SCIENCE & TECHNOLOGY IN SOCIETY

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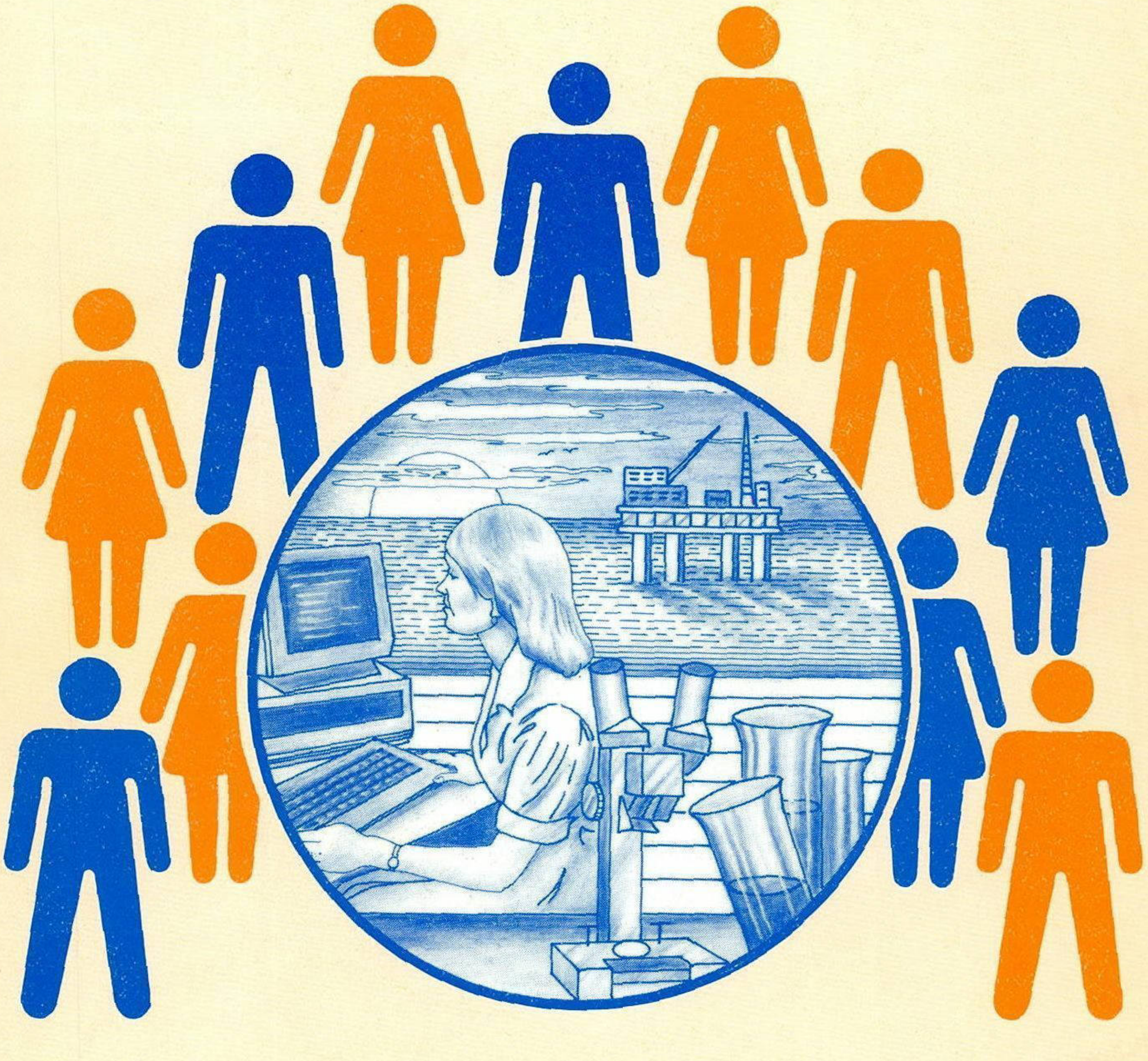

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SATIS

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 2

List of units in this book

201 ENERGY FROM BIOMASS

Reading and problem-solving exercises, including optional practical work, on the production of biomass energy.

202 ELECTRIC VEHICLES

Reading and questions concerning the advantages and limitations of electric vehicles.

203 DRINKING ALCOHOL

Practical work, reading and questions on alcohol and its effects on the body.

204 USING RADIOACTIVITY

Reading and problems concerning the medical and industrial applications of radioisotopes.

205 LOOKING AT MOTOR OIL

Information and questions on the function of motor oil in an engine, and the problems involved in formulating an efficient oil. Optional practical work investigating the change of oil viscosity with temperature.

206 TEST-TUBE BABIES

Information and discussion questions on the problem of infertility and the technique of *in vitro* fertilization.

207 THE STORY OF FRITZ HABER

Reading and discussion questions relating to the life and work of the inventor of the Haber Process.

208 THE PRICE OF FOOD

Survey, analysis and discussion concerning the factors affecting the price of food items.

209 SPECTACLES AND CONTACT LENSES

Reading, questions, practical work and a survey concerning spectacles and contact lenses.

210 THE PESTICIDE PROBLEM

A decision-making and data-analysis exercise concerning the testing and use of pesticides.

List of units in the SATIS series

Energy from Biomass

Contents: Reading and problem-solving exercises, including optional practical work, on the production of biomass energy.

Time: 2 periods or more, depending on number of parts attempted.

Intended use: GCSE Biology, Chemistry and Integrated Science. Links with work on photosynthesis, anaerobic respiration, fermentation, decomposition, combustion and fuels.

Aims:

- To complement work on photosynthesis, anaerobic respiration and fuels
- To show the range of technologies for biomass energy production, and some of the environmental problems encountered
- To develop awareness of the opportunities and problems involved in producing energy in developing countries
- To show some ways waste materials can be put to good use
- To provide opportunities to practise skills in problem solving.

Requirements: Students' worksheets No. 201. If practical work is attempted, apparatus will be needed, as described later.

The following background information may be of use.

Solid biomass fuels There is now considerable interest in certain fast-growing plants for biomass fuels. For example, in Kenya papyrus is grown as an energy fuel. One hectare of land can produce 32 tonnes of papyrus a year, compared with the 10 tonnes of grass produced per year by English pasture. Water hyacinth, a major nuisance which clogs up tropical waterways, can be grown on sewage lagoons. The plants purify sewage and produce a remarkable 712 tonnes of dry biomass per year from 1 hectare. Experiments are also being done with fast-growing seaweeds and with plants grown in CO_2-enriched greenhouses.

Liquid biomass fuels It is interesting to note that the Brazilian government blends the pure alcohol sold at pumps with a small percentage of petrol — apparently to prevent customers drinking it.

Biogas Students might be interested to hear about other anaerobic environments where biogas is produced — for example, in marshes and in the gut of animals, including humans.

Methane production in landfills (Q.3) is quite common. The enormous Fresh Kills landfill is New York State produces 20 billion cubic metres of gas a year.

General Biomass energy has many attractions, but also a number of drawbacks. An obvious problem is that energy crops may take land that is needed for growing food. It is worth noting that of the total material produced by photosynthesis, ten per cent would be needed to provide all the world's energy needs, while only 0.5 per cent is currently used for food. Since much of the world's biomass is in wild plants, grass and forest, to provide all energy needs by 'energy farming' would be a very major enterprise.

Fuel crops often require considerable energy *inputs*, and it is essential to ensure that their energy *output* is substantially in excess of this input. Input energy includes the energy used to manufacture fertilizers, to fuel farm machinery and to process the crops. The production of alcohol, for example, requires substantial energy at the distillation stage.

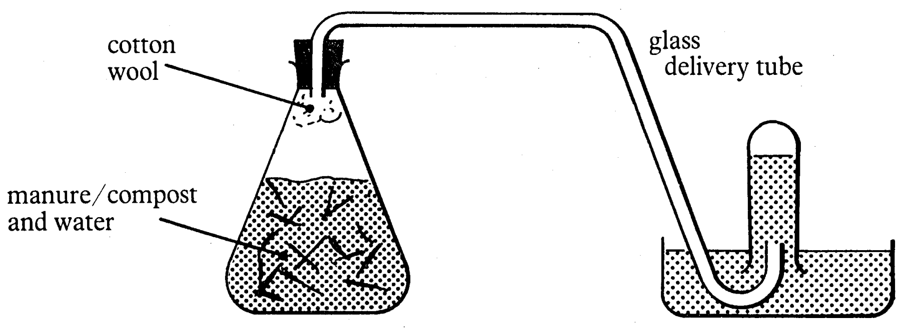
Activities and questions

The questions need not necessarily all be answered, though the Caramina problem is worth tackling as a useful way of drawing together the general information on biomass.

Practical work — Build your own biogas digestor

This problem-solving exercise is well worth attempting with all students at least as far as the design stage. Teachers will need to decide for themselves whether to allow the class to build their own digestors, the alternative being a demonstration one. The problems of an entire class handling manure or compost are obvious. In any case, **disposable gloves should be worn and equipment thoroughly cleaned afterwards.**

Many different designs are possible, the simplest and crudest being the one shown below.



Likely problems

1 *Temperature control* Keeping the 'brew' at a temperature of 30°C is tricky but vital. An electrically heated water-bath could be used, but is hardly appropriate technology. Students could be encouraged to devise solar heating arrangements — in summer, a position by a sunny window is enough to keep fermentation going, at least during the daytime. Thermal insulation can also be effective.

2 *Gas leaks* The small methane molecule diffuses rapidly, and the apparatus should be completely gas-tight. Rubber tubing should be avoided, though plastic tubing appears to be adequate.

3 *Blockage* It is possible for delivery tubes to become blocked by solid material which floats to the top of the 'brew'. This can cause a dangerous build-up of pressure, and can be prevented by using a cotton-wool plug positioned as shown in the diagram above.

Requirements

The apparatus required will of course depend on the design adopted.

A supply of compost or manure is needed: cow, horse and chicken manure all work well. Compost can be used, but will work much better if a little manure is added to ensure that plenty of bacteria are present.

Further practical work

Students could be given further practical problems relating to biomass energy, for example:

1 Design and carry out an experiment to make wood charcoal and collect the gas evolved.

2 Design experiments to make alcohol fuel from sugar.

Other resources

1 'Grow your own Energy', a *New Scientist* guide edited by Michael Cross, is a useful collection of information on the subject.

2 The Third World Science Project includes units entitled 'Methane Digestors' and 'Charcoal'. Available from: Third World Science Project, School of Education, University College of North Wales, Bangor, Gwynedd.

3 The Centre for Alternative Technology produces resource materials on biomass energy, and also has displays that can be visited at the centre in Wales. Centre for Alternative Technology, Machynlleth, Powys SY20 9AZ.

Acknowledgements Figure 3 supplied by United Nations Information Centre; Figure 8 from *Methane Digestors* (Third World Science Project).

ENERGY FROM BIOMASS

With fossil fuels running out, the world needs *renewable* energy sources — energy sources that are re-made as fast as they get used up. Plant material — called **biomass** — is a good renewable energy source. Biomass energy is particularly important in developing countries, which often do not have their own fossil fuels, and cannot afford to buy them.

How do we get energy from biomass?

Plants are able to trap the Sun's energy using the chlorophyll in their leaves. They use the energy to convert carbon dioxide and water to carbohydrate. This process is called **photosynthesis** (Figure 1).

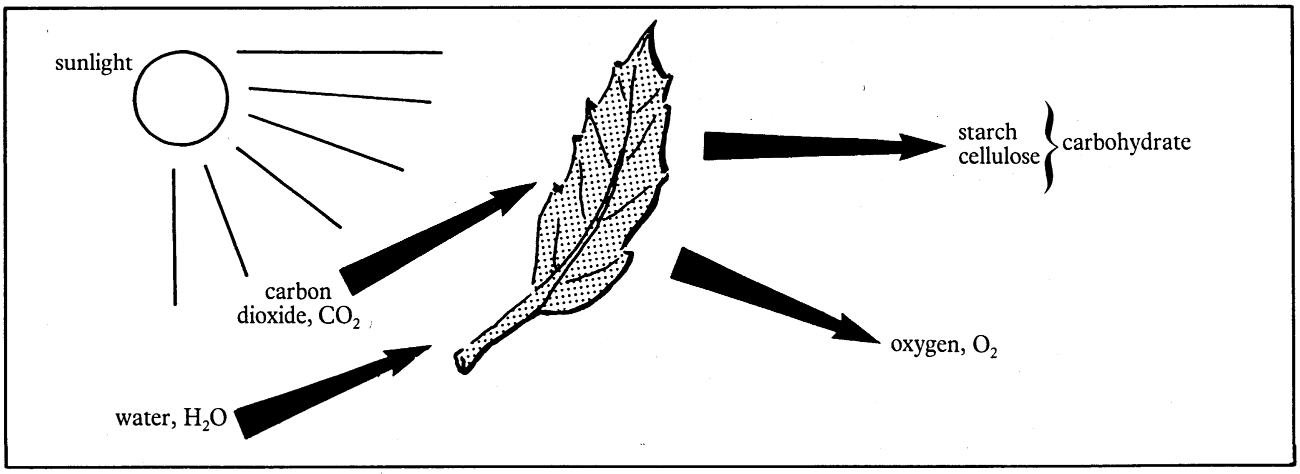


Figure 1 Photosynthesis

Carbohydrates like starch and cellulose store energy. When they are burned in air, this energy is released. A tenth of the energy stored by photosynthesis could provide all the world's energy needs.

Plant material, such as wood, can be burned directly as a fuel. It can also be turned to other fuels, which may be solid, liquid or gaseous (Figure 2).

Question

1 Tropical countries are generally better able to produce biomass fuels than cool countries like Britain. Explain why this is so.

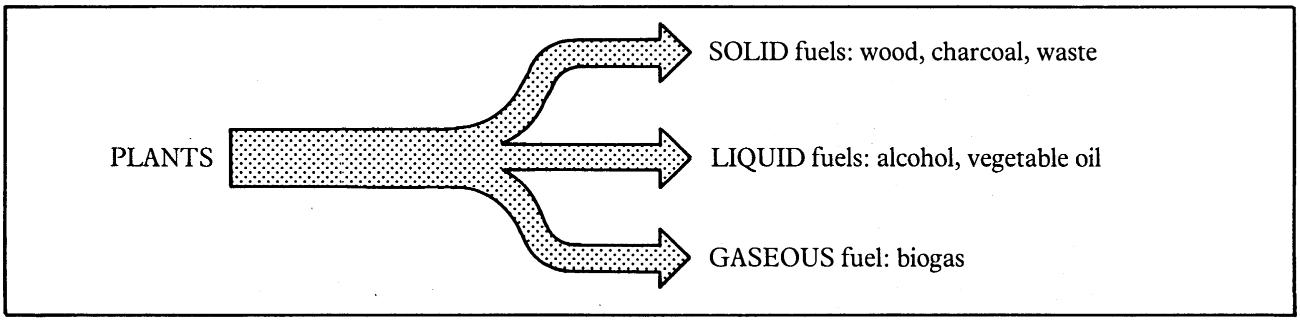


Figure 2 Biomass fuels can be solid, liquid or gaseous

Solid biomass fuels

Wood

Firewood is the oldest fuel of all. It is still the most commonly used fuel. Four out of five families in the developing world depend on wood as their main energy source. In some countries there is a serious shortage of firewood, because so many people need it. Women may walk 10 kilometres a day, five days a week, collecting firewood.

Question

2 *In Britain, wood-burning stoves and log fires are becoming popular. What problems could this cause?*

Figure 3 African women bringing firewood to their village

Firewood is a good renewable fuel, but there are problems if it is over-used. In many places, wood is cut from trees faster than new wood can grow. Eventually the trees will die. Where lots of trees are cut down and not replaced, serious soil erosion can occur.

Charcoal

Wood is heavy to carry about because it contains a lot of moisture. By heating wood without air present, the moisure can be driven out, along with flammable liquids and gases. Almost pure carbon is left, called charcoal. It is an excellent fuel which burns slowly and causes little pollution.

The traditional way of making charcoal is shown in Figure 4.

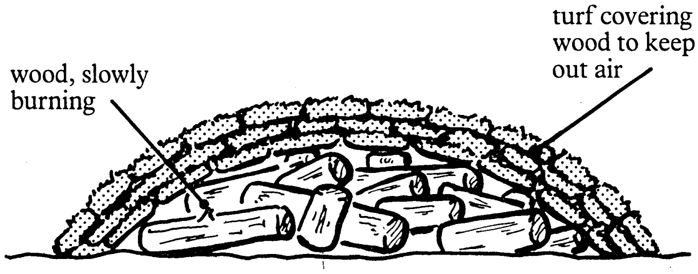


Figure 4 Making charcoal

In Britain we often use charcoal in barbecues. But it is the main fuel in some developing countries.

Waste

In Britain, 4.5 million tonnes of waste straw are burned by farmers each year. If the energy from the burning straw could be used, the farmers could supply all their energy needs from it. Household waste is also a good energy source. The problem is collecting these low-value waste materials and bringing them to the place where they are wanted. The energy used in collecting the waste could be more than the energy it provides when burned.

Question

3 **Landfill bioreactors** *are used to generate biogas from rubbish. Rubbish is tipped into a hole in waste ground, and allowed to produce biogas. (Figure 5).*

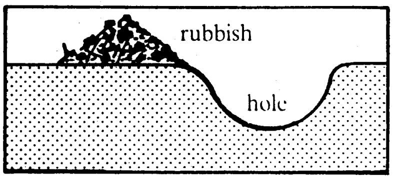


Figure 5

Draw a diagram to show the arrangement you would use to generate and collect biogas from a landfill bioreactor. What kinds of household rubbish would work best?

Liquid biomass fuels

Alcohol

Sugar cane is a fast-growing tropical plant. The sugar it provides can be fermented to make alcohol. Alcohol is an excellent liquid fuel which can be used instead of petrol in cars. It is often mixed with petrol to give **gasohol** (Figure 6).

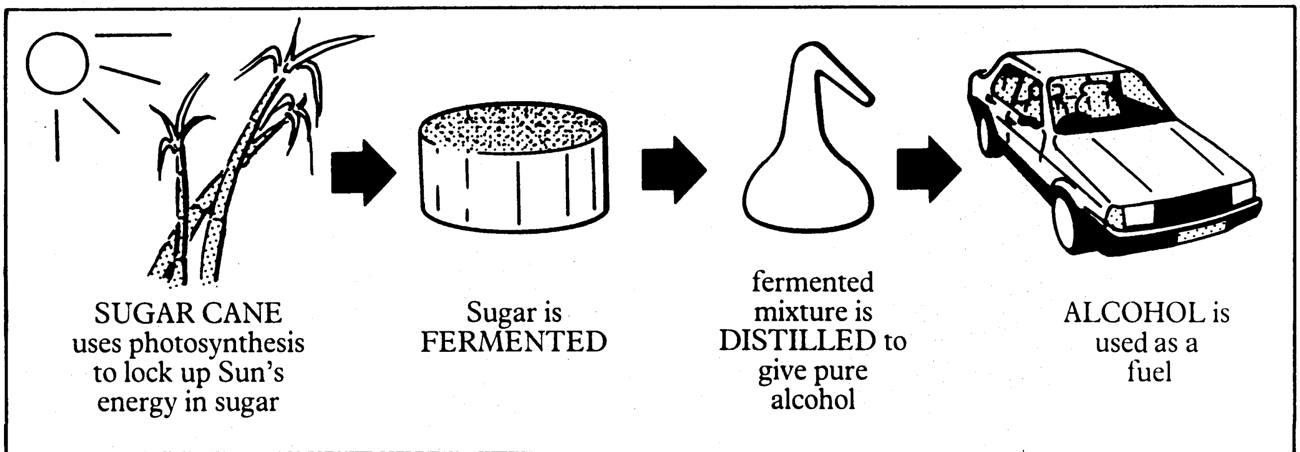


Figure 6 Making alcohol fuel

After the sugar cane has been crushed to remove the sugar, a woody material called **bagasse** is left. It makes a good solid fuel which can be used to provide heat for the distillation stage.

In Brazil, many cars now run on alcohol fuel made this way, and Brazil has plans to replace all petrol by alcohol.

Oil

Many plants produce vegetable oils — sunflower oil and peanut oil are examples. These oils could be used as fuels in the future. Engineers are trying to find ways of making diesel engines run efficiently using vegetable oils.

Question

4 *For Brazil to replace all liquid fuels with alcohol, the country would need to use half its present farmland to grow energy crops like sugar cane. This means new farmland would be needed to grow enough food. The new farmland would have to be provided by clearing part of the Amazon jungle. What problems would this cause?*

Biogas

When vegetable and animal matter rots in the absence of air, a gas is given off. This is **anaerobic respiration.** The gas is usually about 60 per cent methane, the rest being mostly carbon dioxide. This **biogas** is a good fuel, particularly for cooking, heating and lighting in the home.

Biogas is particularly easy to make on farms. Manure and waste vegetable matter such as straw are allowed to rot in a closed tank. The biogas is collected, and the solid material left behind is an excellent fertilizer. Figure 7 shows a typical **biogas digestor.**

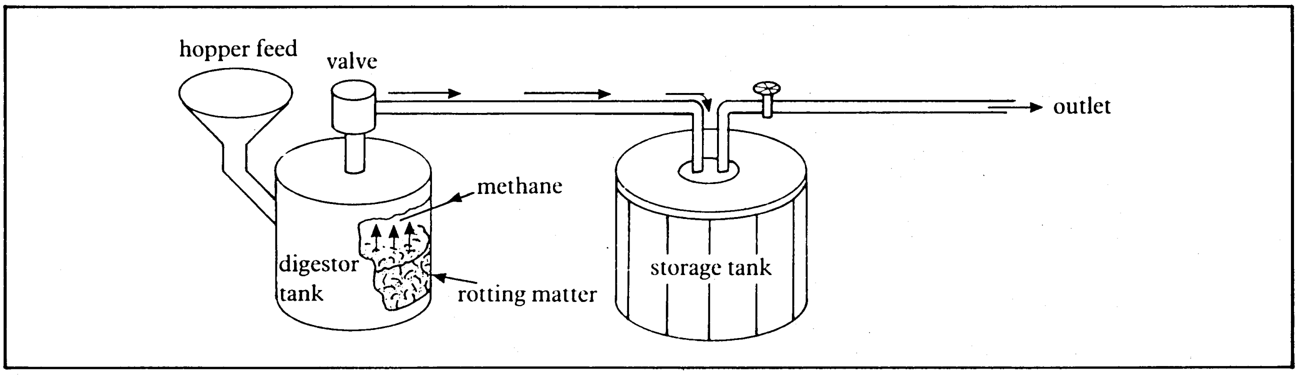


Figure 7 A biogas digestor

There are over 7 million biogas digestors in China, supplying energy for 35 million people. Often digestors are built in underground pits (Figure 8).

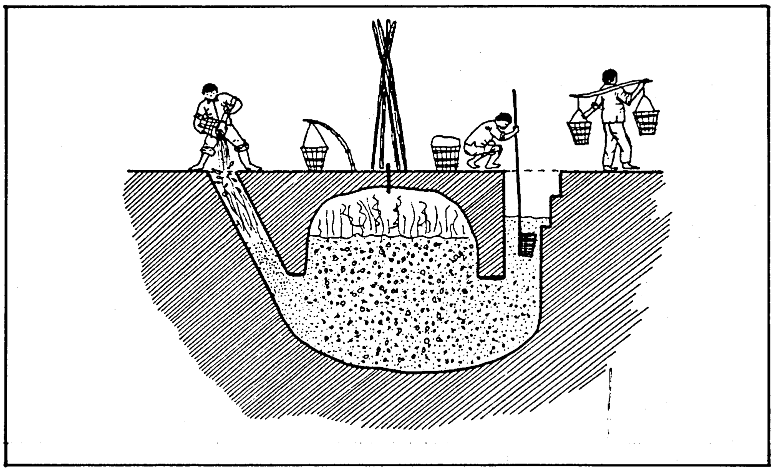


Figure 8 An underground biogas digestor

> *Question*
>
> *5 Look carefully at Figure 8, then write a few sentences about it. What are the different people doing?*

Farmers in Britain are beginning to use biogas too, for generating electricity and for heating. The gas can even be used instead of petrol to fuel cars.

A small biogas digestor will produce enough gas for a family. A typical small digestor would use the manure of five animals (cows and pigs) and some vegetable matter. A digestor like this would produce 2 or 3 cubic metres of gas a day.

One cubic metre of biogas will

- cook 3 meals for a family of 6, or
- drive a 3-tonne lorry 3 kilometres, or
- light a biogas lamp equivalent to a 60-watt bulb for 6 hours, or
- generate 1.25 kilowatt-hours of electricity.

Biogas is produced by bacteria. As they break down the rotting matter, the bacteria release methane. For good biogas production, the bacteria need to be warm — they work best at about 35°C. In tropical countries this is no problem, but in colder countries, some of the biogas has to be used for keeping the digestor warm.

Biogas digestors are simple to build, and you may get a chance to design and build your own.

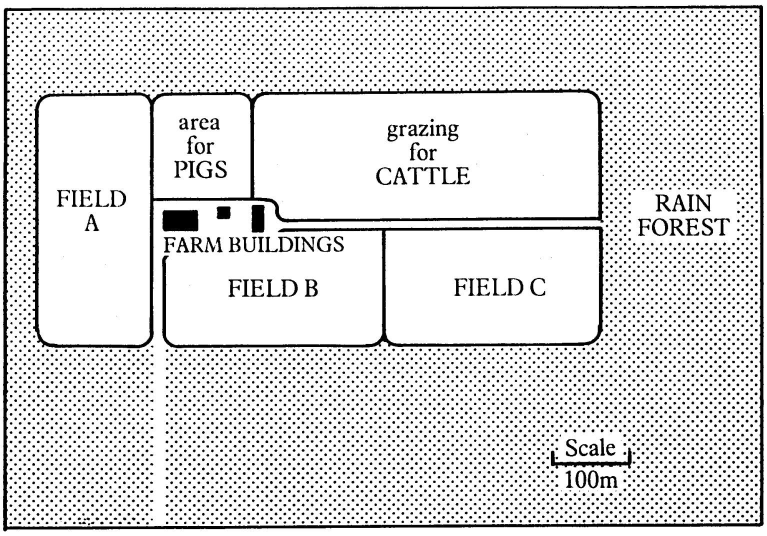


Figure 9 Caramina

Question

6 *Do you think biomass fuels will ever provide* all *the world's energy requirements? Explain your answer.*

Question

7 **The Caramina problem**
Caramina is a small farm built in a clearing in the Amazon rain forest (Figure 9). It has fertile, well watered soil and most crops grow successfully.

Two of the three fields are needed for growing maize. The farm's energy needs are as follows:

- *Lighting and cooking fuel for the farm buildings*
- *Fuel for the farm's small truck*
- *Electricity for the farm buildings.*

How would you provide all the farm's energy needs, using only *biomass produced on the farm or in the forest?*

Describe your plans, and redraw the map showing the crops you would grow and any new equipment you would need.

Build your own biogas digestor

Model biogas digestors are quite simple to make in the laboratory. Your task is to design a digestor that will produce and collect at least 10cm^3 of biogas from a sample of compost or manure.

You will need to bear the following points in mind.

1. The bacteria which produce the biogas work best at around 30°-35°C. This is a little below body temperature. If the temperature of the mixture drops below 20°C you will get very little biogas.
2. The bacteria need water. They work best when the compost is mixed half-and-half with water.
3. The methane molecule is small and can easily escape from apparatus unless it is completely gas-tight. Biogas can escape through the walls of rubber tubing unless they are thick.
4. Biogas does not dissolve in water.
5. As long as there is air in the apparatus, the bacteria will produce carbon dioxide, not methane. Biogas will start to be produced when all the air has been displaced from the apparatus. You will not get much biogas for a week or so.

Your digestor should use the kind of apparatus normally found in a science laboratory.

Draw a diagram to show your design. Your teacher may give you a chance to try it out by actually building the digestor.

Electric Vehicles

Contents: Reading and questions concerning the advantages and limitations of electric vehicles.

Time: 1 to 2 periods, depending on number of questions tackled and amount of discussion.

Intended use: GCSE Physics and Integrated Science. Links with work on electric motors, energy, power and electricity generation.

Aims:

- To complement prior work on energy and electric power
- To show some of the advantages and limitations of electric vehicles
- To illustrate the fact that all technology is limited by the laws of science
- To develop awareness of some of the wider issues associated with road transport, including consumption of fuel resources, efficiency of energy conversion and pollution
- To provide opportunities to practise skills in reading, comprehension and application of knowledge.

Requirements: Students' worksheets No. 202

Notes on some of the questions

There is a large number of questions in the unit and teachers may prefer their students to answer only a selection. This applies particularly to questions 12 to 21 at the end of the unit.

Q.9 This question establishes the remarkable fact that a petrol pump delivers chemical energy at the rate of 30 megawatts. This means a large 2000 MW power station is equivalent to just 67 petrol pumps.

Q.10 The point here, of course, is that while electric vehicles themselves cause little pollution, the energy they store in their batteries has been generated at power stations, which themselves cause pollution. It might be interesting to discuss which causes more pollution: burning primary fuel at a power station or in an internal combustion engine. The answer is probably the latter, and there is also the point that a power station discharges its emissions much higher in the atmosphere.

Q.11 Electric vehicles probably score over petrol vehicles on all these points.

Q.13 A milk float does not need to move fast, and the regular cycle of the milk round fits in well with the recharging requirement. The constant stopping and starting also gives the electric vehicle an advantage over petrol or diesel.

In some electric vehicles, braking is used to advantage, by using 'regenerative braking' to generate electricity.

Q.14 Fork lift trucks and other vehicles for interior factory use need to be quiet and must not produce toxic fumes. Another advantage of electric motors for this application is that they give high torque starting from rest, unlike petrol engines.

Other examples of electric vehicle applications include street cleaning vehicles, works fire tenders, airport support vehicles, servicing platforms, refuse collection vehicles, invalid carriages and hospital patient transporters.

Q.16 The overall efficiency of electric vehicles in the conversion of primary fuel is actually less than that of petrol vehicles, and much less than diesel vehicles, because of the large losses involved in generation and transmission of electricity.

Q.20 It seems there is little chance of introducing electric cars to any significant extent as long as the tremendously flexible petrol vehicle is cheaply available, with its long range, short refuelling time and instant availability.

Acknowledgements Figures 1 and 3 supplied by The Electricity Council; Figure 8, by Sinclair Vehicles.

ELECTRIC VEHICLES

Look at this list of advantages:

- Cheap to run
- Quiet-running
- Cheap to maintain
- Easy starting in winter
- Safe
- Pollution free
- Ideal for stop-start driving
- No road tax

These are some of the impressive advantages of electric vehicles. So why don't we see more of them on our streets? Electric milk floats, yes, but why not electric cars, lorries, buses, and bikes?

Figure 1 An electric milk float

Vehicles need energy

Vehicles need energy to accelerate. Even when a vehicle is running along at a steady speed, it needs energy to overcome resistance — air resistance and friction. Figure 2 shows the amounts of energy needed by a 1-tonne car travelling a distance of 1km at 45km/h.

To provide this energy, the vehicle needs an energy store.

Answer questions 1 to 4.

Questions

1. *What provides the energy store in an ordinary car?*
2. *What is the energy store in an electric car?*
3. *Some electric vehicles do not use an energy store. Instead they collect their energy as they go along. Give an example of such a vehicle.*
4. *Explain why a heavy vehicle needs more energy to accelerate than a light one.*

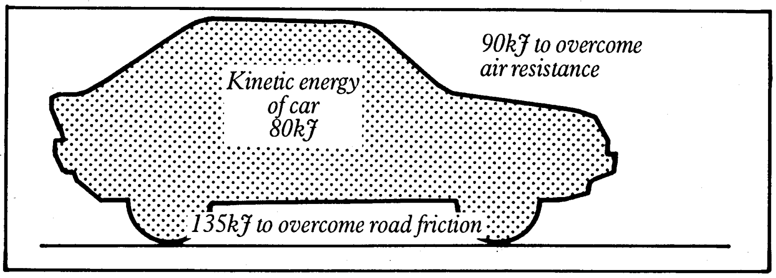


Figure 2 Energy needed by a 1-tonne car travelling 1km at 45km/h.

How do electric vehicles work?

Electric trains can collect their electrical energy from overhead wires or conductor rails. But other electric vehicles need to carry their energy stored in a battery. The batteries drive an electric motor. The main parts of the system are illustrated in Figure 3, which shows an electric lorry.

After the vehicle has been used for a while, the batteries have to be recharged. This takes several hours and is usually done overnight.

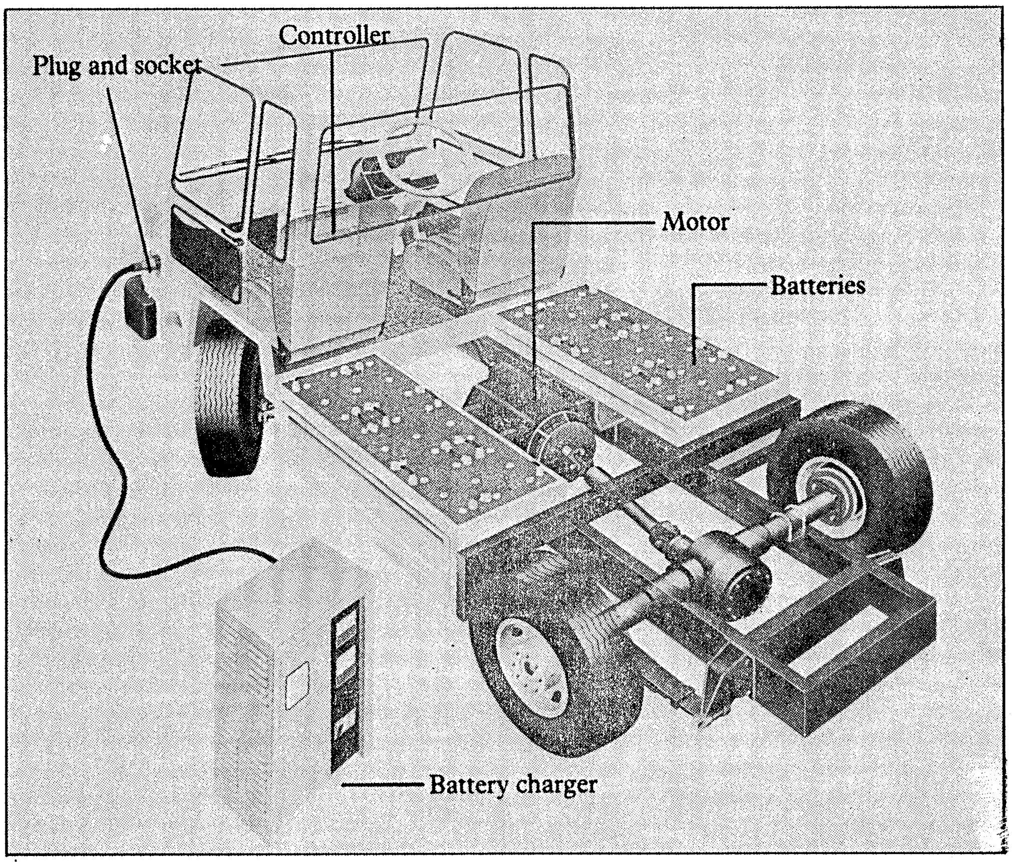


Figure 3 Charging an electric lorry

How do electric vehicles compare with petrol vehicles?

To understand why electric vehicles are still quite rare, we need to compare electricity with petrol as a source of energy. Many vehicles use diesel fuel instead of petrol, but the figures are quite similar.

1 Energy density

To store electricity, you need a battery. Batteries are usually quite heavy . The most commonly used battery is the heavy lead-acid battery. To store petrol you only need a petrol tank. We can compare the 'energy density' of petrol with that of a fully-charged lead-acid battery. The 'energy density' is the energy stored per kilogram of energy store. In the figures given in Figure 4 on the next page, energy is measured in kilojoules. Look at Figure 4, then answer Questions 5 and 6.

Questions

5 *Use the figures in Figure 4 to explain why electric vehicles need charging every night.*

6 *A new lightweight battery, called the sodium-sulphur battery, has been developed. It weighs a fifth of the weight of a lead-acid battery storing the same amount of energy. Calculate the energy density of a sodium-sulphur battery.*

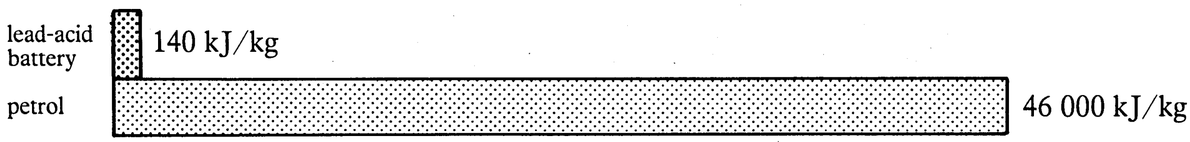


Figure 4 Energy density of lead-acid battery and petrol

2 Efficiency

In any vehicle, stored energy has to be converted to kinetic energy. This is never completely efficient. Some of the stored energy always gets wasted as heat. The *percentage efficiency* gives the percentage of stored energy that gets turned into kinetic energy (Figure 5).

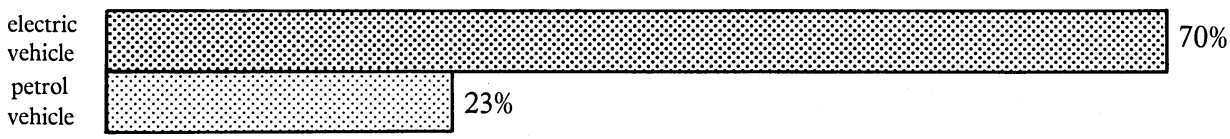


Figure 5 Percentage efficiency of electric and petrol vehicles

Because it is more efficient, the electric vehicle does not need to store as much energy as a petrol vehicle in order to travel a given distance. Even so, petrol is still a much more concentrated energy store. Petrol vehicles can go much further on one tankful than electric vehicles can on one charge.

3 Range

The distance a vehicle can travel on one charging or one tank refill is called its range. Figure 6 compares the range of a typical petrol vehicle and a typical electric vehicle. Answer Question 7.

> *Question*
>
> 7 *Explain why it is not possible to travel more than about 50 miles per day in an electric vehicle.*

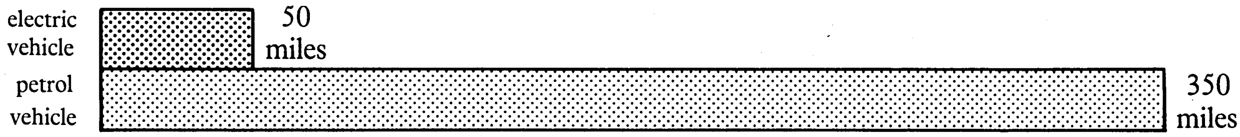


Figure 6 Range of electric and petrol vehicles

4 Recharging

Electric vehicles need to have their batteries recharged each night. They are charged from the ordinary electricity supply. Electricity is generated in power stations, so it is really the power station that is providing energy for the batteries (Figure 7).

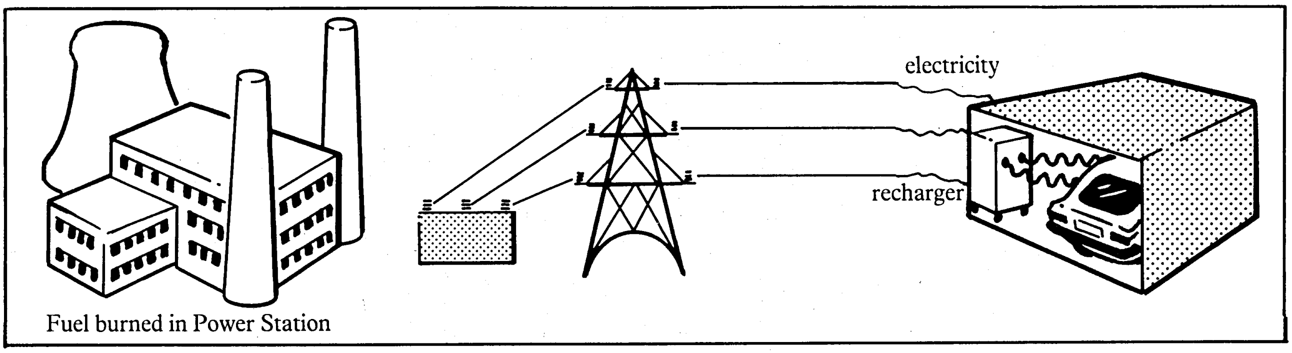


Figure 7 Recharging an electric vehicle

One of the problems with recharging a vehicle's batteries is that it is very slow. A 13-amp socket in your house can supply 3kW, or 3kJ per second. Compare that with a petrol pump, which delivers nearly a kilogram of petrol every second. The amount of energy stored in this petrol is 30 000 kJ, so a petrol pump delivers energy much, much faster than a 13-amp socket. In fact, it takes 17 000 13-amp sockets to deliver energy as fast as one petrol pump! To deliver energy this fast through a single cable would need a cable 40cm thick! Answer Questions 8 and 9.

Questions

8 *A typical electric vehicle stores 45 000kJ in its batteries. How long would it take to charge on a 13-amp socket?*

9 *(a) What is the power in megawatts of a petrol pump like the one described above?*

(b) A large power station has a power of 2000 megawatts. How many petrol pumps is this equivalent to?

5 Weight

Electric vehicles have a weight disadvantage compared with petrol vehicles. Electric motors are four or five times heavier than equivalent petrol motors. What is more, the electric vehicle has to carry around a heavy battery. This is one of the reasons why electric vehicles like milk floats are often slow.

6 Cost

The fuel cost per kilometre of an electric vehicle is about half that of a petrol vehicle. This is mainly because petrol is heavily taxed.

7 Pollution

Electric vehicles cause hardly any pollution on the streets. Petrol vehicles give off a great deal of polluting gases such as sulphur and nitrogen oxides. Exhaust from petrol vehicles is thought to be one of the major causes of acid rain. Answer Question 10.

Questions

10 *An expert on pollution has said: 'Electric vehicles cause no pollution on the street. They shift all their pollution to power stations'. What did she mean?*

11 *How do you think electric vehicles and petrol vehicles compare for: (a) quietness; (b) safety; (c) ease of starting in cold weather; (d) servicing and maintenance costs? Explain your answers.*

Future developments

A lot of money is spent on research into new and better electric vehicles. Yet in spite of this, there are still few of them on our streets — and these all use the same basic technology of a lead-acid battery and an electric motor. They all have the same basic limitations of short range and long recharging time.

The best hope for electric vehicles seems to lie with lightweight batteries. A great deal of research is being done on new battery technology, and the breakthrough may come when a cheap, light rechargeable battery is developed.

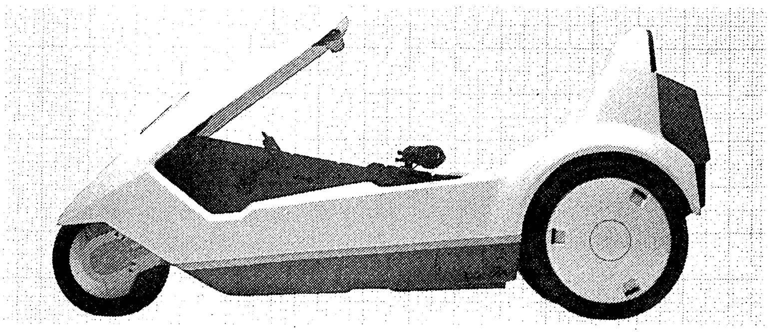


Figure 8 The Sinclair C5 electric tricycle. Brought out in 1985 with much publicity — yet it basically uses milk float technology.

More questions to answer and discuss

12 *Using the ideas you have just read, sum up briefly the reasons why electric vehicles are still uncommon, in spite of their advantages.*

13 *There are about 30 000 electric vehicles in Britain, and 27 000 of them are milk floats. What is it about a milk round that makes an electric vehicle so suitable?*

14 *Fork-lift trucks are used in factories to carry goods around. They are practically always electric. Why is electricity particularly suitable for this use?*

15 *Look back at the section on recharging. Explain in your own words why electric vehicles really get their energy from the fuel burned in power stations.*

16 *Power stations are never 100 per cent efficient. Only 30 per cent of the energy released by burning fuel is turned to electricity. Half of this electricity is lost in transmitting it to the users. So the overall efficiency of a power station is only 15 per cent.*

What does this mean for the overall efficiency of electric vehicles? (Look back at the section on efficiency.)

17 *An expert on electric vehicles has said: 'Electric vehicles are a way we can burn coal and nuclear fuel on our streets.' What did he mean?*

18 *It has been suggested that one way to make electric vehicles more attractive would be to run 'battery exchange stations'. In these stations you would be able to exchange a discharged battery for a fully charged one. Why would this help? What problems might there be?*

19 **Hybrid vehicles** *are vehicles that have both petrol and electric motors. They can run on electricity or petrol. What might be the advantage of such a vehicle?*

20 *An expert on electric vehicles has said: 'As long as we have plenty of petrol available, people are never going to reorganize their life styles to use battery electric vehicles.' What difference would it make to an average family's life style if they had to change their petrol driven car for a battery vehicle?*

21 *Invalid carriages are often electrically powered. Why is electricity particularly suitable for this type of vehicle?*

Drinking Alcohol

Contents: Practical work, reading and questions on alcohol and its effects on the body.

Time: 2 periods or more, depending on amount of discussion.

Intended use: GCSE Chemistry, Biology and Integrated Science. Links with work on ethanol and other alcohols in Chemistry, and work on nerves, absorption and the liver in Biology.

Aims:

- To complement prior work on ethanol, nerves, absorption and the liver (though it is not necessary to have covered all of these)
- To develop awareness of the effects of alcohol on the body
- To develop awareness of the dangers of alcohol abuse, and guidelines for safe drinking
- To provide opportunities to practise skills in reading, comprehension and application of knowledge, and certain practical skills.

Requirements: Students' worksheets No. 203. For practical work requirements in Part 1, see below.

Students may be introduced to the problems of alcohol abuse in other parts of the school curriculum, but it is also helpful to consider them in a scientific context.

The unit is in three parts:

Part 1 How much alcohol is in a drink?
Part 2 What does alcohol do to your body?
Part 3 Safe drinking.

Part 1

In this part, students make measurements which give them a clear idea of the quantities of alcohol present in a typical drink. In each case, the volume of pure alcohol present is approximately $10cm^3$, or a little more. Later, in Part 3, this will be identified as a 'unit' of alcohol.

Requirements

Each group of students will require:
measuring cylinder ($100cm^3$ or $250cm^3$)
evaporating basin or other heatproof dish of at least $100cm^3$ capacity
heatproof mat
access to:
half-pint beer glass
wine glass
small sherry glass
spirits measure, or glass marked off with the correct measure (a single measure of spirit is about $25cm^3$)
laboratory alcohol

Burning one 'unit' of alcohol gives a striking demonstration of the energy stored in this chemical. When alcohol is metabolized in the liver, this energy is either used in exercise, or stored as fat.

For the teacher's information, ethanol is metabolized in the liver by oxidative enzymes, first to ethanol, then to ethanoic acid. Ethanoic acid is then oxidized to carbon dioxide and water by normal biochemical routes. Methanol is also oxidized in the liver, but the methanoic acid so formed is toxic and cannot be removed by further oxidation.

Caution:
The teacher may prefer to demonstrate the burning of alcohol. A heatproof dish *must* be used, standing on a heatproof mat. Alcohol burns with a non-luminous flame, and care must be taken to avoid contact with the flame. Care must also be taken to avoid spills of alcohol, which might ignite on the bench.

If time permits, the concentrations of alcohol in the different drinks could actually be measured, using a relative density method.

A hydrometer can be used if available, or a home-made hydrometer can be contrived using a glass tube of about 1cm diameter and about 25cm in length, closed with a rubber bung at one end.

The hydrometer is first calibrated by floating in alcohol solutions of different concentrations and marking the liquid level on the hydrometer with a waterproof and alcohol-proof pen. Suggested concentrations of alcohol solution are: 8%, 16%, 32%, 48%, 96% by volume.

The calibrated hydrometer can then be used to estimate the alcoholic concentration of different drinks. The results are, of course, only approximate because sugar and other substances are dissolved in the drink as well as alcohol.

Part 2

This part gives a very simple physiological background to the effects of alcohol. The mechanism of the effect of alcohol on the nervous system is highly complex, and far from being well understood. Nevertheless, the idea to get across is that alcohol interferes with the transmission of nervous impulses. It is thought that alcohol has a particular effect on inhibitory nerve cells. These control the excitation of impulses which, unchecked, would lead to unrestrained behaviour and abnormal muscle stimulation. Hence the observed effect of alcohol in making people less inhibited.

Part 3

Here the idea of counting alcohol units is introduced. It is very difficult to quantify the effects of alcohol, since they vary so much according to weight, sex and tolerance. However, the figures in the table below may be useful to the teacher.

Blood alcohol level /mg per 100cm^3	Corresponding number of alcohol units for an average male	Effect
30	2	Increased sociability; feeling of well being; loss of inhibition
60	4	Some loss of muscular control; loss of reasoning
90—100	6—7	Marked loss of muscular control
200—300	14—20	Semi-consciousness or unconsciousness
500	33	Probably death

Other resources

1 A useful booklet, *That's the Limit — a Guide to Sensible Drinking* is produced by the Health Education Council (78 New Oxford Street, London WC1H 1AH). Available free.

2 The Teachers Advisory Council on Alcohol and Drugs Education have a range of resources, including alcohol education syllabuses for 11- to 16- and 16- to 19-year-olds. Details from TACADE, 2 Mount Street, Manchester M2 5NG.

3 The Schools Council/Health Education Council Project, 'Health Education', published by Forbes Publications, includes a useful treatment of alcohol.

4 A number of 'trigger' films on alcohol are available on free loan from The Central Film Library, Chalfont Grove, Gerrards Cross, Bucks.

Acknowledgements Figure 2 supplied by Whitbread; Figure 5 by the Metropolitan Police.

DRINKING ALCOHOL

The substance chemists call ethanol is a member of a family of compounds called the alcohols. All alcohols have the O-H group of atoms in their molecules. The structure of a molecule of ethanol is shown in Figure 1. In common, everyday language, ethanol is just called 'alcohol'.

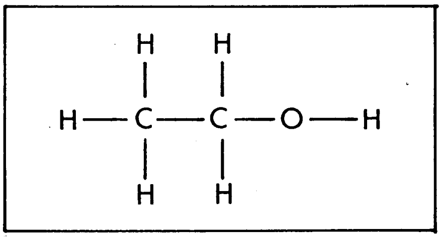


Figure 1 A molecule of ethanol

People have been drinking alcoholic drinks for thousands of years. Alcohol can give people a lot of pleasure, but it also causes a lot of sadness, illness and even death. In this unit you will find out more about alcohol, what it does to your body and how to use it safely.

This unit is in three parts:

- Part 1 How much alcohol is in a drink?
- Part 2 What does alcohol do to your body?
- Part 3 Safe drinking.

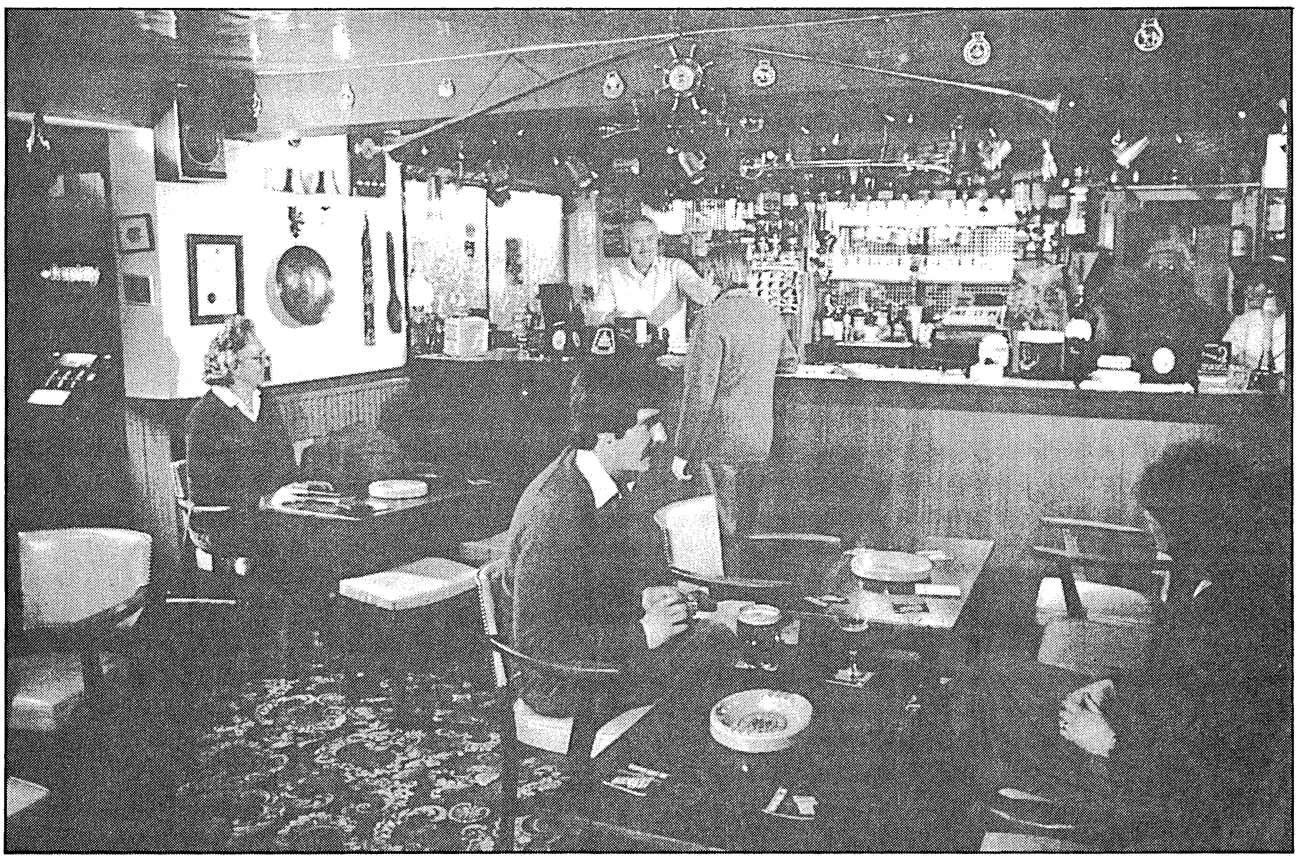


Figure 2 The sociable atmosphere of the local pub

Part 1 How much alcohol is in a drink?

Different drinks contain different amounts of alcohol. Many people drink without knowing how strong their drink is. In this activity you will be finding out the amount of alcohol in different drinks.

You will need

measuring cylinder ($100cm^3$ or $250cm^3$)
evaporating basin or other heatproof dish of at least $100cm^3$ capacity
heatproof mat

access to:
- half-pint beer glass
- wine glass
- small sherry glass
- spirits measure, or glass marked off with the correct measure (a single measure of spirit is about $25cm^3$)
- laboratory alcohol

What you do

A Copy out the table below.

Drink	*Percentage of alcohol in the drink*	*Volume of drink*	*Volume of alcohol in the drink*
Beer (half pint)	4		
Wine (one glass)	10		
Sherry (one small glass)	20		
Spirit — whisky, gin or vodka (single measure)	40		

B Collect one of the glasses and measure the volume of drink, in cm^3, that it holds. You can do this by finding the volume of water needed to fill the glass. Enter the result in the 'Volume of drink' column.

C Repeat this for the other glasses.

D You have now found the volume, in cm^3, of each of the four drinks. All drinks are a mixture of water, alcohol and other substances.Calculate the *volume of pure alcohol* in each drink. You can do this using the 'Percentage of alcohol in the drink' figures in the table. Enter your results in the last column of the table.

E To get an idea of what these amounts of alcohol look like, try measuring it out. Choose one of the drinks in the table, and collect the appropriate glass. Using a measuring cylinder and a bottle of pure alcohol, measure out the correct volume of pure alcohol and pour it into the glass. Remember, this is the amount of pure alcohol that goes into your body every time you have the drink. Read the note on 'Alcohol you cannot drink' in the box on the next page.

F Alcohol may look like water, but it behaves very differently. For one thing it is a fuel.

Get an evaporating basin or other heatproof dish. Stand it on a heatproof mat. Pour the pure alcohol from the glass into the dish, making sure you do not spill any.

Wearing safety goggles, carefully set light to the alcohol using a burning splint. How long does it burn for? What does the flame look like?

Questions

1 *All the drinks investigated contain a similar volume of alcohol. Very roughly, to the nearest whole number, what is this volume?*

2 *David and Susan went to a party. David drank two pints of beer and a double whisky. Susan drank three glasses of wine. What volume of pure alcohol did each of them drink?*

3 *You have found that alcohol is a good fuel. In fact, it is used to fuel motor cars in some countries. When you have alcohol in your body, your body also uses it as a fuel. The oxidation of alcohol is slower in your body, but it still gives out energy. What happens to this energy if your body does not use it in exercise?*

Alcohol you cannot drink

Alcohol has many important uses apart from drinking. It is an important solvent in perfumes, paints and polishes, and of course it is a fuel.

The Government puts a tax on all alcohol sold for drinking. This raises money, and it helps to stop people drinking too much. But 'non-drinking' alcohol carries no tax, so it is much cheaper. To stop people drinking this cheap **industrial alcohol**, poisonous substances are added to it. The substance most usually added is methanol. Methanol is a member of the family of alcohols, and similar to ethanol, but it is much more poisonous. Alcohol with methanol added is called **methylated spirit.** Drinking it can make you very ill.

Sometimes methylated spirit has a coloured dye added, to put you off it even more. The alcohol used in school laboratories is methylated spirit but usually without the dye added.

Part 2 What does alcohol do to your body?

Alcohol is a drug.

Like all drugs, alcohol stops your body working properly. Taken in large quantities, it is a poison and can do permanent harm to your body. But in small quantities it does no permanent damage.

Alcohol and the nervous system

Your body is controlled by nerves. Like tiny telephone wires, nerves run all over the body, carrying messages. Your brain is a mass of nerve fibres connected together. Just as a computer depends on electrical impulses carried along conductors, your brain uses impulses sent along nerves.

There are millions of nerve fibres in the brain, and millions of connections between them. These connections are called **synapses**. Impulses are carried across synapses by messenger molecules (Figure 3).

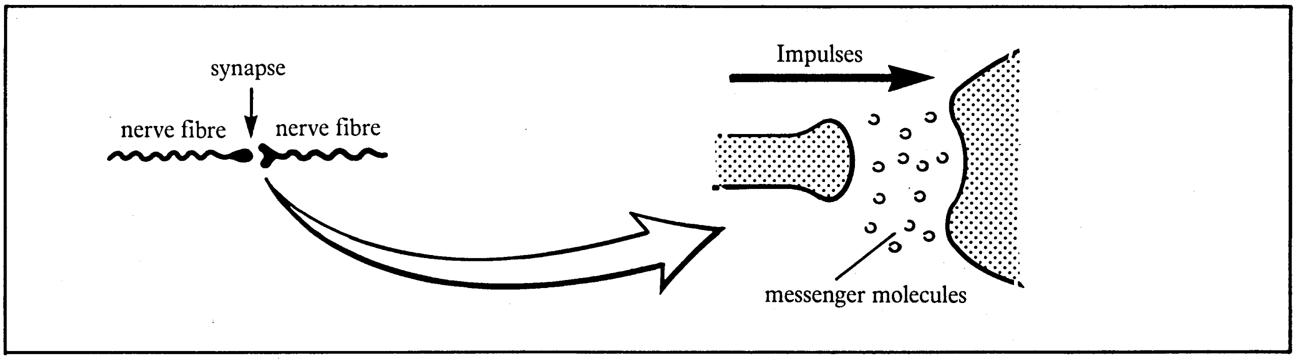


Figure 3 How nervous impulses travel across synapses.

Scientists believe that drugs like alcohol interfere with the nerves. Somehow the alcohol molecules stop the messenger molecules carrying their messages efficiently. This slows down the messages passing across synapses.

In this way, alcohol slows down the messages being sent around the body and brain. It 'damps down' the brain and nervous system, so it is called a *sedative.* In small amounts, it helps people feel less tense and worried, and it makes them more sociable. However, with the nerves sending their messages more slowly, driving and operating machinery can be dangerous.

As the amount of alcohol inside you increases, you start to lose control of your body. Your speech becomes slurred, you lose your sense of balance, and your vision becomes blurred. Very large amounts of alcohol cause unconsciouness, and eventually death.

How does your body get rid of alcohol?

After you have taken a drink, alcohol passes quickly into your bloodsteam. Alcohol molecules are small, so they are quickly absorbed through the walls of the stomach and gut. Once in the blood, alcohol is carried to all parts of your body (Figure 4).

Alcohol is removed from the blood in the liver. It is oxidized to give carbon dioxide and water, releasing energy. This is very like the oxidation of sugars during respiration. If the energy is not needed for exercise, it will be stored as fat.

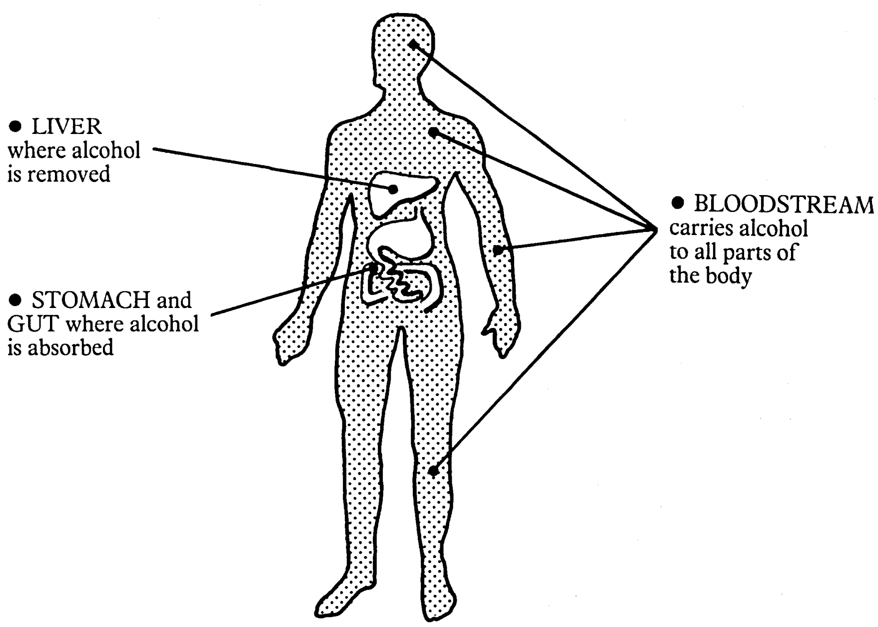


Figure 4 How alcohol gets around your body

Your liver can only deal with about 10cm^3 of alcohol per hour. If your blood regularly has a lot of alcohol in it, the liver begins to get damaged by it. This can cause a disease called **cirrhosis of the liver**.

What other damage does alcohol do?

People who have drunk too much often wake up next day with a hangover. The headache and feeling of sickness soon wear off, but people who regularly drink too much may damage their bodies permanently. Apart from damaging the liver, alcohol can cause brain damage, stomach damage and problems with the nervous system. Excessive drinking can also cause sexual difficulties, depression and other mental problems. Some people get so they cannot manage without alcohol. They are addicted, and they are called alcoholics.

Alcohol in a pregnant woman's blood can pass into the blood of the unborn baby. When the mother drinks, the baby gets a drink too. Doctors therefore advise pregnant women not to drink alcohol at all.

Questions

4 *Drivers who have been drinking are much more likely to have accidents. This is because their reaction time is slowed down. It takes longer for them to react to information received by their eyes. Explain why.*

5 *Explain why the liver is especially likely to be damaged by heavy drinking.*

6 *Explain why alcohol makes you sleepy.*

7 *John drinks three pints of beer. How long will it take before all the alcohol has been removed from his blood by his liver? (Assume half a pint of beer contains 10cm^3 of pure alcohol.)*

Part 3 Safe drinking

Drinking and driving

Alcohol is a major cause of road accidents. The law sets a legal limit on how much you can drink if you are driving. If you have more than 80 milligrams of alcohol in every 100cm^3 of blood, you are not legally fit to drive. Police use breath tests and blood tests to check motorists' blood alcohol levels. Even when the level is just below the legal limit, you are still four times more likely to crash than when you have had no alcohol. One in three of all drivers killed in road accidents has an alcohol level over the legal limit.

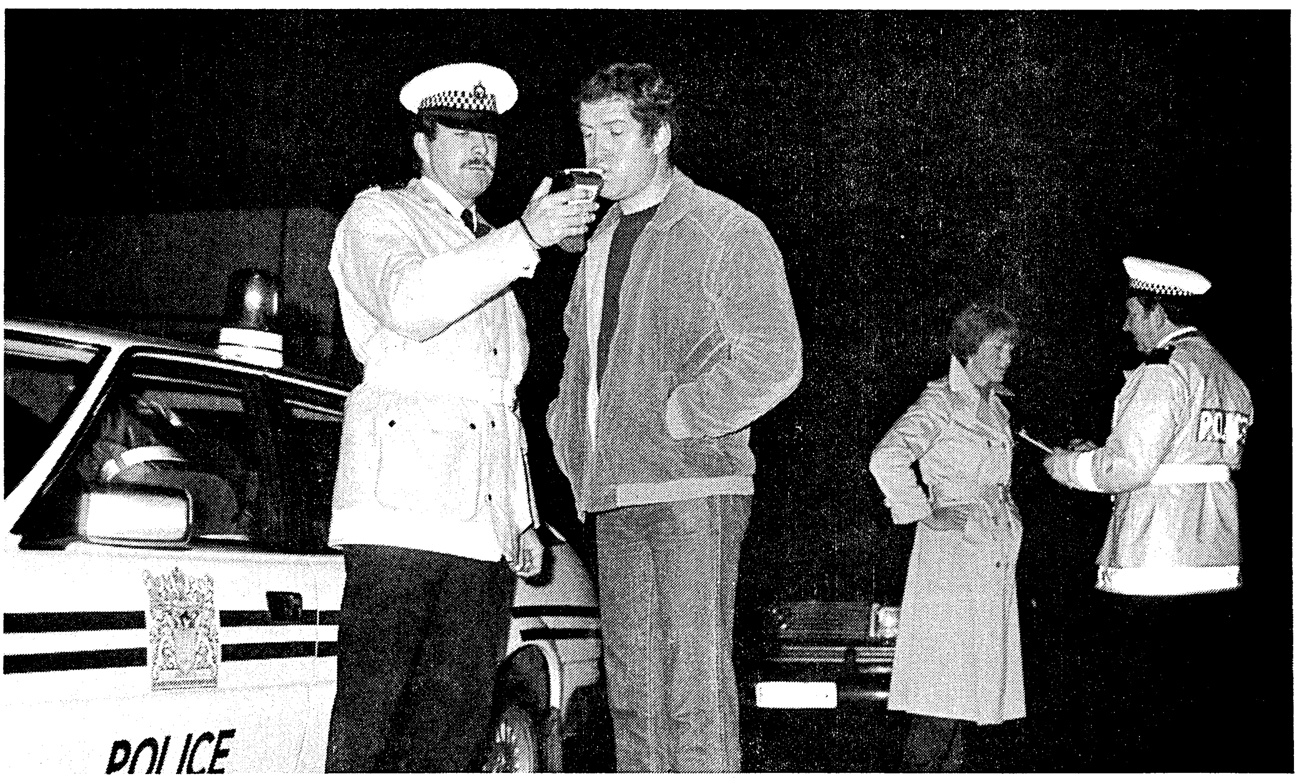


Figure 5 Police giving breath test to motorist

Counting the drinks

In Part 1 of this unit, you probably found the four drinks all contained roughly the same amount of alcohol. This is about $10cm^3$ of pure alcohol. This is sometimes called *one unit* of alcohol (Figure 6).

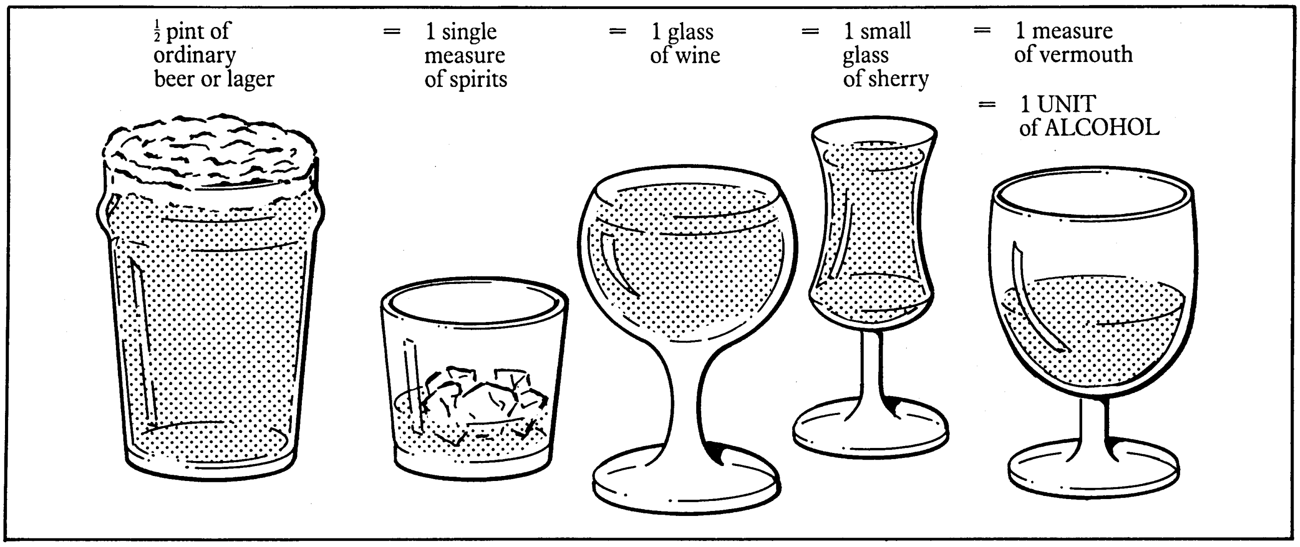


Figure 6 These drinks all contain 1 unit of alcohol

People who want to keep an eye on their drinking can count the units they have drunk. The more units of alcohol you drink, the higher your blood alcohol level becomes (Figure 7). But the blood alcohol level also depends on other factors, such as body size. Small, light people have less fluid in their bodies. This means their blood alcohol level goes up faster than for larger people.

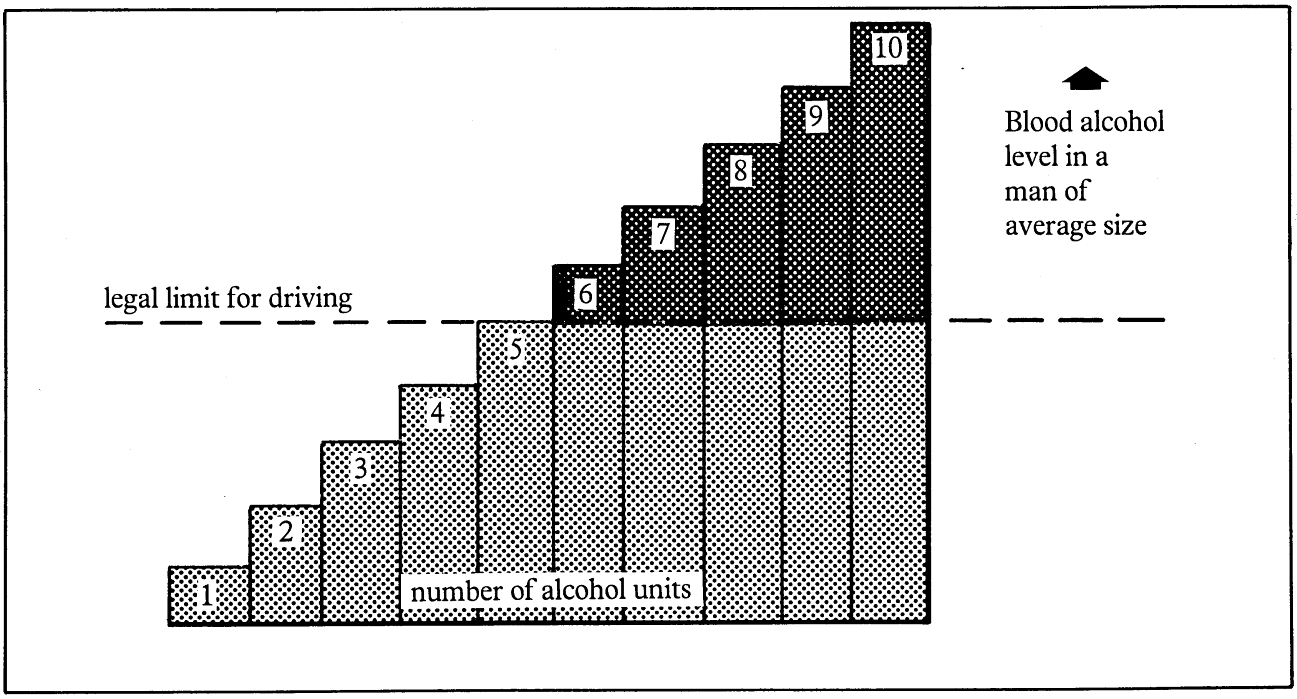


Figure 7 The effect of drinks on blood alcohol level

As Figure 7 shows, an average man reaches the legal limit for driving after about five alcohol units.

Each alcohol unit takes about an hour to get broken down in the liver. So a person who has had, say, two pints of beer will need about four hours before their blood is clear of alcohol.

How much alcohol is safe?

If you are driving or operating machinery, it is safest not to drink at all. At other times, a few units of alcohol are quite safe. In fact, many doctors believe alcohol helps people relax, and may even protect against heart attacks and high blood pressure. Certainly a few units help make you more sociable.

But regular *heavy* drinking can damage your health. Doctors say that an average man who drinks more than eight units a day is risking his health. Women tend to be affected more by alcohol than men, and for them the figure is lower — about 5 units a day.

Questions

Karen, Jane, Paul and Scott got together for a few drinks one evening. This is what each drank:

Karen: *three glasses of wine and a double vodka and tonic*
Jane: *one glass of sherry and three glasses of orange juice*
Paul: *five pints of beer*
Scott: *two pints of beer and a single whisky.*

8 *Work out how many alcohol units each had.*

9 *Who is* legally *fit to drive home?*

10 *Who is* most *fit to drive home?*

11 *How long would Paul have to wait until he is legally fit to drive home? (Assume he is an average size man.)*

12 *Suppose these people drink this amount of alcohol* every *night. What advice might their doctor give to each?*