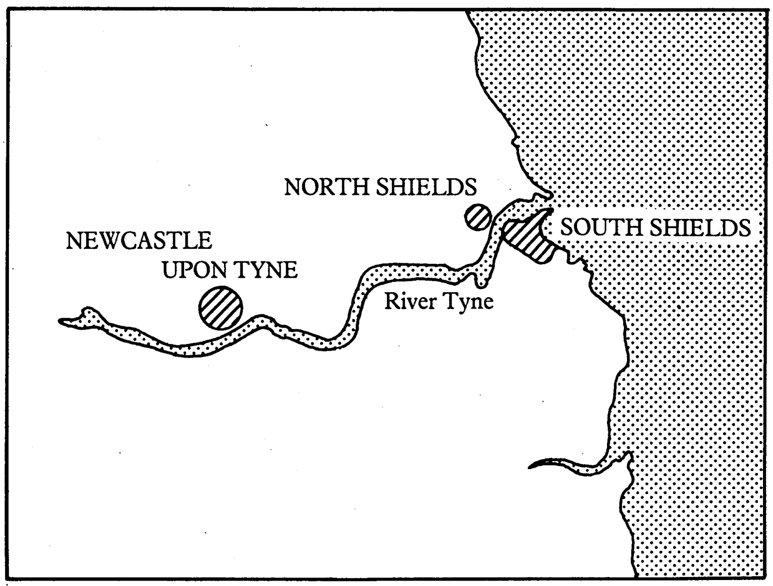


Figure 2 Tyneside

Questions

4 *Explain what the results in Figure 3 tell you about the effectiveness of fluoride.*

5 *Suppose you were a member of the National Pure Water Campaign, who are against adding fluoride to water supplies. How would you argue* against *this evidence?*

Across the River Tyne the town of North Shields took its water from a different source. This source had a fluoride content of less than 0.25mg per litre. Weaver inspected the teeth of 1000 children from each of the two towns. Half of these children were 5 years old, when we normally have 20 temporary 'milk teeth'. The rest were 12 years old with 28 permanent teeth. The number of decayed, missing or filled (DMF) teeth that he found are shown in Figure 3 on the next page. They show upper and lower jaws separately. Results on the left and right side of the mouth are added together. The total teeth inspected in each position was 1000.

Look carefully at the diagrams in Figure 3, then answer questions 4 and 5.

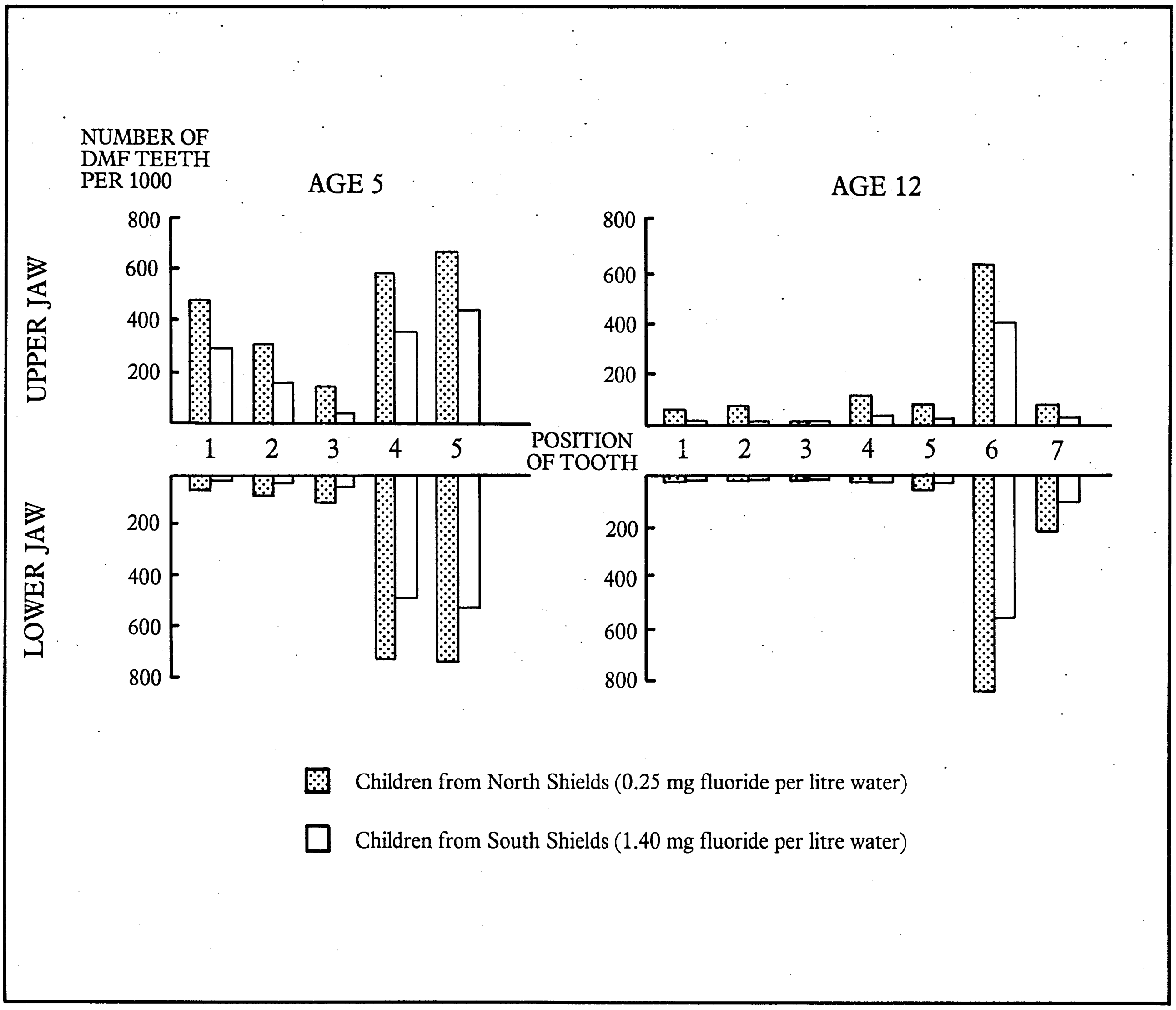


Figure 3 Results of the dental surveys

Fluoridation today

Many countries in the world now fluoridate water supplies. It is estimated that more than 230 million people in over 40 countries drink fluoridated water. It has no effect on the taste or smell or colour of the water so most people probably do not realise that they are drinking it.

In some areas of Britain the water supply has enough natural fluoride in it to strengthen teeth, and people who have lived there all their lives show no harmful effects. In other places extra fluoride is added to bring the concentration to one mg per litre. 5.5 million people drink such treated water.

The British Medical and Dental Associations and the Royal College of Physicians support fluoridation. It is said that fluoridation can reduce tooth decay by 50 per cent at a cost of 10p a person a year. The average cost of filling one decayed tooth is £4.70.

Figure 4 Toothpaste is another way you can get fluoride

Objections to fluoridation

In spite of the support for fluoridation, many people are against adding fluoride to drinking water.

- Some people say a cheaper and more effective way of preventing tooth decay is to make sure people eat the right food and clean their teeth properly.
- People who want to take fluoride can buy fluoride tablets very cheaply.
- There are doubts about the safety of fluoride. Fluoride ions are poisonous in medium or large quantities — 2500mg of fluoride is a fatal dose.
- Some people feel that fluoridating water supplies breaks a basic human right. It makes people swallow fluoride whether they want to or not. These people feel everyone should have the right to decide what goes into their body.

  In 1983 a court in Edinburgh ruled that Strathclyde Council should not add fluoride to their water because it took away the freedom of choice of individuals. However, in 1985 the British Parliament debated on the Fluoridation Bill, which would allow water authorities to add fluoride to water suplies. Many MPs voted against the bill, but it was eventually passed.

Other ways you can get fluoride

We get fluoride from other places as well as drinking water. An average tea drinker swallows 2 to 4mg of fluoride a day. Brushing your teeth with fluoride toothpaste might give about 0.5mg a day.

Fluoride tablets for children can be bought from the chemist and are taken once a day.

Answer questions 6 to 8.

Questions

6 *A man in a pub was heard to say, 'My daughter does chemistry at school and she says fluorine is the most reactive element known. I bet it plays havoc with your teeth. I don't reckon they should add it to drinking water.' How would you explain to him his statement was wrong?*

7 *Apart from fluoride, what other substance or substances do you know of which are added to drinking water? Why are they added?*

8 *Find out if the water supply in your area is fluoridated. Your dentist should be able to tell you, or you could ask the Water Board.*

Part 2 What are your opinions about fluoridation?

Work in pairs on this activity.

The following are different people's opinions about fluoridation of water supplies. Discuss each of them in the light of what you know. Make a copy of the table below and put a tick in the appropriate column. When you have made your decisions, compare them with other pairs and discuss any differences.

Decide whether you *Strongly agree/Agree/ are Unsure/Disagree/ Strongly disagree.*

	Strongly agree	*Agree*	*Unsure*	*Disagree*	*Strongly disagree*
1 Fluoridation reduces dental decay by about 50 per cent.					
2 The reduction in decay is small. It is no bigger than the variation you expect between different samples of people.					
3 Decay is caused by bad eating habits, such as eating too much sugar, and by inadequate tooth brushing, not by lack of fluoride.					
4 The evidence for the effectiveness of water fluoridation is completely convincing.					
5 Fluoride is perfectly safe and there is no possibility of anyone being harmed by it.					
6 Fluoride is a horrible poison.					
7 Fluoridation is just a way of getting rid of industry's fluoride waste.					
8 Bringing the fluoride content of water up to 1mg per litre by artificial fluoridation does not make it 'normal'.					
9 Fluoridation takes away a basic human right, to decide what goes into our bodies.					

Further points to discuss

Discuss these points with other members of your group.

- Suppose a substance was discovered that prevented people wanting to smoke tobacco. Would you be in favour of adding it to drinking water?
- One day it might be possible to add a contraceptive to water to prevent most people living in an area from having babies. Do you think this could ever be justified?

DDT and Malaria

Contents: Reading, questions and discussion on the benefits and drawbacks of DDT.

Time: 1 to 2 periods, depending on amount of discussion.

Intended use: GCSE Biology and Integrated Science. Links with work on malaria, parasites, disease control, insects, food chains and balance in ecosystems. Assumes familiarity with the concept of food chains.

Aims:

- To complement and revise work on parasites and disease, and food chains and ecology
- To show the impact of malaria in tropical countries
- To develop awareness of the benefits and drawbacks of pesticides, and a more general awareness that scientific and technological developments may have both positive and negative aspects
- To provide opportunities to practise skills in reading and comprehension, and to encourage students to enter discussion.

Requirements: Students' worksheets No. 402. If possible, some packs of insecticides.

The discussion points at the end are best tackled in small groups, although they could also be opened up for class discussion. There may not be time to cover all the points.

Notes on some of the questions

Qs 1 and 2 There are a number of points to be made here. Organisms at risk from DDT include those which feed specifically on insects, or on crops treated with insecticides. Organisms at the end of food chains are also vulnerable because of the tendency of DDT to become concentrated along the chain. Birds of prey are particularly affected by DDT, which appears to cause their eggs to have exceptionally thin shells, thus lowering their rate of breeding success.

Q.3 The resurgence of malaria in the late 1960s has been blamed on a number of factors. In particular, over-confidence following the successful WHO campaign, high pesticide prices, shortages of pesticides, and the establishment of new mosquito breeding sites may all have played a part, though many experts also blame the DDT ban.

Notes on the discussion points

The quotation by Professor Kenneth Mellanby, of Monks Wood Experimental Station, is from an article in *The Times Literary Supplement,* 21 August 1981.

The accumulation of DDT in the fatty tissue of humans has been a major cause for concern. Humans are often secondary consumers, and as such are subject to the effect of insecticide concentration along food chains. Insecticides can also enter the body from residues on food crops.

Pyrethrum is produced from *Chrysanthemum cineariaefolium.* It is widely harvested in Rwanda, Kenya, and other parts of Africa. It has no toxic effects on plants and its toxicity to animals other than insects is relatively low. It is effective against insects in very low doses. In terms of environmental acceptability it is a nearly ideal insecticide: the main obstacle to its wider use is cost.

It might be helpful to have one or two samples of insecticide packs for the students to look at when discussing the last point. Alternatively, they could look at some at home.

Other resources

Man and the Environment (2nd edn) by Arthur Boughey (Macmillan) contains a good deal of information on the environmental problems of DDT use. The story of 'Operation Cat Drop' is adapted from this book.

The British Agrochemicals Association, Alembic House, 93 Albert Embankment, London SE1 7TU, has a useful booklet called *The Fight for Food*, putting the case for pesticides. Available free to teachers.

Acknowlegements Figure 1 supplied by Shell; Figure 3 is reproduced by permission from *Science* by Graham Hill and John Holman (Nelson); Figures 4 and 5 supplied by United Nations Information Centre.

DDT AND MALARIA

Every year about 200 million people get malaria in tropical countries, and about two million die of it. Malaria is spread by mosquitoes. The disease can be controlled by using insecticides to kill the mosquitoes. An insecticide called DDT has been very successful in doing this, but it has also brought problems, as you will see in this unit.

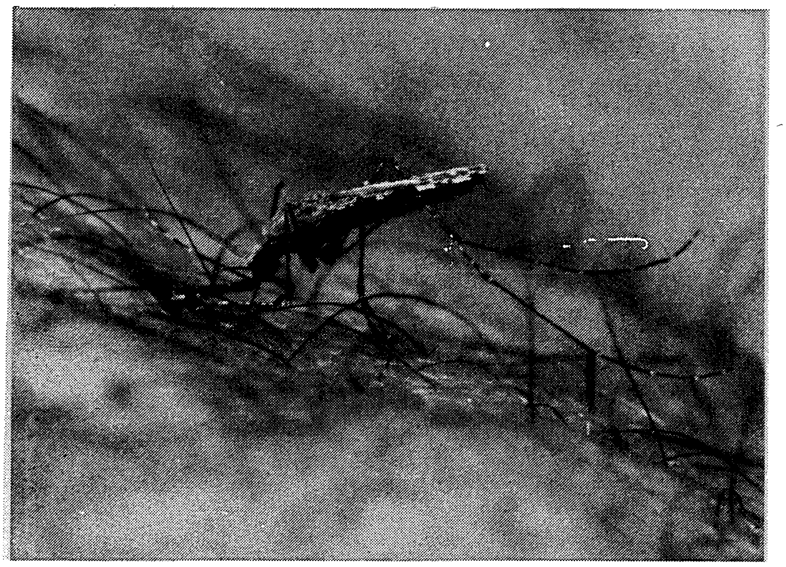


Figure 1 A magnified malaria mosquito on a human forearm

What is malaria?

Malaria is caused by single celled organisms called *Plasmodium*. These parasites are injected into the blood by the bite of a tropical mosquito, called *Anopheles*. Once in the body, the parasites head for the liver, where they feed and multiply. Later they invade the bloodstream. The parasites bore their way into the red blood cells. Inside the red cells, they multiply for a few days, then break out. This causes very serious fever, with high temperature, sweating and delirium. Eventually the fever passes, but it keeps coming back as long as the parasite is present in the body.

The malarial parasite reproduces very rapidly in the liver and the blood. Next time the person is bitten by a mosquito, some of the parasites are sucked into the mosquito's stomach along with the person's blood. The parasites continue to multiply in the mosquito's stomach. They are passed on to the next person the mosquito bites.

The whole *life cycle* of the parasite is shown in Figure 2 on the next page.

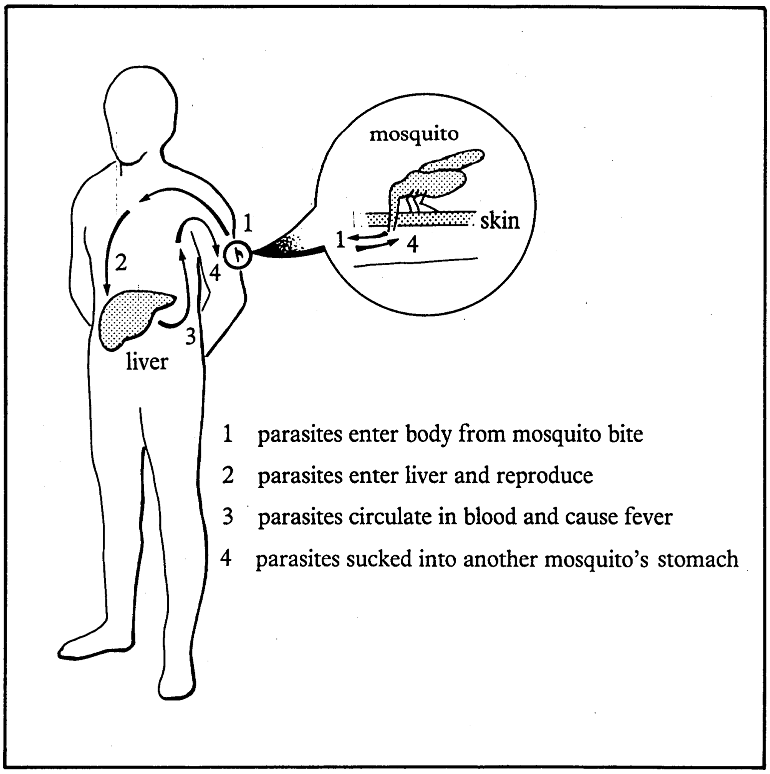


Figure 2 Life cycle of the malaria parasite

Malaria can be cured with medicines, but it is best to prevent it in the first place. This means avoiding being bitten by the malaria mosquito — perhaps by sleeping under a net at night. But the most effective way of preventing malaria is to control the mosquitoes, using insecticide.

What is DDT?

DDT stands for *dichlorodiphenyltrichloroethane.* It is quite a complicated chemical compound whose formula is $C_{14}H_9Cl_5$. DDT is very poisonous to insects. DDT is not as poisonous to birds, animals and humans as to insects, though it is still harmful.

DDT is a very stable chemical. This means it is slow to break down in the environment. So it stays around a long time. DDT stays in the insect's body long after the insect has eaten it. The DDT gets concentrated along food chains, building up in the body from one organism to the next. In this way, organisms at the end of the food chain may get a lethal dose of DDT. Figure 3 on the next page illustrates this problem.

In the 1960s many species of animals, particularly birds and frogs, were found to be affected by DDT. DDT was even found to be present in human milk.

Questions

1 Why are birds and frogs particularly affected by DDT?

2 What type of birds do you think are likely to be worst affected by DDT?

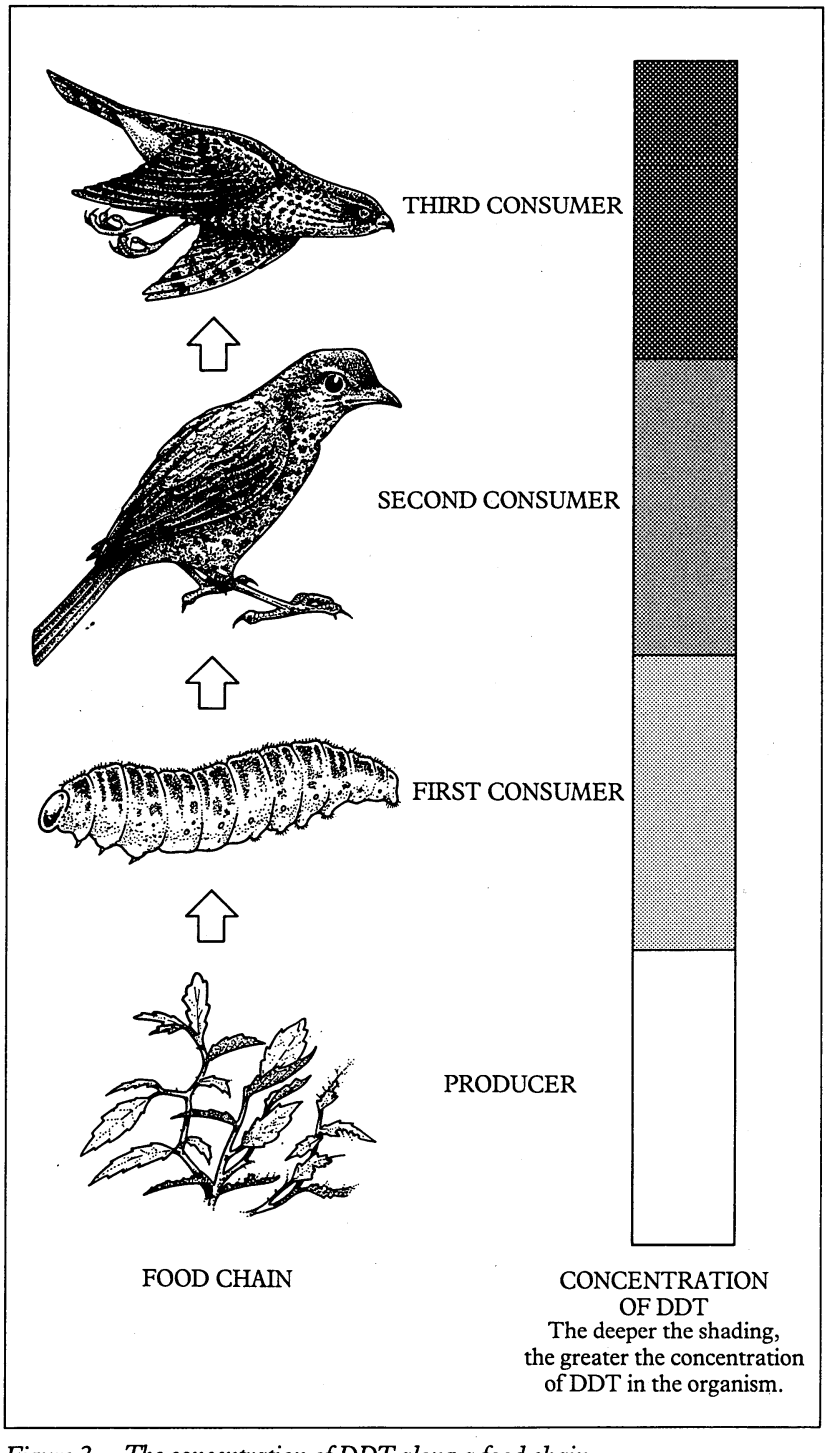


Figure 3 The concentration of DDT along a food chain

DDT and malaria control

In 1955 the World Health Organization (WHO) began a programme to try to wipe out malaria using insecticides. DDT was the major insecticide used. The mosquitoes' breeding sites were sprayed with DDT. This greatly reduced their number. The programme was very successful. It has been estimated that in fifteen years, 2000 million malaria cases were prevented, and fifteen million lives were saved.

However, in the early 1960s, people began to be concerned about the effects of DDT on the environment. DDT was banned in the USA, and later in other countries. In 1964 the WHO stopped using it in the anti-malaria programme.

In the late 1960s, malaria began to increase again. For example, in India the number of malaria cases rose from 49 000 in 1961 to 6.5 million by 1976. There were several reasons for this, but one reason was the fact that DDT was no longer being used. Other insecticides were used, but these were less effective than DDT.

Question

3 *Apart from the DDT ban, what other causes could have been responsible for the increase in malaria in the late 1960s?*

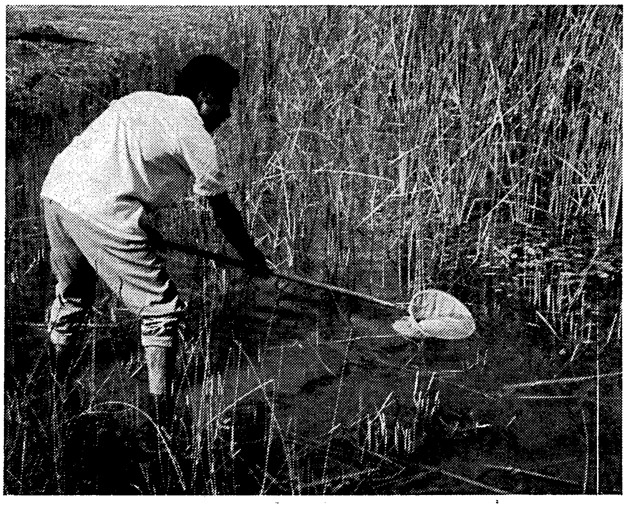


Figure 4 A health worker making a 'count' of the larvae of malaria- carrying mosquitoes

Figure 5 A drop of blood is taken to test for signs of the malaria parasite — a routine check among schoolchildren in Comoros.

Operation Cat Drop: a cautionary tale from Borneo

Read this story carefully, then answer questions 4 to 7.

The Dayak people of Borneo live in large thatched huts called longhouses. At the time of this true story they suffered seriously from malaria.The World Health Organization decided to try controlling the mosquitoes which were causing the disease.

Every longhouse was sprayed with DDT. Sure enough, the numbers of mosquitoes dropped dramatically. This greatly reduced the number of cases of malaria.

Unfortunately, spraying with DDT interfered with other parts of the ecosytem within the Dayak longhouses. Cockroaches lived in the longhouses in large numbers, and were eaten by lizards. The cockroaches absorbed DDT, which became concentrated in the bodies of the lizards which ate them. The lizards were eaten in turn by domestic cats. By the time the food chain reached the cats, the DDT had become concentrated enough to kill them.

With the death of many of the cats, the rat population of the longhouses began to increase. These rats carried parasites, such as fleas and lice, that spread a disease known as *sylvatic plague.* The Dayak people no longer suffered from malaria, but sylvatic plague became common. Eventually a new population of cats was brought into the Dayak community by parachute, dropped from helicopers. These helped to bring the rat population under control.

But this is not the end of the sad story. Caterpillars lived in the thatched roofs of the huts, eating the thatch. If their numbers became too great they seriously damaged the roofs. Spraying with DDT killed the caterpillars, but also killed the predators and parasites which kept the caterpillars under control. Some time after the spraying, the caterpillar population began to grow again. But the populations of predators and parasites were much slower to recover. The result was a caterpillar population explosion. By the time the rainy season came, the thatched roofs of the longhouses had been so badly damaged by caterpillars that they collapsed.

Questions

4 *Explain why DDT spraying led to the death of domestic cats in the longhouses.*

5 *Explain why there was an outbreak of sylvatic plague following the DDT spraying.*

6 *Why did the DDT spraying lead to the collapse of the thatched roofs?*

7 *An ecologist has said 'When we use insecticides, we must think of their effects on the whole ecosystem, not just on insects.' Why is this important?*

General points for discussion

You might prefer to discuss these in small groups.

- Professor Kenneth Mellanby, one of the world's leading experts on insects, has said:

  > On a world scale, the effects of the American ban on DDT have been disastrous, as it has probably led to more deaths than the 1939-45 war.

  What do you think he meant? Why did he only say the ban had *probably* led to these deaths?

- Consider the benefits and drawbacks of DDT.

Benefits	*Drawbacks*
Valuable for controlling insect-spread diseases like malaria and typhus	Kills animals other than insects
Valuable for controlling insects which eat food crops	Disturbs the balance of the ecosystem

How do you think these benefits and drawbacks weigh up against each other? Was it right to ban DDT?

- Research in 1964–66 showed that English people had an average of 3 parts per million of DDT in their body tissues. How did it get there?
- Nowadays many different kinds of insecticides are available. Many of them are designed to break down quickly after spraying. Why is this important?
- Do you or your family use insecticides? If so, what for?
- Some plants produce their own, natural insecticide. This can be collected from the plant and used by humans. An example is pyrethrum, which is produced by one type of chrysanthemum. Pyrethrum is widely used in parts of Africa.

  Why might natural insecticides like pyrethrum be preferable to synthetic insecticides like DDT?
- Have a look at the labels on some insecticide packs. What is the active chemical in the insecticide? Read the safety warning on the pack. What does the warning tell you about the insecticide?

Britain's Energy Sources

Contents: A data analysis exercise concerning the costs and contributions of different energy sources in Britain.

Time: Homework plus two periods or more, depending on number of parts attempted.

Intended use: GCSE Physics, Chemistry and Integrated Science. Links with work on energy, fuels, energy sources, electricity generation, efficiency of energy conversion.

Aims:

- To complement work on energy and energy sources.
- To develop awareness of different energy sources, their uses and costs.
- To develop awareness of patterns of energy use in Britain.
- To provide opportunities to practise data-handling skills.

Requirements: Students' worksheets No. 403. If possible, the current UK Energy Statistics card (see 'Further resources' below).

This unit is in four parts. There is no need to use all four parts, though Parts 1 and 2 are fairly closely linked.

Part 1 Energy in your home
Part 2 Comparing the costs of energy sources
Part 3 Why is electricity more expensive?
Part 4 Who are the big energy users?

Part 1 should preferably be done at home, perhaps for homework preceding the lesson in which the rest of the unit is to be tackled. It will be necessary to go over the results to correct mistakes, fill in gaps and discuss discrepancies (see note on question 4 below). Students should not be given Part 2 until they have completed Part 1.

Part 2 The prices given in Table 2 are average domestic prices for 1985. Teachers may prefer to replace them with more up-to-date local prices, consistent with those in Table 1. Industrial energy prices are usually considerably cheaper.

Part 3 The figures in Table 5 are for Drax Power Station. Similar figures can be obtained from most CEGB power stations.

Part 4 The figures in Table 6 are taken from the UK Energy Statistics Card for 1984, and they relate to 1983. It is recommended that the teacher update the figures using the latest edition of the card (see 'Further resources'). Able pupils could retrieve data directly from the cards, but this is made difficult by the variety of units used. For simplicity, all energy values in this topic are given in megajoules (MJ).

Useful conversion factors:

1 million tonnes coal	$= 2.64 \times 10^{10}$ MJ
1 million tonnes oil	$= 4.48 \times 10^{10}$ MJ
1 million therms	$= 1.06 \times 10^{8}$ MJ
1 TWh (terawatt-hour)	$= 3.59 \times 10^{9}$ MJ

Any figures less than 25 in Table 6 have been ignored. Non-energy uses are included in the table: this is particularly significant in the case of oil, where the non-energy uses are included in the figure for Industry. Significant quantities of coal are used to make coke and other smokeless fuels: the figures for this use are included in Other Uses.

It may be worth reminding students that oil needs to be refined before it can be used. The figures given for oil in Table 6 include all the various petroleum products.

Notes on some of the questions

Q.4 The costs of similar fuels may vary according to quality and calorific value, the time of year, the quantity bought and the geographical location.

Q.5 The figures (1985 prices) are:

Coal	249 MJ for £1
Oil	207 MJ for £1
Gas	283 MJ for £1
Electricity	72 MJ for £1

Thus the prices of coal, oil and gas are all quite similar. This reflects government pricing and taxing policy rather than the intrinsic cost of the fuel.

Q.9 The efficiency of the power station is 37 per cent. Most of the rest of the energy is lost as waste heat through the cooling water. There are of course further losses on transmission of electricity from the power station to the user.

Q.10 A typical breakdown of the cost of generating a unit of electricity is as follows:

	%
Fuel	50
Salaries	16
Depreciation	11
Interest	8
Rates	3
Other	12

Thus fuel costs account for about half the total cost of electricity generation.

Qs 12 and 13 Most of the energy used in the domestic sector is for heating. Gas is both cheap and convenient for this purpose. Electricity, while highly convenient, is more expensive.

Q.14 In order to avoid counting twice, Table 6 omits figures for fuel use in electricity generation. The majority of coal is used for this purpose (2150 billion MJ in 1983).

Q.15 Nuclear power is missing from the table. In 1983, about 17 per cent of Britain's electricity was generated from nuclear power.

Q.16 Lubricants, bitumen, wax and petrochemicals might all be mentioned. Note that natural gas is an increasingly important petrochemical feedstock.

Q.17 This is a highly speculative area. It is likely that less oil and gas, and more coal, will be used in twenty years time. Nuclear power may also become more important, and perhaps alternative sources such as tidal power and wind power.

Further activities

Teachers will no doubt be able to devise other activities based on the data in this unit and in the UK Energy Statistics Card.

It is interesting to extend this survey to a comparison with energy use in other parts of the world. BP's *World Energy Statistics* are useful in this connection (see 'Further resources').

Further resources

A wealth of resource material is available relating to energy, much of it free. The major oil companies, British Gas, the National Coal Board and the Electricity Council all have extensive resource catalogues.

The following are useful sources of statistics:

The *UK Energy Statistics Card* is available free, in single copies or class sets, from: Department of Energy, Information Division, Thames House South, London SW1P 4QJ.

The *Handbook of Electricity Supply Statistics* is available free from: Secretary's Department, The Electricity Council, 30 Millbank, London SW1P 4RD.

BP produce a useful pack, *World Energy Statistics*, containing worksheets and overhead projector transparencies as well as comprehensive statistical information. Available from: BP Educational Service, Britannic House, Moor Lane, London EC2Y 9BU.

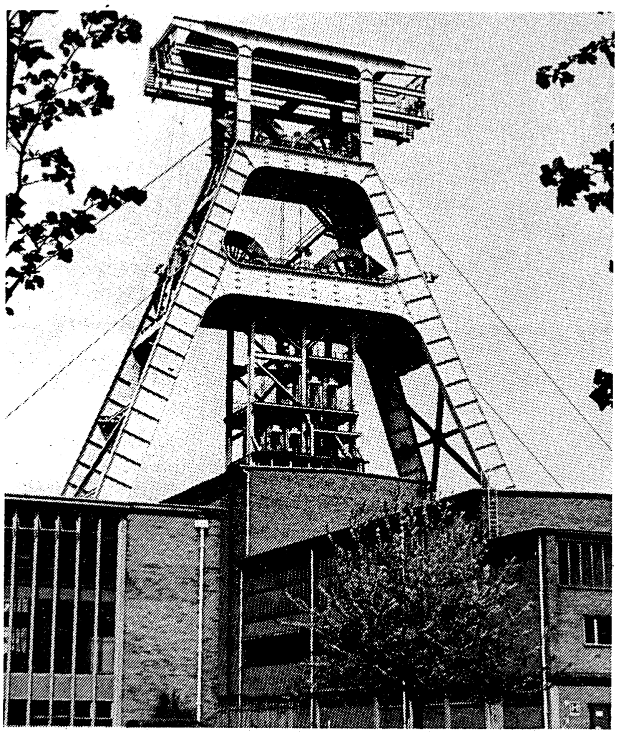
Acknowledgements Photographs in Figure 1 supplied by the National Coal Board, British Gas Corporation and British Petroleum.

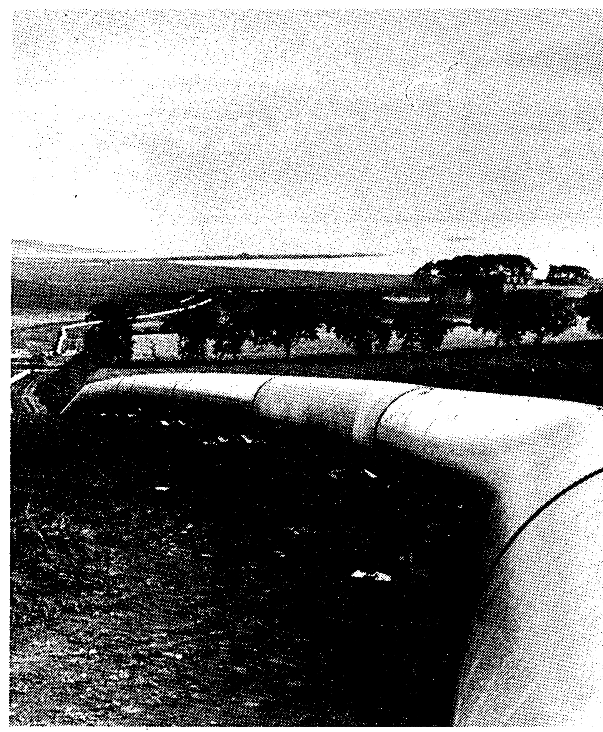
BRITAIN'S ENERGY SOURCES

Where does Britain get its energy, and how is it used? These are the questions we will be asking in this unit. We will be looking at some major types of energy source.

The unit is in four parts:

Part 1 Energy in your home
Part 2 Comparing the costs of energy sources
Part 3 Why is electricity more expensive?
Part 4 Who are the big energy users?





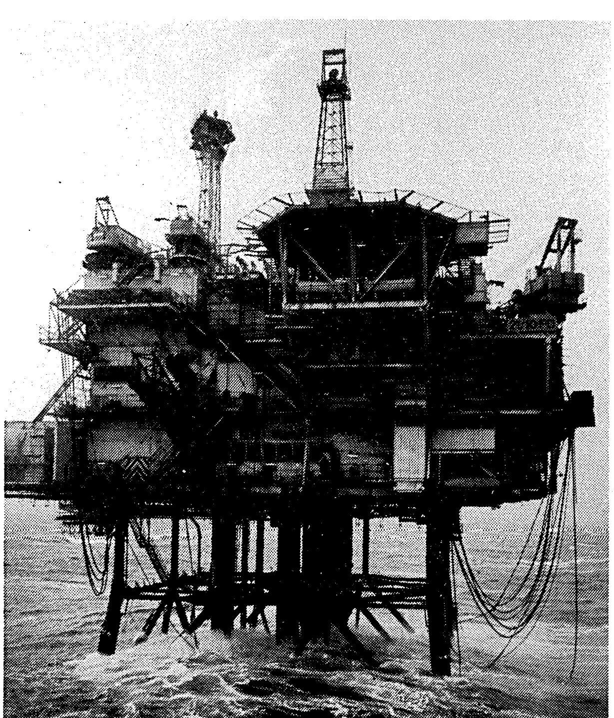


Figure 1 *Coal, gas and oil production.*
Above left: *Hem Heath Colliery near Stoke-on-Trent, from which coal is transported to power stations by 'merry-go-round' rapid load trains.*
Above right: *Part of the metre diameter pipeline laid down the east coast of Britain to handle supplies of gas from the North Sea. Here the pipeline is strung out before being buried underground.*
Below left: *Production platform in BP's Forties oilfield in the North Sea.*

Part 1 Energy in your home

A and **B** are to be done at home. **C** will be done in class afterwards.

A Find out which energy sources are used in your home. Draw up a table like Table 1, and write the names of the energy sources in the first column of the table.

Table 1

Name of energy source	*Units in which you buy it*	*Cost of one unit*
Coal.	tonnes	£120

B In Part 2 we will be comparing the costs of the different energy sources. But unfortunately different sources are sold in different units. Try to find out what unit each energy source is sold in. Put this information in the second column of Table 1. Try to find out also the *cost* of one unit. You might be able to find this out from fuel bills. Put the cost in column 3. An example, 'Coal', has been filled in already.

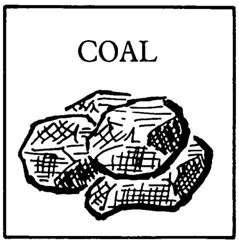
C Before going on to Part 2, compare your results with other members of your class. Fill in any gaps in your table, and correct any mistakes. Add any energy sources you did not include.

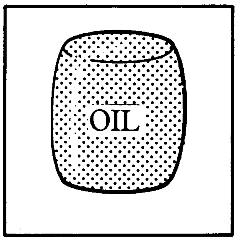
Questions

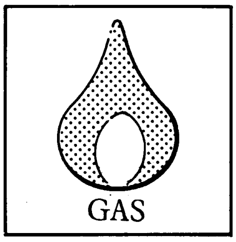
1. *What is the energy source used in the largest number of homes of people in the class?*
2. *What is the least used energy source?*
3. *Why is it impossible to compare the costs of the different energy sources using Table 1 alone?*
4. *You have probably found that different people pay different prices for the same energy source. Suggest reasons for this.*

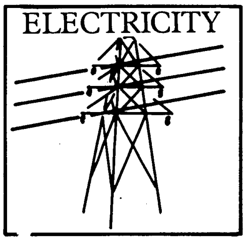
Part 2 Comparing the costs of energy sources

In this part we will concentrate on four major energy sources.









Apart from electricity, all of these energy sources are **fuels** — substances which burn in air to release heat.

Table 2 gives the units in which they are sold, the price per unit and the amount bought for £1. Compare Table 2 with your own Table 1. The prices are only averages, because they vary according to quality, the time of year and the amount you buy. They are 1985 prices, and you may like to replace them with your own, up-to-date local prices.

Table 2 Costs of different energy sources

Energy source	*Unit in which you buy it*	*Cost of one unit*	*Amount bought for £1*
Coal	tonne (1000 kg)	£120	8.3 kg
Fuel oil	litre	£ 0.18	5.6 litres
Mains gas	therm	£ 0.37	2.7 therms
Electricity	kilowatt-hour (kWh)	£ 0.05	20 kWh

Which is the cheapest? Of course, you cannot tell, because these figures are not very helpful when it comes to comparing fuels. If you want to know which fuel is cheapest, you need to know whether, say, 1 kWh of electricity represents more or less energy than 1 litre of oil.

To make comparisons possible, we need to have the prices of all the energy sources in the same unit. Since they are all energy sources, it makes sense to use energy units. A convenient energy unit is the megajoule (MJ). 1 MJ = 1 million joules.

Table 3 shows the number of megajoules that can be obtained from the various energy sources.

Table 3 Converting energy sources to megajoule units

Energy source				
Coal	1 kg coal	=	30	MJ
Fuel oil	1 litre fuel oil	=	37	MJ
Gas	1 therm	=	105	MJ
Electricity	1 kilowatt-hour	=	3.6	MJ

Table 2 showed you how much fuel you can buy for £1. Table 3 shows how many MJ you get from different quantities of fuel. From these two sets of figures, you can work out for each fuel how many MJ you get for £1.

Table 4

Energy source	*Energy in MJ bought for £1*
Coal	
Fuel oil	
Gas	
Electricity	

Questions

5 *Draw up a table like Table 4 below and put your answers in it.*

6 *Which energy source is the cheapest?*

7 *Which is the most expensive?*

Part 3 Why is electricity more expensive?

Unlike coal, oil and gas, electricity is a **secondary energy source**. This means it can only be made from another, **primary energy source** — such as coal, oil or nuclear power.

Most electricity is generated by burning coal in a power station (Figure 2). Heat produced by burning fuel is used to turn water to steam. The steam then drives turbines, which in turn drive electrical generators. But not all the energy in the fuel is converted to electricity. A lot escapes in hot air from the cooling towers and chimney of the power station.

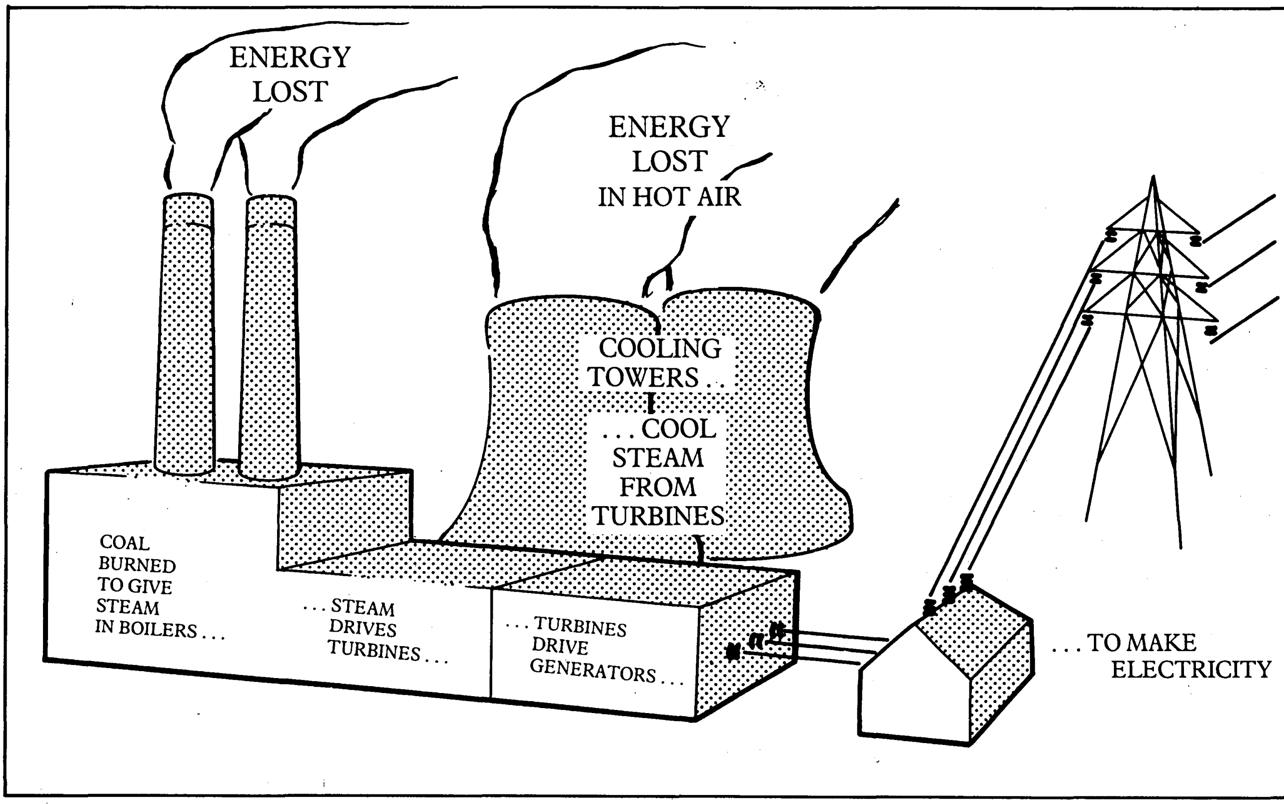


Figure 2 Generating electricity in a coal-fired power station

Table 5 gives data for a big coal-fired power station. Look carefully at the data, then answer questions 8 to 10.

Table 5 Energy use in a major coal-fired power station (the figures are in thousands of megajoules per hour)

Input energy		*Output energy*	
Energy input from burning coal	6073	Energy output:	
		Electricity	2250
		Heat lost to cooling water	3078
		Heat lost up chimney	516
		Other losses	103
		Electricity used in running power station	126
		Total output	6073

Questions

8 *Where does* most *of the input energy go to?*

9 *The percentage efficiency of a power station is given by*

$$\frac{\textit{Useful energy output as electricity}}{\textit{Total energy output}} \times 100$$

What is the percentage efficiency of this particular power station?

10 *Apart from the cost of the coal, what other costs do you think are involved in running a power station?*

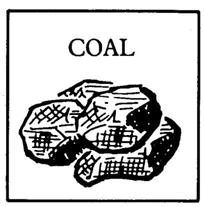
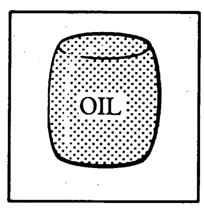
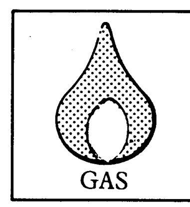
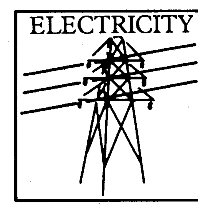
Part 4 Who are the big energy users?

There are many different types of energy users. But we can group them into five major classes:

Power stations
Industry
Road transport
Domestic (households)
Other uses.

Table 6 shows the way the different energy sources are divided between four of these uses. The figures are in billions of megajoules per year. The table does *not* show the amounts used in power stations. Use Table 6 to answer questions 11 to 17.

Table 6 Final users of different energy sources. (The figures are in billions of megajoules per year (1 billion megajoules = 10^{15} J). They apply to the year 1983.)

	 COAL	 OIL	 GAS	 ELECTRICITY
Industry	190	870	600	260
Road transport	—	1160	—	—
Domestic	210	90	940	300
Other	390	1382	240	220
Total	790	3502	1780	780

Questions

11 Road transport has only one important energy source. What is it? Why is this source particularly useful for road transport?

12 What is the biggest single energy source for domestic use? Why is it particularly suitable for this?

13 Electricity is a very convenient energy source for domestic heating. Why, then, is it not used more?

14 The total amount of coal used per year is 2940 billion megajoules. Compare this with the total in the table. Explain what the missing coal is used for.

15 One important energy source, used only for generating electricity, is missing from Table 6. What is it?

16 Industry uses a lot of oil. Most of it is used as an energy source, but not all of it. What non-energy uses are there for oil products?

17 Look at the 'Total' row. This compares the total contributions of Britain's different energy sources. In what ways might the figures be different in twenty years time?