Ashton Island – a problem in renewable energy

Contents: Information and problem-solving exercise on the use of renewable energy sources.

Time: 1 to 2 periods.

Intended use: GCSE Physics, Chemistry or Integrated Science. Links with work on energy sources, alternative energy and fuels.

Aims:

- To complement and revise prior work on alternative and renewable energy sources.
- To develop an awareness of the problems of energy provision and of the importance of renewable energy sources, particularly in situations where fossil fuels are not available or need to be conserved.
- To develop problem-solving skills and an imaginative approach to the application of scientific ideas.

Requirements: Students' worksheets No. 107.

The information about renewable energy sources given on the students' worksheets is only a summary, and it is envisaged that the topic of renewable energy will have been introduced in a prior lesson, perhaps by means of a film, video or tape-slide programme. A number of useful films are available dealing with this topic. A particularly good one is *Time for Energy*, produced in 1982 (running time 33 minutes). It is available on free loan, as film or video, from:

Shell Film Library
25 The Burroughs
Hendon
London NW4 4AT

Having read the information in Part 1, pupils should tackle the questions on Ashton Island in Part 2, preferably working in small groups.

At some stage, the teacher may wish to discuss the economic viability of various alternative energy sources in Britain. At present most of the sources discussed in this unit are marginal in economic terms, and indeed in 1985 the government reduced funding for geothermal and wave energy research projects. Much depends on the price of competing energy sources, and alternative sources may only become viable when the prices of fossil fuels rise substantially due to depletion of reserves.

The SATIS units 'Energy from Biomass' and 'The Second Law of What?' deal with related topics.

Acknowledgements Figure 1 is reproduced from *Science in Society*, Book F, published by the Association for Science Education. Figure 4 is based on a diagram in *Science in Society*, Book F.

ASHTON ISLAND – a problem in renewable energy

Part 1 gives information on renewable energy sources. Read the information, then tackle the questions on Ashton Island in Part 2.

Part 1 Renewable Energy Sources

Fossil fuels like coal, oil and gas are **non-renewable** energy sources. Once used, they cannot be replaced. **Renewable energy** is energy which does not get used up. The energy provided by the source can be renewed as fast as it is used.

Some of the most important forms of renewable energy are described below.

Solar power

The Sun produces an enormous amount of heat and light energy. There are a number of ways we can use the Sun to produce useful energy on earth.

Solar panels

Solar roof panels can be used to provide hot water for homes. The Sun shines through a transparent cover and the heat is absorbed by a black panel (Figure 1). A liquid is passed around pipes by a small pump. As the liquid slowly passes the panel it heats up. It then passes through a tank where it heats up the water. This hot water can then be used in the building. Solar panels are used in buildings all over the world, particularly where it is hot. In Britain they obviously work best in summer, but even in winter the Sun can help to heat water.

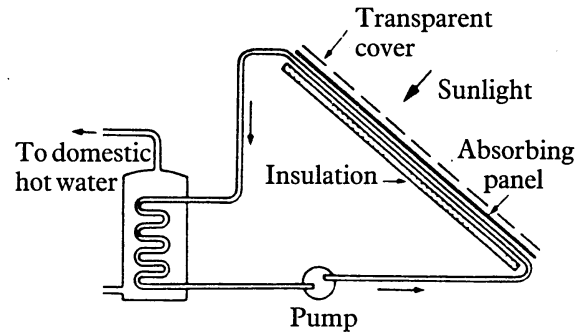

Figure 1 A solar panel

Solar power stations

Solar power stations use lots of concave mirrors to reflect the Sun's rays onto a boiler (Figure 2). The water in the boiler heats up to produce steam. The steam can then be used to drive turbines and produce electricity. The Americans have built such a power station in a hot desert. Some people say we could build solar power stations in space and beam the electricity to Earth.

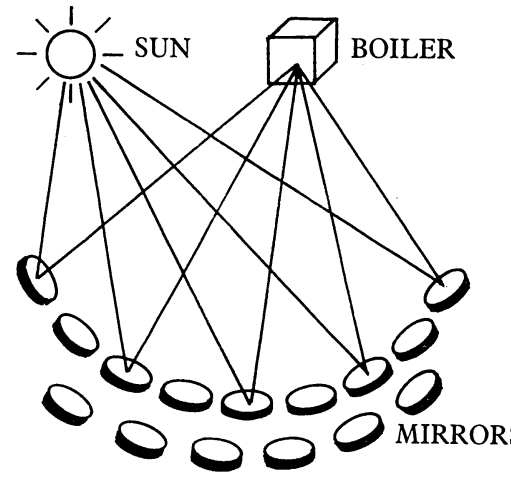

Figure 2 A solar power station

Solar cells

These are cells or batteries that can be charged by the Sun's energy (Figure 3). Spacecraft often use solar cells to work their instruments but here on Earth solar cells are still expensive and do not give a lot of electricity.

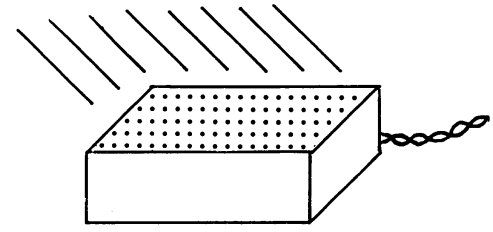

Figure 3 Solar cells

Geothermal energy

The rocks under the Earth are very hot and can be used to produce hot water and steam. This is called *geothermal energy*. In Southampton scientists have drilled 1600 metres down and found they can obtain hot water at 70°C. This could be used to heat nearby homes or factories and to provide hot water for washing.

Another way of using the heat in the Earth is to make a *geothermal power station*. Two parallel holes are bored down. An explosive charge is placed at the bottom of the holes and the resulting fracture joins the holes up. Cold water is then passed down one hole. It heats up and comes back as steam. The steam is then used to drive turbines and generate electricity (Figure 4). Geothermal power stations are already working in New Zealand, America, Mexico, Iceland and Japan. In Cornwall scientists have found they will have to drill down nearly 5 kilometres to reach temperatures of 200°C.

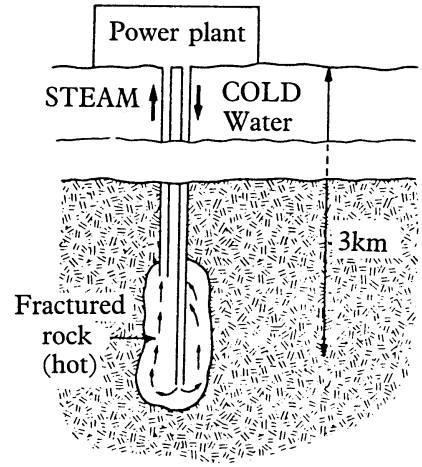

Figure 4 A geothermal power station

Tidal power

The idea of tidal power is to place a barrier or dam across an estuary and use the rushing of the tide to turn turbines and produce electricity (Figure 5).

There is a large tidal power station in France on the River Rance. There are possible sites in Britain too. The government is considering a tidal station across the Severn Estuary which could produce up to 10% of all the electricity we now use. There is also a possibility of building one across the River Mersey near Liverpool.

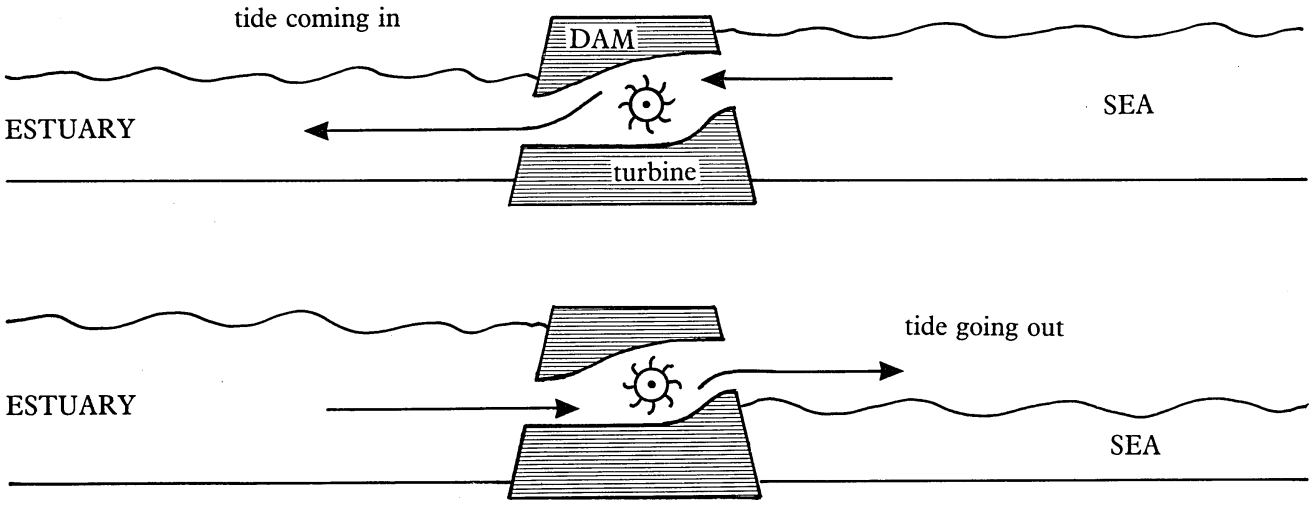

Figure 5 A tidal power station

Wind power

Windmills have been used to drive machinery for hundreds of years. We do not use many today but there is now a lot of interest in building large windmills to produce electricity. These **wind turbines** can generate 3 megawatts. Even so, 200 or more of these turbines would be needed to generate as much electricity as a conventional power station (Figure 6). One way to get around this problem is to have **windfarms** at sea. This involves lots of windmills being built along the coast. One idea is to build them off the East Anglia coast, where it is very windy. The electricity could be sent to shore through cables.

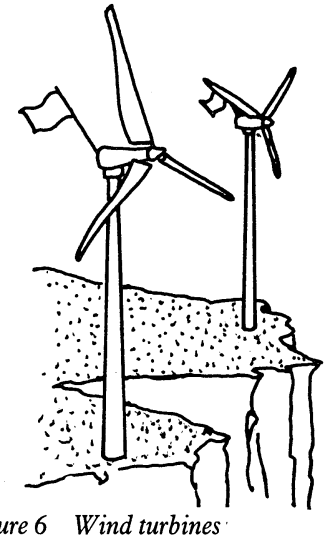

Figure 6 Wind turbines

Wave power

The motion of waves can be used to generate electricity. One design being looked into is called the Salter Duck. The action of the waves makes the duck bob up and down in the sea and the motion is used to produce electricity (Figure 7).

The idea is that a number of wave power machines, each with a number of ducks on, could be placed out in the ocean. Britain, being an island, has a number of good sites. The best is probably off North West Scotland.

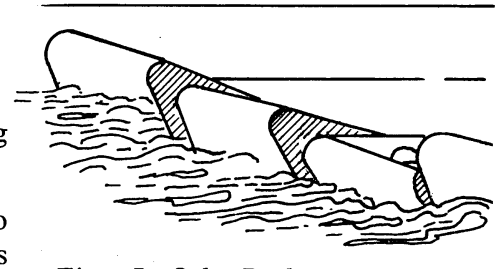

Figure 7 Salter Ducks

Other renewable energy sources

There are many other renewable energy sources that are being developed in Britain and other parts of the world.

- *Energy from rubbish* Nottingham burns a lot of its rubbish to produce hot water. 7000 dwellings, shops and public buildings get hot water this way. The rubbish, together with some coal, can also produce electricity. Scientists at Manchester University have found a way of producing oil from the city's rubbish.
- *Energy from plants* Energy from plants is called **biomass energy**. Some plants grow very fast and can be burnt as fuels. Wood has been used as a fuel for thousands of years, but it is important to conserve it so it is not used up faster than it grows. In some countries, sugar is grown as an 'energy crop'. The sugar is fermented to give alcohol, which is used as a fuel.
- *Energy from rotting matter* If manure and organic matter are left to rot in a closed tank, methane gas is given off (Figure 8). This is called **anaerobic digestion**. The gas, called **biogas**, can be used for cooking, heating or lighting. This is a common way of producing energy in many parts of the world, particularly China. Some farms in Britain are beginning to use it too.

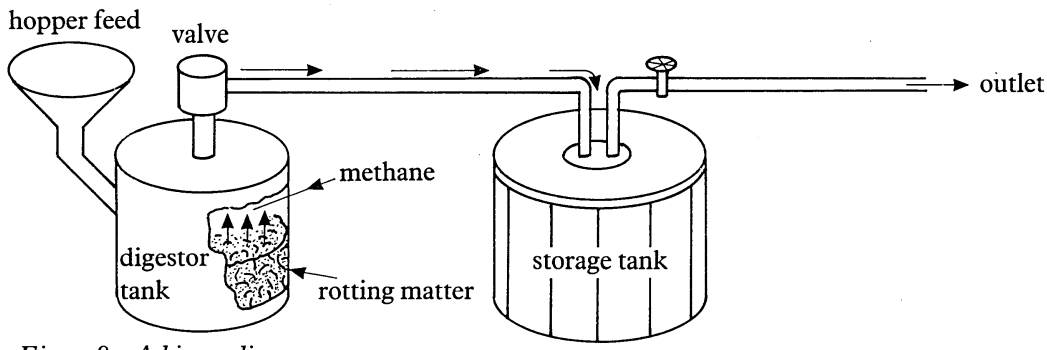

Figure 8 A biogas digestor

Part 2 Ashton Island

Ashton Island is in the Pacific Ocean and many miles from the mainland (Figure 9). You are a member of a 20-strong scientific team which is planning to study the island for five years. You are the expert given the job of providing all the energy which the team will need. The island has:

- No oil, coal or natural gas
- Hot weather by day, but cool nights
- Strong winds from the south west
- Mountains with fast-flowing streams
- Forests
- Hot springs

Answer questions 1 to 8 on the next page.

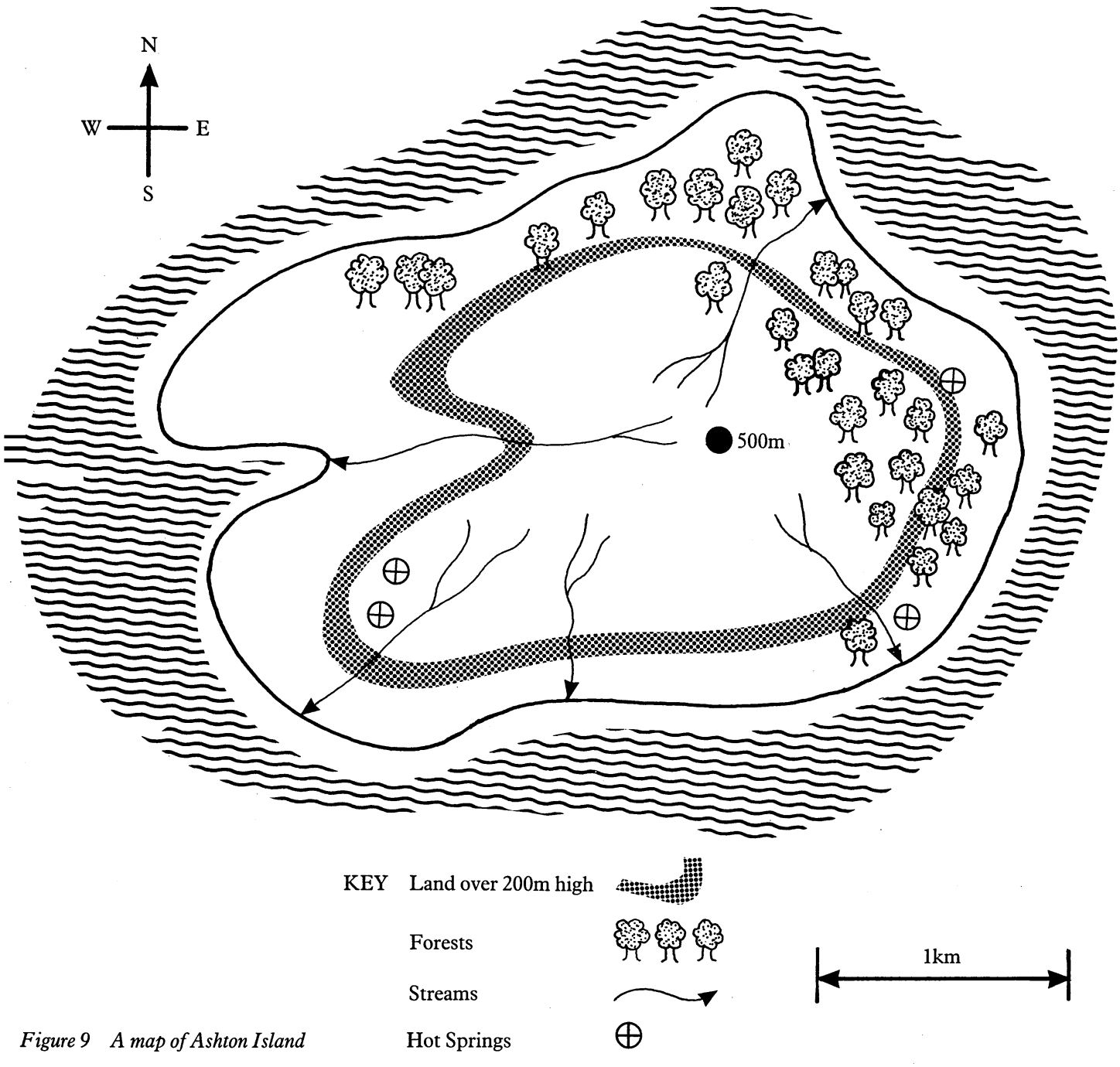

Figure 9 A map of Ashton Island

Questions

1 *The team will need four wooden buildings and a laboratory. Describe two ways by which the buildings could be heated.*

2 *Describe a source of hot water for the buildings.*

3 *Describe two possible ways of supplying heat for cooking food.*

4 *How would you supply the electricity needed to run machinery?*

5 *The team will have medicines and chemicals which must be kept cool at all times. How would you make sure that the supply of electricity to run the refrigerators was continuous?*

6 *Which natural resource on the island should be carefully conserved?*

7 *Copy the map of the island. (Use colours instead of shading if you wish – but remember to change the key if you do so.) Mark on your map where you would plan to site the buildings. Mark on your map the various energy-producing installations you would provide and show how the energy would be transferred (if necessary) to the buildings. Explain your reasons for choosing these particular sites.*

8 *So far we have not mentioned the* cost *of providing energy. Would your answers be different if the team had only a limited amount of money to spend on supplying energy? Explain your answer.*

Fibre in your Diet

Contents: Information, questions and data analysis on the link between dietary fibre and disease.

Time: 1–2 periods

Intended use: GCSE Biology and Integrated Science. Links with work on diet, food, digestion and disease.

Aims:

- To complement and revise prior work on diet, food, digestion and disease.
- To develop awareness of possible links between disease and diet.
- To develop awareness of the different diets of people in different parts of the world.
- To develop awareness of the difficulty of using statistical evidence to prove a medical hypothesis.
- To provide an opportunity to practise reading, comprehension and data-handling skills.

Requirements: Students' worksheets No. 108.

The unit is in four parts:

Part 1 What is dietary fibre?
Part 2 Why is fibre good for you?
Part 3 How can you make sure of dietary fibre?
Part 4 Looking at the evidence.

Parts 1 and 2 give information only, but must be read before doing the exercises in Parts 3 and 4.

Part 3 Notes on some of the questions

Q.3 The ingredients of All-Bran are listed as wheat bran, sugar, salt, malt and vitamins.

Q.4 A hundred years ago the average British diet would have included less animal food and sugar, and more unrefined vegetable food.

Q.6 The National Advisory Committee on Nutritional Education (NACNE) recommended in 1983 that the average intake of dietary fibre should be increased from 20g per day to 30g per day. For most people this is easily done by increasing consumption of bread – particularly wholemeal bread, though even white bread is a good source of fibre. It is worth noting that NACNE also recommends that average fat intake should be reduced from 128g per day to 101g per day, and average sugar intake from 104g per day to 55g per day. Increased consumption of bread would help achieve both these reductions, by replacing sugar and fat as energy sources, though it must be borne in mind that most people eat butter or margarine with their bread.

Part 4 Notes on some of the questions

Q.7 It is not intended that students should carry out accurate calculations of percentages of fibre in the different diets. They should attempt an approximate classification of fibre content on the basis of amounts of cereals and other high-fibre foods eaten, bearing in mind that Western diets are likely to include more refined plant foods than in developing countries.

Q.9 The comparison of USA Blacks of African origin with Uganda is intended to make the point that frequency of bowel cancer does not seem to be linked to ethnic type. Further evidence for this was given by a study of Japanese migrants to the USA. The change to a Western diet was accompanied by an increase in the incidence of bowel cancer.

Q.10 The intention of questions 10 and 11 is to show that while evidence may appear compelling, other interpretations are often possible. Several other dietary links suggest themselves – for example, the proportion of meat, sugar or fat in the diet. However, the link to fibre is perhaps stronger in view of its specific action in the colon.

Q.11 Several other possible interpretations of the data suggest themselves. Other features of Western life-style, such as stress, urban living, exposure to industrial carcinogens, etc., might be involved.

Q.12 A larger sample of countries is needed to ensure no quirks are involved, though the survey from which the figures were taken in fact involved about forty countries, and showed the same pattern throughout.

Other references

The most vociferous proponent of the case for dietary fibre is Dr Denis Burkitt. He has written simply on the subject in the following article and book:

'Your health in your hands', *School Science Review* (December 1983).

Don't Forget Fibre in Your Diet (Martin Dunitz, 1979; 4th rev. edn, 1983).

Acknowledgments Figure 1 is reproduced by permission from *Science* by Graham Hill and John Holman (Nelson); Figure 3 and the data in Table 1 by permission from *Don't Forget Fibre in Your Diet* by Dr Denis Burkitt (Martin Dunitz).

FIBRE IN YOUR DIET

A hundred years ago in Britain, only six babies out of ten survived to become adults. The average life expectancy of a boy was 41 years. Today, a boy can expect to live to over 70 years of age.

Modern medicine and improved living conditions have helped wipe out most of the old 'killer diseases' like typhoid, smallpox and tuberculosis in Britain. The cause of death in the 1980s is likely to be from one of the so-called 'diseases of modern society', such as heart disease and cancer. Why is this? Why are these diseases so common in modern Western countries? Many people believe it has a lot to do with the modern diet. A feature of our diet that has attracted a lot of attention is dietary fibre.

Part 1 What is dietary fibre?

Fibre is only found in plant food. It is the parts of plant cells, mainly the cell walls, that cannot be digested by humans, though some bacteria can digest it. The table in Part 3 gives the amounts of fibre in different foods.

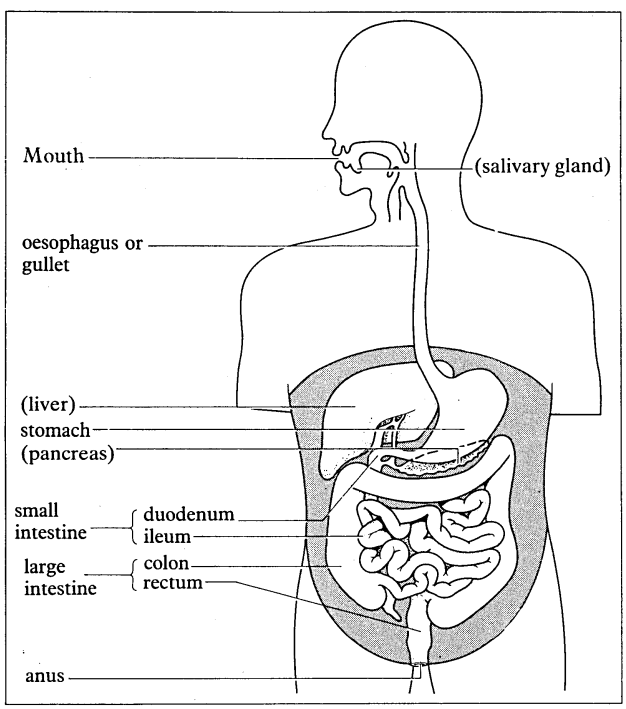

Figure 1 The main parts of the human digestive system

Figure 1 shows the main parts of the human digestive system. As food passes along the gut, it is broken down and absorbed into the bloodstream. By the time it reaches the colon, only fibre is left undigested. It passes out in the faeces, which also contain water and millions of bacteria.

People who eat a lot of fibre produce more faeces than people who do not. People in developing countries eating high-fibre, mostly vegetarian diets produce 300 to 500 grams of faeces daily. In developed Western countries where the diet contains less fibre, only 80 to 120 grams of faeces are produced daily. What is more, with the high fibre diet, it only takes about 30 hours for food to pass through the gut from mouth to anus. A typical Western diet low in fibre may take 70 hours to pass through the gut.

Part 2 Why is fibre good for you?

It has been claimed that fibre helps prevent many modern diseases. In some cases the evidence is good, but often it is difficult to prove that fibre helps prevent the disease. In any case, many doctors suspect that other features of the modern diet, such as eating too much fat and sugar, may help cause modern diseases.

Some diseases involving the gut

- *Constipation* There is no doubt that fibre prevents constipation, by keeping the contents of the gut moving. What is more, fibre keeps the faeces soft. With low-fibre diets, faeces become hard and difficult to pass out of the anus.
- *Appendicitis* The appendix is a small 'blind alley' leading off from the colon. Sometimes it becomes infected and inflamed: this is appendicitis. Often appendicitis is caused by a small, hard lump of faeces, which blocks the appendix (Figure 2). By softening the faeces, and making them move faster, fibre helps prevent this happening.

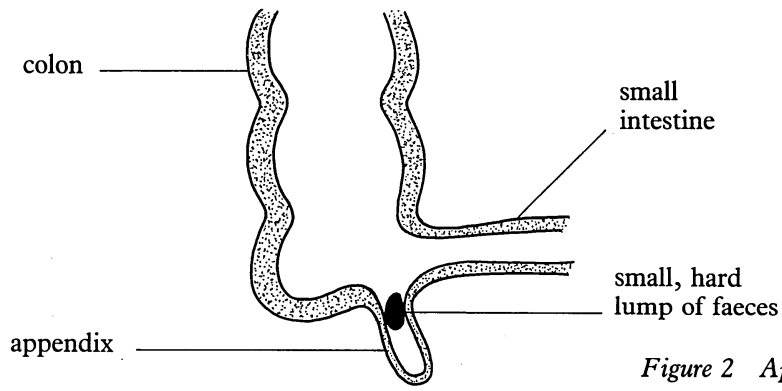

Figure 2 Appendicitis is often caused by a small, hard lump of faeces

- *Bowel cancer* Cancer of the bowel or colon is the commonest cause of cancer death apart from lung cancer. There is quite a lot of evidence that high-fibre diets help prevent bowel cancer (see Part 4). Many doctors believe that bowel cancer is caused by cancer-producing chemicals (**carcinogens**) made by bacteria in the colon. These carcinogens are present in the faeces. It is thought that fibre helps by increasing the bulk of the faeces, which dilutes the carcinogens. Fibre also makes the faeces move faster through the colon, so that the lining of the colon has less time in contact with the carcinogens.

Other diseases

- *Obesity* Many people in Western countries are overweight (obese). Fibre helps prevent obesity, because it makes you feel full after you have eaten. This helps stop overeating.
- *Diabetes* Some doctors believe fibre helps prevent diabetes, though there is not yet strong enough evidence to be sure.

Part 3 How can you make sure of dietary fibre?

Fibre comes only from plant foods. You cannot get any fibre from animal food such as meat, fish, eggs, cheese and milk.

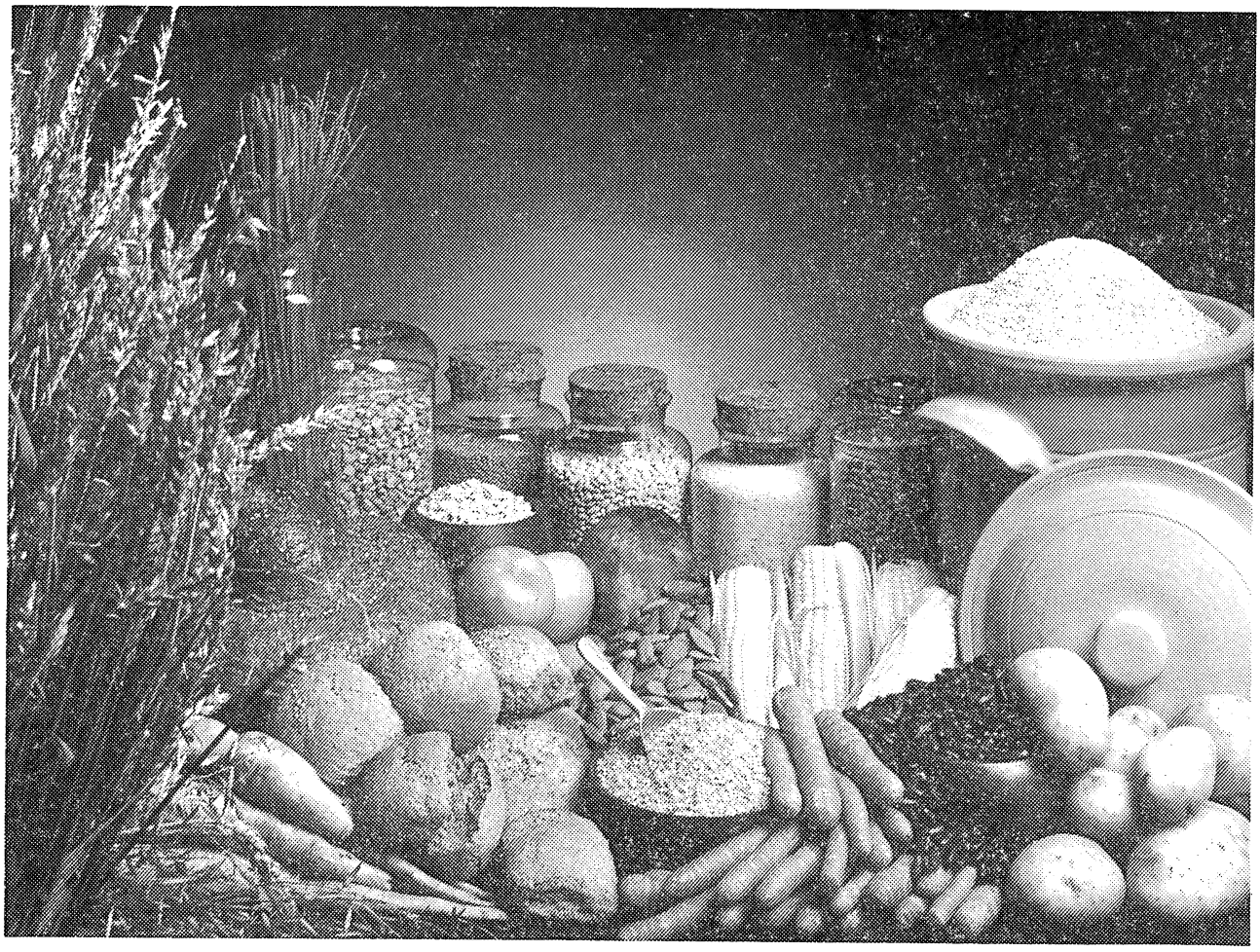

Figure 3 A selection of high-fibre foods

Cereals like wheat are a particularly good source of fibre. Bran, which is the outer part of the wheat grain, is nearly half fibre. When wheat is ground into flour, the bran is often removed – this gives white flour. If the bran is not removed, you get wholemeal flour. In general, the more a food is refined, the more fibre is removed. For example, *sugar cane* contains a lot of fibre, but *sugar* contains none at all.

Table 1 on the next page gives the fibre content of different foods. Look at the table, then answer questions 1 to 6.

Table 1 Dietary fibre values of food, expressed as a percentage by mass

Cereals	%
Wheat bran (miller's bran)	44.0
Wholemeal flour (100% unrefined)	9.6
Brown flour (85% refined)	7.5
White flour (72% refined)	3.0
Soya flour (low fat)	14.3
Sweetcorn, canned	5.7
Corn-on-the-cob, boiled	4.7
Rice, white polished, boiled	0.8
brown, unpolished, boiled	5.5
Bread	
Wholemeal	8.5
Brown	5.1
Hovis (UK)	4.6
White	2.7
Breakfast cereals	
All-Bran	28.3
Bran Buds	26.2
Puffed Wheat	15.4
Bran Flakes	14.7
Sultana Bran	12.8
Weetabix	12.7
Shredded Wheat	12.3
Muesli	7.4
Grapenuts	7.0
Sugar Puffs	6.1
Country Store	5.1
Cornflakes	2.0
Special K	1.6
Rice Krispies	1.0
Porridge	0.8
Biscuits	
Ry-King Fibre Plus	28.0
Crispbread rye (Ryvita)	11.7
Digestive, plain	5.5
Energen crispbread	4.9
Shortbread	2.1
Nuts	
Almonds	14.3
Coconut, fresh	13.6
Brazil	9.0
Peanuts	8.1
Hazel	6.1
Vegetables	
Spinach, boiled	6.3
Spring greens, boiled	3.8
Spring onions	3.1
Broccoli tops, boiled	2.9
Brussel sprouts, boiled	2.9
Aubergines, raw	2.5
Cabbage, boiled	1.8
Cauliflower, boiled	1.8
Celery, raw	1.8
Lettuce	1.5
Onions, boiled	1.3
Asparagus, cooked	0.8
Marrow, boiled	0.6
Cucumber, raw	0.4
Root vegetables	
Horseradish, raw	8.3
Yam, boiled	3.9
Carrots, boiled	3.0
raw	2.9
Parsnips, boiled	2.5
Beetroots, boiled	2.5
Potatoes, baked in skins (flesh only)	2.5
Turnip, boiled	2.2
Potatoes, boiled (new)	2.0
Legumes	
Peas, frozen, boiled	12.0
Kidney beans, cooked	7.4
Beans, haricot (whole beans), boiled	7.4
baked and canned in tomato sauce	7.3
Peas, canned	6.3
fresh, boiled	5.2
Broad beans, boiled	5.1
Butter beans, cooked	5.1
Lentils, split, boiled	3.7
Runner beans, boiled	3.4
Fruits	
Dates, dried	8.7
Prunes, stewed	7.4
Raspberries	7.4
Blackberries	7.3
Raisins	6.8
Cranberries	4.2
Bananas	3.4
Pears, fresh, eating	3.3
Strawberries	2.2
Plums, raw, eating	2.1
Apples	2.0
Oranges	2.0
Cherries	1.7
Apricots, stewed	1.6
Tomatoes, raw	1.5
Peaches	1.4
Pineapple, fresh	1.2
Grapes	0.9
Melon (honeydew)	0.9
Grapefruit	0.6
Puddings	
Apple crumble	2.5
Fruit pie	2.4
Rhubarb stewed – no sugar	2.4
Christmas pudding	2.0
Sponge	1.2

Look carefully at the figures in Table 1, then answer these questions:

1 *Why does wholemeal flour have more fibre than white flour?*

2 *What is the difference between white rice and brown rice? Why does brown rice contain more fibre?*

3 *Is All-Bran really all bran? Explain your answer.*

4 *The British diet of a hundred years ago included more fibre than it does today. Suggest a reason why.*

5 *Think about your own diet – the food you normally eat. Would you describe it as being high, medium or low in fibre?*

6 *What would be the simplest way to increase the amount of fibre in your own diet?*

Part 4 Looking at the evidence

Trying to find evidence for the causes of diseases is always difficult, because there are so many factors that can vary. In this section we will look at some of the evidence linking bowel cancer to lack of dietary fibre. First, look back at the section on bowel cancer in Part 2, and read it again.

Now read through the information given below, and answer the questions.

1 Bowel cancer in different parts of the world

The chart in Figure 4 compares the number of cases of bowel cancer among men aged 35–64 in different parts of the world. The figures were collected in the 1960s.

Table 2 shows the diet of the countries shown in the chart. These figures were also collected in the 1960s.

Answer questions 7 to 12.

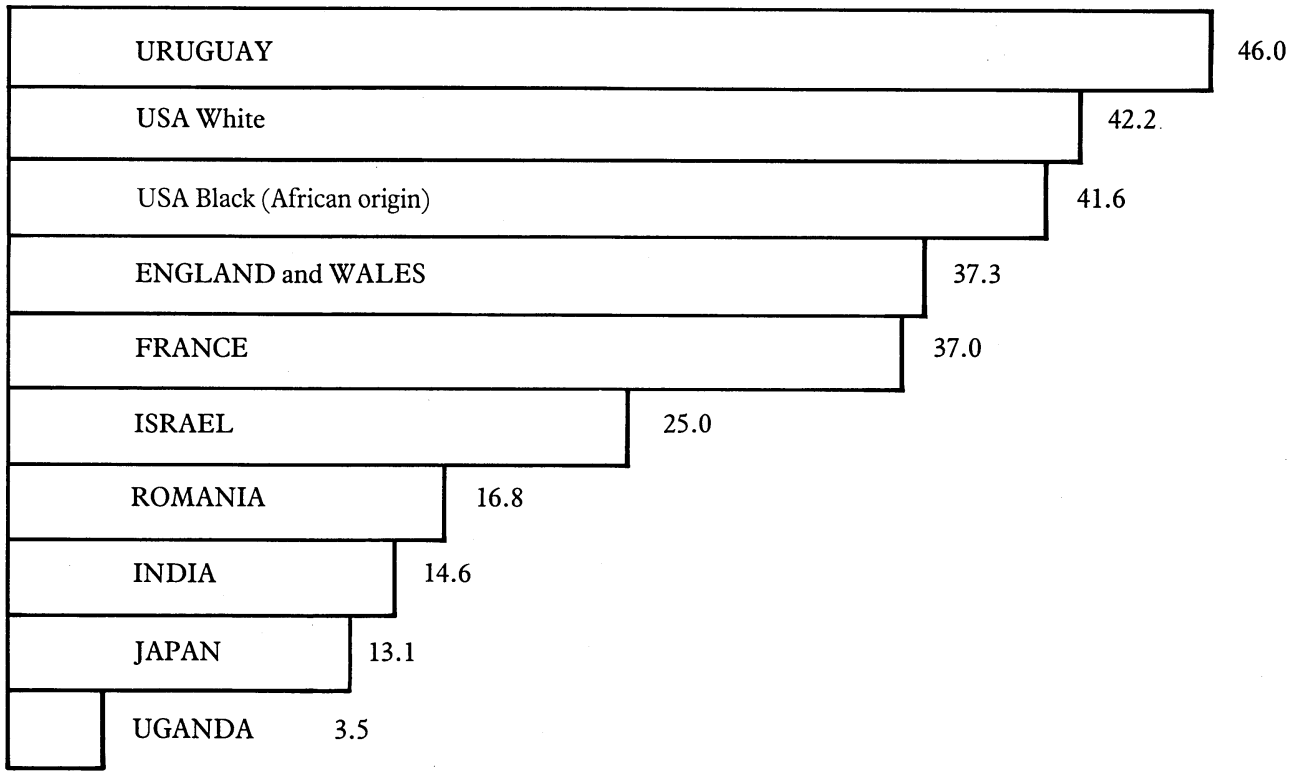

Figure 4 Numbers of men aged 35–64 per 100 000 suffering from bowel cancer per year

Questions

7 *Using Table 1 and Table 2 together, roughly classify each of the countries in Table 2 as having (a) high-fibre; (b) medium-fibre; (c) low-fibre diets. Bear in mind that in developed countries, cereals and other vegetable foods are likely to be eaten in a refined form.*

8 *Now look at the chart in Figure 4 showing numbers of cases of bowel cancer. Does there seem to be any link between the amount of fibre in the diet and the amount of bowel cancer in the country?*

9 *Compare the rate of bowel cancer between Uganda and USA Blacks of African origin. What does this tell you?*

10 *Is the link with dietary fibre the* only *possible explanation for the differences in bowel cancer rates? Are there any other items in the different diets that might explain the differences?*

11 *Are there any other factors* apart from diet *that might explain the differences?*

12 *This comparison looks at only nine different countries. Explain why it would be necessary to look at more countries before drawing any firm conclusion. What kind of countries would you choose?*

Table 2 Percentages of different types of food eaten in different countries.

Country	Cereals	Starchy root vegetables	Nuts	Vegetables	Fruit	Sugar	Meat	Eggs	Fish	Milk
England and Wales	17	21	1	13	12	11	16	3	2	4
France	18	18	1	26	12	5	14	2	1	3
India	63	5	10	1	8	8	2	–	1	2
Israel	19	6	2	18	23	5	22	3	1	1
Japan	36	17	4	22	6	4	2	1	7	1
Romania	44	15	2	14	10	3	8	2	–	2
Uganda	10	76	4	4	1	2	2	–	1	1
Uruguay	20	19	1	10	17	8	22	2	1	2
USA	13	10	1	20	20	8	19	4	1	4

After doing this exercise, you will probably have realized that these figures give *some* evidence for a link between fibre and bowel cancer. However, it is very difficult to *prove* the link, because there are so many variable factors. Of course, these figures are not the only evidence available – doctors have done many other studies. For example, doctors in Israel found that colon cancer patients ate significantly less fibre-containing food than average. But in spite of all the evidence, there is still plenty of room for doubt. At present, therefore, most doctors *suspect* the link is there, but they cannot be sure.