Catalyst

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Fighting malaria

philip allan UPDATES
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Catalyst

The front cover shows a red blood cell infected with malaria parasites (Dr Tony Brain/SPL).

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Editorial

Reading matter

When I was working with Susie Dunachie and Anne Moore on their article about developing a vaccine against malaria they told me about a recently published book called simply *Mosquito*. I picked up a paperback copy and my eye was caught by some of the reviews printed on the cover: 'A fascinating and terrifying investigation into a vicious little killer' and 'This is both a war epic and a love story. The enemy is about the size of a grape seed and is old at 6 months… Yet it is obvious that Professor Spielman, who has spent his life fighting the mosquito, has also been seduced by her'.

Andrew Spielman has written a great book with the help of a journalist, Michael D'Antonio. Much of the book is taken up with amazing or horrifying tales, such as the deaths of thousands of people involved in huge civil engineering projects like building the Suez or Panama Canals, mostly from diseases spread by mosquitoes. It describes how the causes were eventually identified and in part avoided. It also tells of how West Nile fever virus, which can have fatal consequences, has recently become established in North America.

You can read about mosquitoes, malaria and civil engineering in this CATALYST. Is there any tie in with other articles? You bet — global warming? In a warmer Britain diseases from hotter climates may have a chance of spreading.

We wish you well in your examinations this summer. But remember, as you embark on heavy revision sessions, that you could do well to relax sometimes by curling up with a good book like *Mosquito*…or *Trilobite* by Richard Fortey, *Longitude* by Dava Sobel, *Almost Like a Whale* by Steve Jones…and learn some science at the same time. And remember too — curl up with your back issues of CATALYST for GCSE success.

Nigel Collins

Jeremy Walker/SPL

DAVID SANG

LED lighting
A bright future

Electric light bulbs have been in use for over a century. They work, but they waste most of the energy they receive. At Cambridge University, Professor Colin Humphreys and his team are working to produce a new type of energy-efficient lighting, based on light-emitting diodes.

Look at the lighting around you — room lights, street lights, car lights. We use a lot of electric light. Much of it comes from tungsten filament lamps, in which a thin filament of tungsten wire heats up when an electric current passes through it. Over 90% of the energy transferred by the current is wasted as heat energy. That's very inefficient. Roughly 20% of the UK's electricity is used for lighting, so we're generating large amounts of carbon dioxide and other polluting gases for little benefit.

Colin Humphreys of the Department of Materials at Cambridge University thinks we can do much better. He's developing a new generation of light-emitting diodes (LEDs) which he thinks will replace filament lamps before too long. And already he has had some success, with traffic lights.

BOX 1 DON'T WE ALREADY HAVE ENERGY-EFFICIENT LIGHTS?

You are probably aware of another type of energy-efficient lamp, the compact fluorescent tube. These save both money and energy over their lifetimes, compared to filament lamps (see Table 1). However, they haven't made a great impact on domestic or commercial users. This may be because of their high initial cost, or because they are bulkier than a filament lamp and take a few minutes to reach full brightness. They have another problem: they contain mercury, which is a hazard when they are disposed of.

LEDs are those small lamps which glow red to show that your stereo system is switched on, or which flicker when your modem is transferring data to and from the internet. The first LED was invented in 1960, and since then their design has greatly

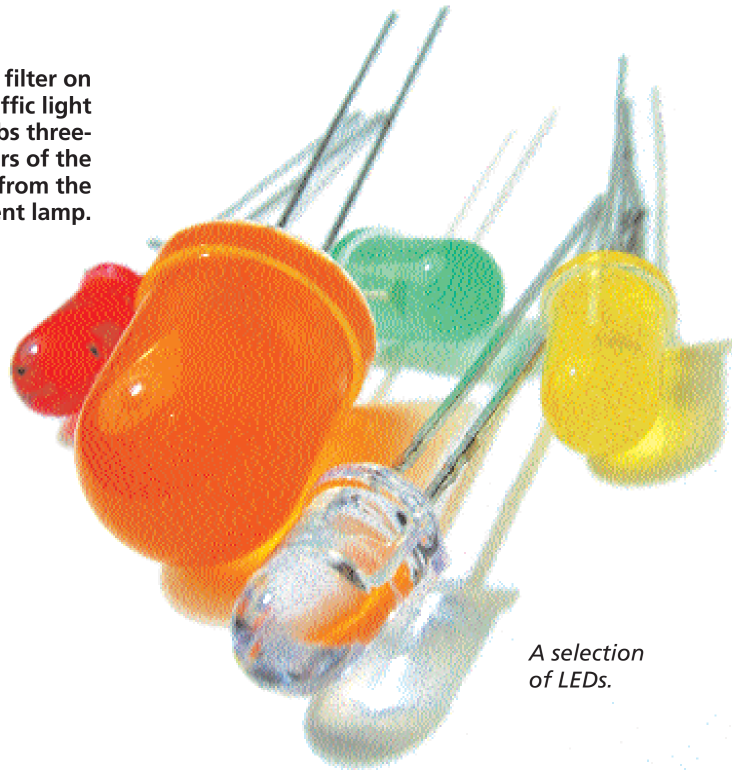
GCSE key words
Energy efficiency
Energy transfers
Diodes

- **Use Table 1 to show that a compact lamp saves money in the long run, compared to a filament lamp. Assume that it costs 0.7p to run a 100 W device for 1 hour.**

Table 1 *Comparing compact and filament lamps*

	Initial cost (£)	Lifetime (hours)	Power rating (W)
Filament lamp	0.50	1000	100
Compact fluorescent lamp	5.00	10 000	12

The red filter on a red traffic light absorbs three-quarters of the light from the filament lamp.



A selection of LEDs.

- **Read the interview with Professor Humphreys at: http://www.admin.cam.ac.uk/univ/science/working/humphreys.html**

improved. By altering the material from which they are made, it is possible to have yellow, green and blue LEDs.

Modern LEDs are much more energy-efficient than light bulbs. Because a much smaller fraction of the energy supplied to them is lost as heat, they are noticeably cooler than equivalent filament lamps. Red LEDs have a valuable use in the rear lights of bicycles. Their batteries last 20 times longer than those in old-fashioned rear lights.

RED, AMBER, GREEN

Most traffic lights use filament lamps. These are replaced every 6 months, before they can fail and cause traffic chaos. LED traffic lights have a lifetime

Below: *Professor Humphreys with some different coloured LEDs.*

Guzelian

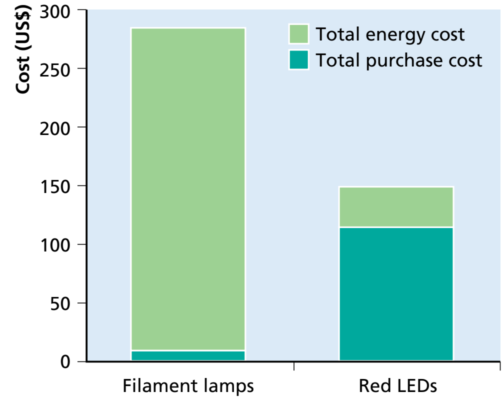


Figure 1 *Comparison of lifecycle costs for red traffic lights.*

of 10 years or more, representing a saving in maintenance costs. A 12 W LED replaces a 150 W bulb, so there are also great savings in electricity costs (see Figure 1).

The UK's first set of LED traffic lights has been installed in London, near the headquarters of the Department of Transport. The American city of Denver in Colorado is switching entirely to LED traffic lights and its power bill has decreased from \$330 000 to \$26 000 per year. Even though LEDs have a higher initial capital cost, the reduced electricity costs represent a saving of \$5 million over 10 years. The environment will benefit too, with almost 10 000 tonnes less carbon dioxide pumped into the atmosphere. This is equivalent to planting an 800 ha forest, or removing over 1000 cars from the roads.

The UK Department of Transport tells us that this technology is becoming increasingly well-known, and Highways Authorities across the country are installing LED traffic lights wherever possible.

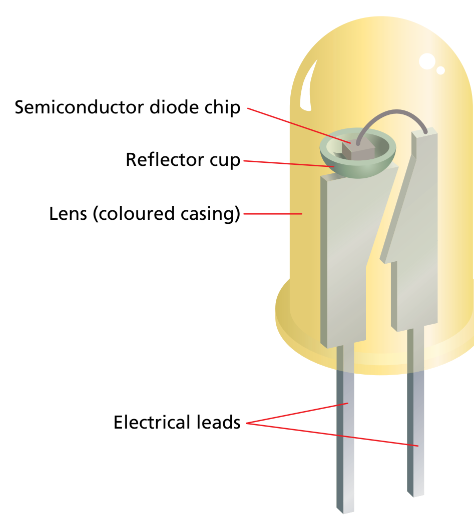


Figure 2 *At the heart of an LED is a tiny sliver of semiconducting material. As a current flows, light emerges, and the reflector and lens are designed to ensure that as much as possible of this light is directed where it is wanted.*

ONE WAY TRAFFIC

All diodes allow electric current to flow in one direction only. An LED is unusual in that it emits light as a current flows through it. You can think of a diode as a waterfall in a circuit. Current flowing over the fall loses energy; current cannot flow up the fall (Figure 3).

In an LED, some of the energy lost is converted to light, represented by the arrows in the circuit symbol. The height of the waterfall determines the colour of the light emitted — the smallest drop gives red, the greatest drop gives blue or ultraviolet.

An LED is a semiconductor device. Semiconductors are materials which allow an electric current to flow, but their resistance is much greater than that of metals. Silicon, the basis of many computer chips, is an example of a semiconductor.

Professor Humphreys and his team are working with a different material, gallium nitride (GaN). He describes it as 'probably the most important semiconductor material since silicon', and it will find many new applications, such as in transistors which can operate at high temperatures.

The problem with GaN is that, during its manufacture, large numbers of defects appear in its crystal structure. These limit the mobility of electrons — a major problem which must be overcome if it is to achieve its potential.

LET THERE BE WHITE LIGHT

To replace filament lamps, we need white LEDs, and these are tricky to produce. One solution might be a combination of red, green and blue (as in a television screen), but this has proved difficult. The combined colour tends to alter as the LEDs age.

Colin Humphreys' approach is different. He hopes to make an LED which emits ultraviolet light. It will be coated in a phosphor, a substance which absorbs the ultraviolet light and re-emits it as visible light.

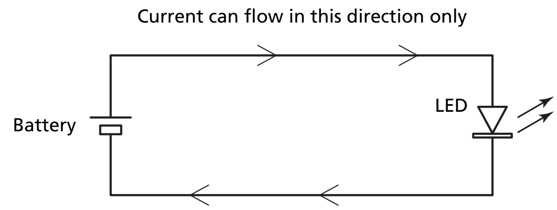
He is also working on a violet LED which will be used in detecting cancerous tumours at an early stage of their development. This, and the environmental aspect of his work on LEDs, gives him great satisfaction. He says, 'This is very motivating and I really think our research can save many lives.'

***David Sang** writes textbooks and is an editor of* CATALYST.

BOX 2 SAVING LIVES ON THE ROAD

LED brake lights come on almost instantaneously — within a millionth of a second of the driver pressing the brakes. Conventional filament lamps, as fitted in most cars, take 0.25 s to warm up enough to glow. In that time, a car moving at 70 mph will travel 8 m, the length of two small cars.

So the new LED brake lights give following drivers extra warning in case of a sudden halt, and in that way can save lives.



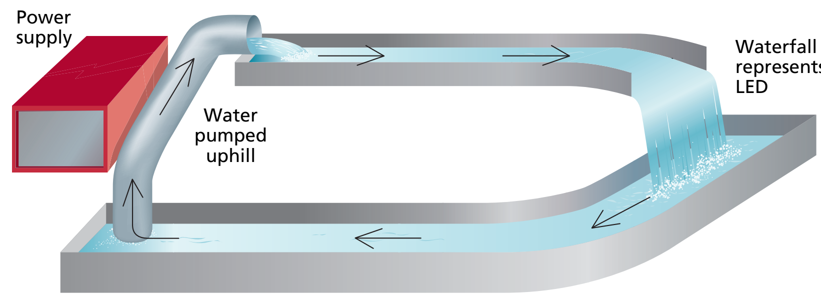


***Figure 3** Comparing an electric circuit with water flow. The battery is like a pump pushing water uphill. The LED is like a waterfall.*

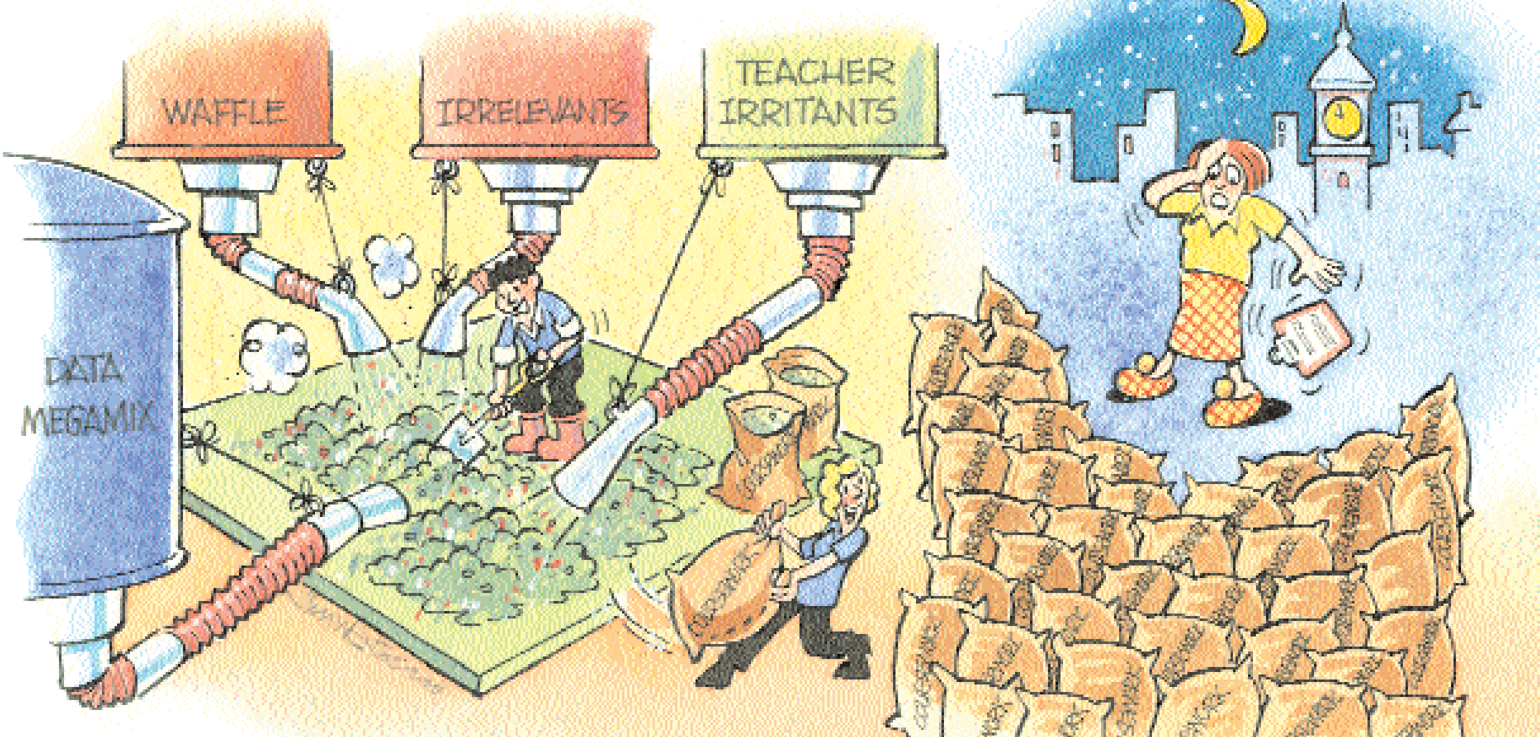
Element wordsearch

There are names of 48 different elements here — can you find them all? Words can run in any direction.

Answers on page 15.

A	F	E	R	M	I	U	M	E	S	E	N	A	G	N	A	M
M	M	U	O	N	E	N	I	R	O	L	H	C	O	P	U	M
O	A	U	N	Z	C	A	R	B	O	N	N	A	T	I	U	E
L	R	I	I	I	R	A	C	I	X	E	N	O	N	I	R	N
Y	E	T	C	N	E	O	N	U	E	O	T	I	S	Z	A	D
B	I	A	A	C	I	A	F	M	A	M	M	E	M	L	N	E
D	M	M	D	L	O	T	E	R	N	U	N	U	I	V	I	L
E	U	U	M	E	D	S	C	E	L	G	I	T	O	A	U	E
N	N	I	I	K	L	I	T	A	A	M	H	P	D	N	M	V
U	A	B	U	C	O	S	H	M	L	I	A	N	I	A	R	I
M	H	R	M	I	G	P	E	O	U	C	M	W	N	D	E	U
A	T	E	E	N	L	R	H	M	X	L	I	U	E	I	V	M
M	N	T	U	U	I	C	E	E	U	Y	T	U	I	U	L	U
U	A	T	S	C	I	N	M	R	L	I	G	I	M	M	I	I
L	L	Y	I	N	I	U	T	C	H	I	N	E	N	S	S	D
A	P	U	E	M	I	N	I	U	R	A	D	O	N	S	N	O
T	M	S	O	N	O	B	O	R	O	N	V	E	C	R	O	H
N	R	R	F	G	Y	N	E	Y	M	U	I	D	A	R	R	R
A	B	A	R	X	C	I	Y	T	T	R	I	U	M	T	I	A
T	H	A	L	L	I	U	M	U	I	D	A	L	L	A	P	Z

Coursework



It's the spring term and a GCSE student's thoughts turn lightly to…coursework. There is such a lot of effort involved that you want to make sure you get maximum reward. In this Improve Your Grade we focus on how to write up your report. Your work is mainly assessed through your written report and even a good investigation can get bad marks if you fail to write it up correctly. Follow these five simple rules for success.

1 *Be economical*

Your teachers don't weigh your report before giving it marks — they are looking for quality not quantity. You waste effort (and annoy your teacher) when you are long-winded — using sentences when a word or phrase will do, or explaining the same point in three different ways. Students often waste time describing in words what has already been shown in a good results table and well-drawn graph. You should focus on explaining the outcome of your experiment. Box 1 gives you an idea of a right way and a wrong way of doing things.

2 *Don't flannel*

In your plan you have to justify how and why you are going to investigate your question. You should select the appropriate science as you explain each

BOX 1 HOW TO EVALUATE

WRONG

The time it took for the starch solution to stop turning the iodine black was 12 min when the enzyme mixture was at 20°C. It took 8 min at 30°C and it took 3 min at 40°C. The mixture was still black after 20 min at 60°C when we stopped testing. The reaction worked better when it was warmer but the enzyme stopped working when it was hot.

No marks. You have failed to state any pattern in your results. What do you mean by better? What was happening to the starch? Why did it change? You haven't explained what was going on.

RIGHT

The results of the iodine test showed that the starch disappeared from the mixture more quickly when it was kept at higher temperatures. However the starch did not disappear when the mixture was kept at the highest temperature.

This happens because at temperatures between 20 and 40°C the enzyme is breaking down the starch molecules to glucose molecules. As the temperature increases from 20 to 40°C the enzyme and starch molecules gain more energy and collide more frequently. There are more successful collisions. Above the optimum temperature for the enzyme, its molecules were denatured.

part of your plan. Just because you've found lots of stuff about enzymes made by fungi, washing powder enzymes and digestive enzymes of camels in *Encarta* or your sister's A-level textbook doesn't mean that it's relevant.

When discussing a variable that needs to be controlled explain how it could affect the outcome of your investigation. If it cannot be controlled, as in some ecological investigations, you should say how you are going to take account of it. Box 2 is an example of a good account that uses science to justify design decisions.

3 *Lay out tables properly*

Check how you have set out your results. A poor table can lose you several marks. Tables must have headings and each column in the table must be fully labelled. You should include units in the column headers. Don't produce sheets of separate tables when the data would be more informative combined into one. Figure 1 shows some common mark losers — and how to avoid them.

4 *Check continuity*

You may write your report in sections and then join them together. Reread your drafts from time to time to make sure that any variable mentioned in the plan is controlled in the procedure. When you do your practical work you will meet problems and have to deal with factors that were not in your original plans. Check that these are properly introduced and discussed in the evaluation section. They may affect the validity of the experiment, lead to inaccuracy in your overall findings, or contribute to variation between repeated measurements. You gain marks for recognising this.

5 *Make your report easy to read*

Think about your reader who has had a hard day and is settled down with a headache pill and 25 reports to mark before bedtime. Here are some simple dos and don'ts that will gain you marks.

BOX 2 USING SCIENCE TO JUSTIFY DESIGN DECISIONS

In a previous experiment we found that time taken for amylase to break down starch varied with pH so it will be necessary to control pH in my investigation. I shall ensure that the starch/enzyme mixture is at pH 8 at all test temperatures. I chose pH 8 because I found that the reaction was quickest at pH 8. I shall add drops of sodium hydrogen carbonate to the starch solution to reach the set pH, tested with Universal Indicator paper, before adding the enzyme. As the enzyme volume is very small compared to the volume of starch the pH will not change significantly.

You have shown that you know about a significant variable and how it can affect the outcome. You have explained how to control it, used science and secondary data to justify the decision, and thought about how error could be introduced into your investigation. Lots of marks gained here.

WRONG

At 20°C 1st go

time	colour
20 sec	black
40 sec	black
1 min	black
1 min 20 sec	black

At 20°C 2nd go

time	colour
20 sec	black
40 sec	black
1 min	black
1 min 20 sec	black

RIGHT

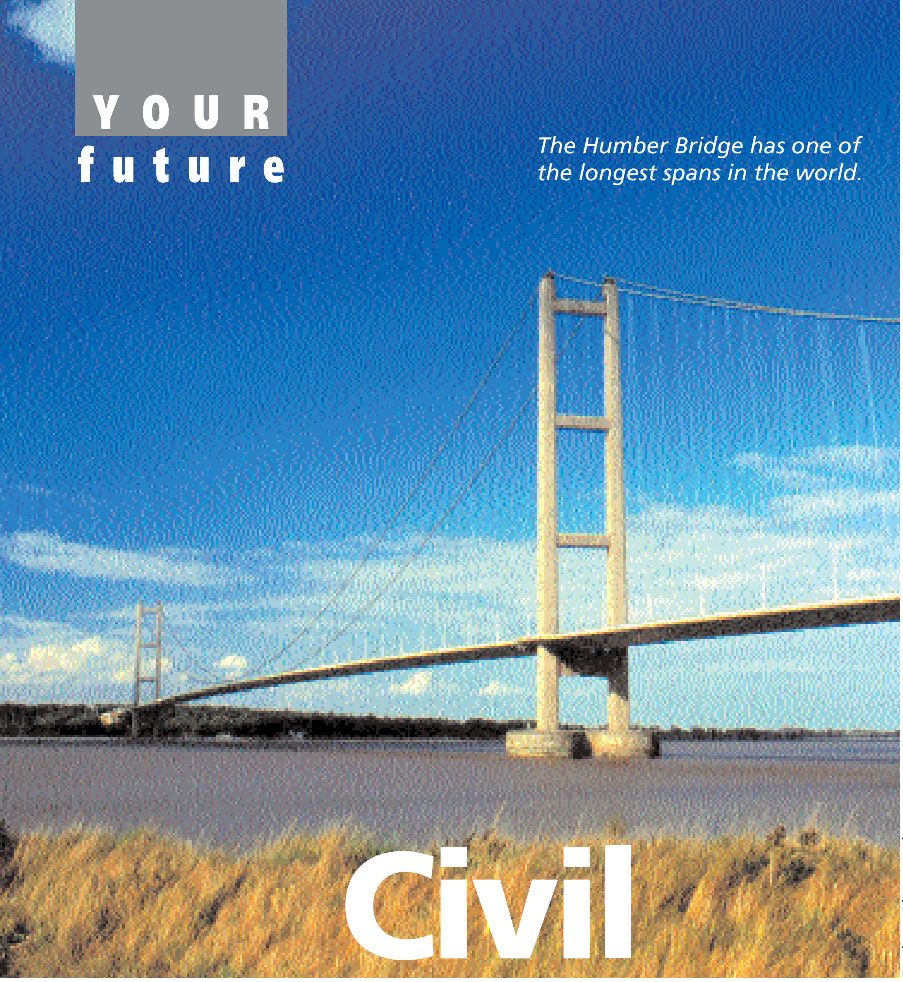
Temperature of starch/ enzyme mix (°C)	Time for starch to disappear (sec)			
	Trial 1	Trial 2	Trial 3	Average
20	125	120	135	127
30	40	42	25*	41
40	29	27	25	27

* Anomalous result, discarded.

Figure 1
Laying out tables.

- **Don't** use a gold or pale blue gel pen.
- **Don't** use a blunt pencil to draw graphs — a thick line may cover several units and introduce inaccuracy.
- **Do** use a reasonable size handwriting that doesn't slope like a ski-jump or crab together as though the letters were frightened. The internal and external moderators won't be used to your writing.
- **Do** number the pages and put your name and a title on your graphs.
- **Don't** submit your account in a plastic pocket unless asked to — taking them out uses a lot of marking time. Your report cannot be submitted to a moderator in a pocket.
- **Do** use a treasury tag through the punched holes, not staples or fancy bits of origami at the corner which stop the reader turning the pages easily.

***Jane Taylor** teaches biology, writes textbooks and edits* CATALYST.



The Humber Bridge has one of the longest spans in the world.

Topham Picturepoint

Civil engineering

Simon Reading, who works for Atkin, a firm of consulting engineers in Birmingham, describes what his job involves.

Simon Reading

The author at a ceremony opening a bridge in Nepal constructed to his design.

Turning up at work this morning, I'm once again wondering what challenges are in store for me. Recently I've been involved with clearing up industrial contamination, reforesting blighted coal tips and introducing new business processes into my part of the company. It's an interesting job, especially when you consider that my early career was spent designing multi-storey buildings, water pipelines and bridges.

GETTING STARTED

I was good at maths and physics at A-level, and I looked for a degree course that would let me apply these subjects in the 'real world'. Civil engineering seemed to be a career where I could see the application of science, and where I could work outdoors. It was only later that I began to understand all its possibilities, especially the opportunities to work abroad and as an aid worker.

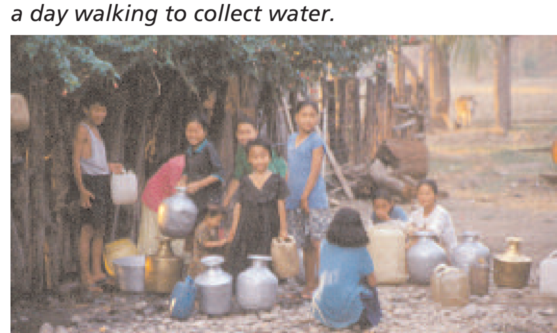
I worked as a bridge engineer for 5 years, a period that included constructing a trunk road in the Black Country, designing long span bridges in Hong Kong and working with an aid organisation constructing rural footbridges in Nepal.

AID WORK

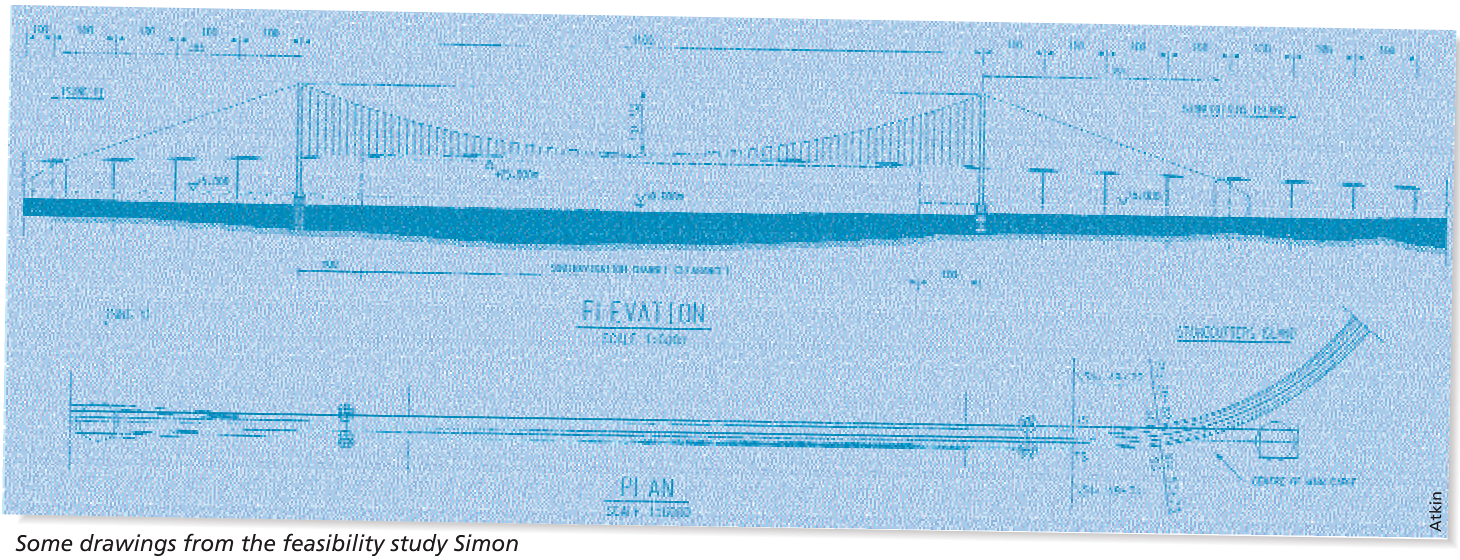
After I gained my professional qualifications I began to look into the broader possibilities that civil engineering offered. I applied to join a charity called RedR (Registered Engineers for Disaster Relief), which sends engineers to situations caused by natural disasters and human conflicts. Civil engineers, along with medical professionals, are the most important people needed to establish a refugee camp. They have the knowledge to supply clean water, ensure adequate sanitation and provide shelter, as well as establishing supply lines by building roads, bridges and airstrips.

I succeeded in joining the register and, after some training, was asked to go to Nepal to give advice to a charity constructing rural footbridges and water systems in remote parts of the country. Over a 4 month period I travelled extensively, mostly on

Nepalese women collecting water from a supply Simon helped provide. This saved them several hours a day walking to collect water.



Simon Reading



Atkin

Some drawings from the feasibility study Simon worked on for Stonecutters Bridge, Hong Kong.

Simon Reading/Atkin

A bridge at Ironbridge designed by Simon. The river banks are shifting and the foundations had to be built so that one side took all the load.

***Table 1** The world's longest bridge spans*

Bridge	Main span (m)	Year of completion
Suspension bridge		
Akashi-Kaikyo, Japan	1990	1998
Great Belt East, Denmark	1624	1996
Humber, UK	1410	1981
Verrazano Narrows, USA	1298	1964
Golden Gate, USA	1280	1937
Cable-stayed bridge		
Tatara, Japan	890	1999
Normandy, France	856	1993
Meiko-Chuo, Japan	590	1996
Skarnsundet, Norway	530	1991
Tsurumi Koro, Japan	510	1995

Note: Span refers to the distance between supports, not the whole length of the bridge.

foot, examining bridge design, construction and maintenance. It was a challenge applying my knowledge of bridge engineering in England to a totally different environment, but I was able to give advice on design procedure, assist in recruitment and recommend improved supply of the bridge materials.

I returned 2 years later, and it was immensely satisfying to see the results of the work I had done. Needless to say, I felt I learned at least as much from the Nepali people as they learned from me, and it was a privilege to spend the time I did working in such a remote location.

FURTHER CHALLENGES

Not long after completing the assignment in Nepal, I was given the chance to work in my company's offices in Hong Kong. This work could not have been more different. I was involved in assessing the feasibility of constructing a new bridge to span 1 km — longer than any bridge in England except the Humber Bridge. We examined a number of options including a suspension bridge and a cable-stayed bridge, taking advice from other consultants based in China, Germany and Japan.

On my return from Hong Kong, I was given yet another unexpected challenge. I was asked to assist in a large project, managing coal-mining liabilities across the whole of Great Britain. This has led me to design a number of environmental clean-up contracts, and allowed me to work closely with archaeologists, landscape architects and environmental scientists.

Projects that I might get involved with today include:

- A structural survey on a historic colliery site for English Heritage.
- Decontaminating the ground around a former oil storage depot.
- Finding an ancient viaduct buried in a coal tip.
- Remediation of a burning coal tip.
- Redevelopment of a former colliery site for light industry and housing.
- Assessing some old brick arch bridges.
- Designing databases to manage a portfolio of sites.
- Developing part of our website.

All in a day's work for a civil engineer. I'd better start by checking my e-mails....

Simon Reading

Registered Engineers for Disaster Relief is at http://www.RedR.org

Remediation is work which deals with industrial pollution of land.

You can find out more about civil engineering as a career from the Institute of Civil Engineering at http://www.ice.org.uk which also has links to university courses.

NIGEL
COLLINS

Enzymes outside the body

Enzymes allow chemical reactions in all living things to proceed quickly, under conditions where they would normally be very slow. Scientists realised that enzymes could be isolated and used to catalyse reactions outside living organisms. This was the start of a major biotechnology industry, which is still developing.

GCSE key words
Enzyme
Carbohydrase
Lipase
Protease
Protein

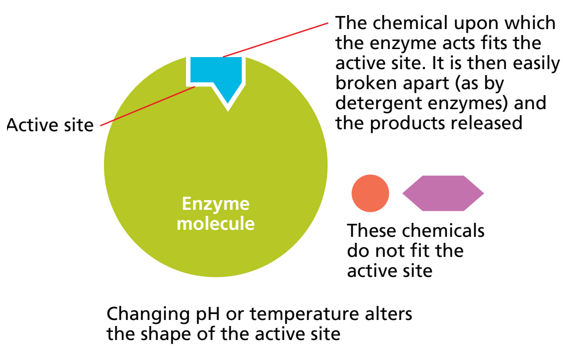
Above: *A computer graphic showing the structure of the enzyme lipase. Each amino acid appears in a different colour.*

Enzymes are catalysts made by living organisms. There are thousands of different chemical reactions taking place in living things and almost every reaction has its own associated enzyme. There are, therefore, vast numbers of different enzymes.

How can there be so many? Enzymes are proteins, polymers of amino acids. Most of the biological molecules you need to know about are made up of pretty standard basic units — for example starch and glycogen are made up of lots of glucose molecules. But when proteins are formed there are 20 *different* amino acids to be drawn upon. Box 1 gives you some idea of how such a vast diversity of proteins can be built from 20 amino acids.

- **Work out exactly how many combinations of amino acids there could be for a chain of 50, with any of the 20 occurring at each position.**

Figure 1 *The active site in an enzyme molecule.*



Enzyme literally means *in yeast*.

HOW DO ENZYMES WORK?

The shape of each enzyme is determined by the sequence of amino acids it contains and the way in which they link up to form a particular three-dimensional molecule. One part of this molecule is an active site — the part of the enzyme that interacts with the chemical or chemicals involved in the reaction it catalyses (Figure 1). This site recognises the shape of the chemicals and reduces the amount of

BOX 1 ENZYME DIVERSITY

There are 20 common amino acids. Each amino acid molecule includes a standard component (which is involved in the link with other amino acids as the protein forms) but the rest of the molecule varies greatly between amino acids. In some the rest of the molecule mixes with water, in others it doesn't, some carry a small positive charge, others a negative charge.

Imagine an enzyme to be 50 amino acids long. How many possible combinations are there? At each of the 50 positions in the amino acid chain there could be any of 20 amino acids. This provides vast numbers of possible combinations — and some proteins are made up of much longer chains of amino acids.

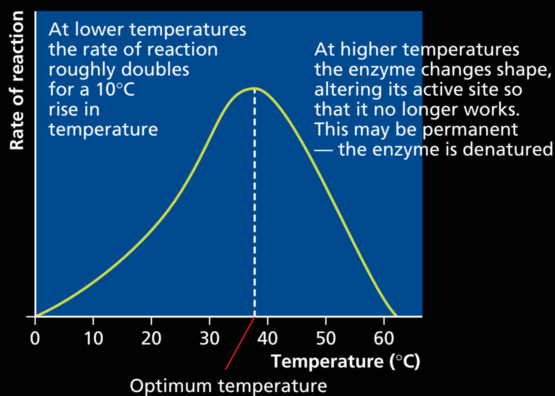


Figure 2 *The effect of temperature on a reaction catalysed by an enzyme.*

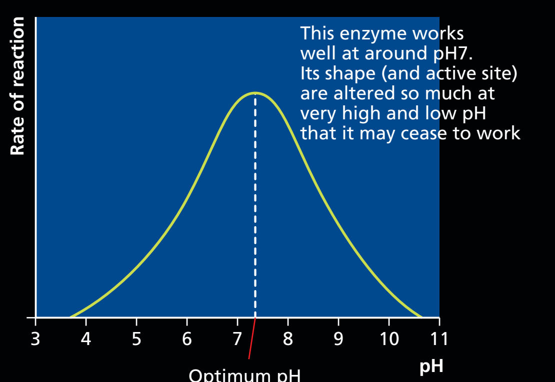


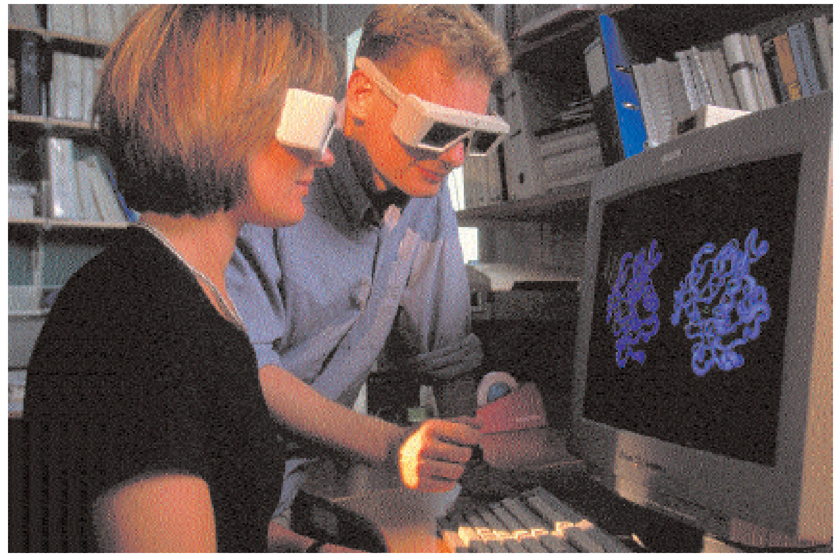
Figure 3 *The effect of pH on a reaction catalysed by an enzyme.*

Prof K. Seddon & Dr T. Evans, Queens University Belfast/SPL

energy needed to join them together — or split them apart, as happens in digestive processes.

Enzymes are affected by temperature and pH (Figures 2 and 3). At both high temperatures and extremes of pH, they change shape. The active site changes shape too, and no longer matches up with the chemicals involved in the reaction, which slows down or stops. The effect on protein structure can be permanent, in which case the enzymes are **denatured**.

Figure 2 shows the effect of temperature upon enzymes in humans or other organisms living in temperate regions. The temperature of their surroundings does not normally go above 30°C and their body temperature does not exceed 37°C, so their enzyme systems are unaffected.



Novozyme

Computer-aided research is important in developing enzymes for industrial use. The goggles provide a three-dimensional image.

Some organisms, especially bacteria, live in extreme conditions, for example around volcanic steam vents. There are evidently some proteins that are much less affected by what we regard as 'extreme' temperatures.

BIOLOGICAL DETERGENTS

The widest general commercial use of enzymes is in detergents. Before the First World War Biotex — a prewash for soaking stained clothes — was developed by a Dutchman who had noticed that extracts from the pancreas could digest protein stains. By 1914 tablets of a product called Burnus containing the protease trypsin were being sold in Germany. It took many years to develop a way of including enzymes in washing powder granules (see Box 2). They needed to be encapsulated and stable in the presence of bleaching agents in the powder. Before automatic washing machines people washed clothes at high temperatures which would denature most common enzymes. Nowadays most domestic washing is done at 40°C, or at most 60°C.

The enzymes incorporated into modern detergents are shown in Table 1. These detergents are effective

One of the first enzymes to have its structure determined was lysozyme, which occurs in tears. When bacteria land on the eye it breaks open their walls and kills them.

- **Find out how and why enzymes are 'immobilised'.**

- **Look at packaging on prepared foods to see if enzymes are mentioned. If they are, can you work out why they were used?**

Cotton fibres develop from unicellular hairs that grow out from the seed coats inside the fruit of the cotton plant. They die, leaving nothing but the cellulose cell wall and these fibres are spun to make thread.

Table 1 *The label on detergent packets often says no more than 'contains enzymes'. Which enzymes are used?*

Enzymes	What they do	End product
Amylases (carbohydrases)	Hydrolyse starch	Soluble sugars
Lipases	Break down fats and oils	Soluble glycerol and fatty acids
Proteases	Break down proteins	Soluble peptides or amino acids
Cellulases (carbohydrases)	Work on loose cellulose fibres sticking out from the surface of cotton clothes. This helps maintain the original appearance of the cloth	Soluble sugars

Enzymes in pure form as powders could cause allergic responses if inhaled. Precautions are taken in detergent factories to prevent workers inhaling them.

Allergies have been reported by users of 'biological' detergents, but there is little hard evidence for these.

Right: *Gene technology is used in the development of enzymes.*

- Find out about the role of enzymes in the production of 'corn syrup'.

BOX 2 CHRONOLOGY OF ENZYME-CONTAINING DETERGENTS

1833 Payen and Persoz isolate the enzyme diastase from germinating barley.

1835 Bercelius demonstrates that starch can be broken down more efficiently with malt extract from germinating seeds than with sulphuric acid and coins the term **catalysis**.

1878 Kühne introduces the term **enzyme** for the substances in yeast responsible for fermentation.

1913 Otto Röhm patents the use of pancreatic enzymes in prewash soaking solutions.

1926 James Summers identifies urease as a protein after purification and crystallisation.

1920s K. Linderstrøm-Lang and M. Ottesen isolate subtilisin, an alkaline protease produced by bacteria. In the 1950s a similar enzyme product was the first important protease used in laundry detergents.

1930s The use of enzymes in detergents — their largest industrial application — begins slowly, based on Röhm's 1913 patent on the use of pancreatic enzymes in prewash solutions.

1950 Novo Nordisk launches the first enzyme produced by growing bacteria in a fermenter, a bacterial alpha-amylase.

1963 A protease with a low alkaline optimum pH (Alcalase®) is isolated — the first breakthrough for detergent enzymes.

1980s A lipase (Lipolase®) is developed for detergents, using a genetically-modified bacterium.

Novozyme

Topham Picturepoint

Before automatic washing machines people washed clothes at high temperatures.

at moderate temperature and pH values. The presence of enzymes gives:

- shorter washing times by quickly degrading dirt;
- reduced energy consumption because lower wash temperatures can be used;
- reduced water consumption;
- minimal impact on the environment because they are biodegradable and a renewable resource.

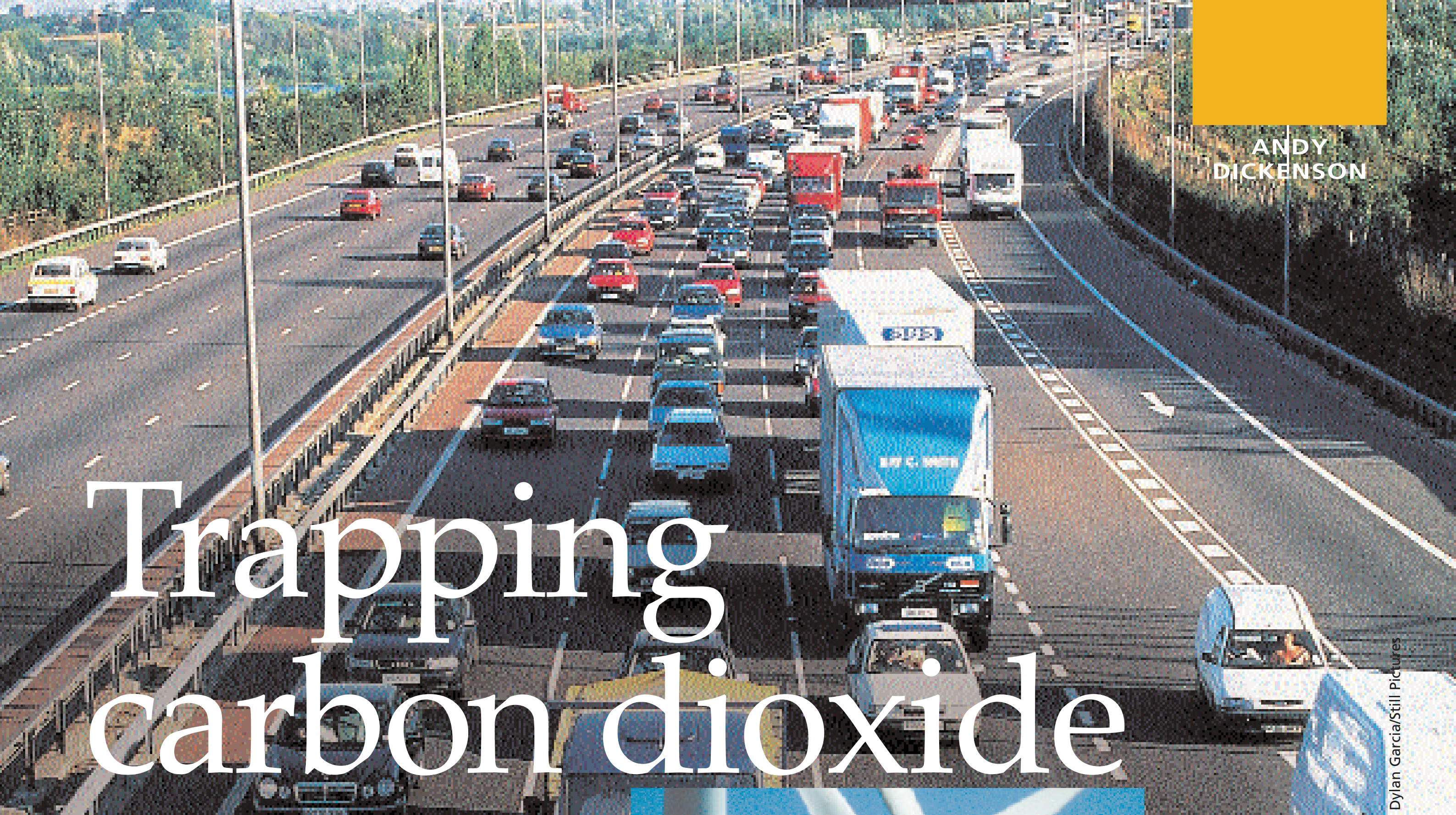
IMPROVING ENZYMES

The enzymes included in detergents might be improved in two ways. First, microorganisms are being screened all the time to see if they have enzymes that might be useful. Enzymes which are stable at higher temperatures might be found in bacteria which live in hot environments. The genes for the enzymes of interest might then be genetically engineered into other bacteria which are grown in bioreactors to produce the enzyme in quantity. Second, genetic engineering techniques might be used to produce modified enzyme structures with improved performance.

Examples of ways in which this could be of benefit include making enzymes which are adapted to work under more alkaline conditions (pH 8–12) in automatic dishwashers. Industrial laundries often operate at higher temperatures — for this purpose enzymes that are stable at 55°C are developed.

In some hot countries washing is traditionally done in cold water. Enzymes which offer efficient operation at temperatures of 20°C and below are needed.

Nigel Collins is an editor of CATALYST.



Dylan Garcia/Still Pictures

ANDY DICKENSON

Trapping carbon dioxide

Global warming is being caused by increased levels of carbon dioxide in the atmosphere. This carbon dioxide is released when fossil fuels such as petrol are burnt. Despite concern about global warming, it seems that nobody wants to use their cars less, however expensive fuel becomes. What else can be done to slow the rate of carbon dioxide accumulation in the atmosphere?

GCSE key words
Greenhouse effect
Global warming
Combustion
Photosynthesis

Chris Knapton/SPL

*Carbon dioxide levels are going up but no-one wants to use their cars less **(above)**. Alternative sources of electricity like wind farms can help **(left)**.*

Suppose a car is filled with fuel at a petrol station. The fuel will have a mass of about 25 kg. As you know, when a fuel is burned in sufficient oxygen the products are carbon dioxide and water. Both of these are released as gases; for example, for octane:

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

What mass of carbon dioxide is released by this fuel when it is burned? Is it more, less or the same as the mass of the fuel? It may surprise you to learn that the mass of carbon dioxide released is a lot more than that of the original fuel. Approximately 77 kg of carbon dioxide will be released from 25 kg of octane.

Multiply this up by the number of cars on the road and you can see that large masses of carbon dioxide are being released every day. Add in the emissions from gas, coal and oil-fired power stations and the total becomes huge. In 1995 each person in the UK contributed 9.3 tonnes of carbon dioxide to the atmosphere. In the US the figure was 20.5 tonnes, while in less industrialised Swaziland it was only 0.5 tonnes per person. These figures are not decreasing.

ENERGY TRAP

This level of emissions is worrying because of the effect carbon dioxide has in the atmosphere. When the Sun shines on the Earth, the Earth warms up. It radiates this energy back into space, at a different

● Explain why the mass of the gases released when petrol is burnt is greater than the mass of the fuel. Use the equation in the text to help you, and remember the principle of the conservation of mass.

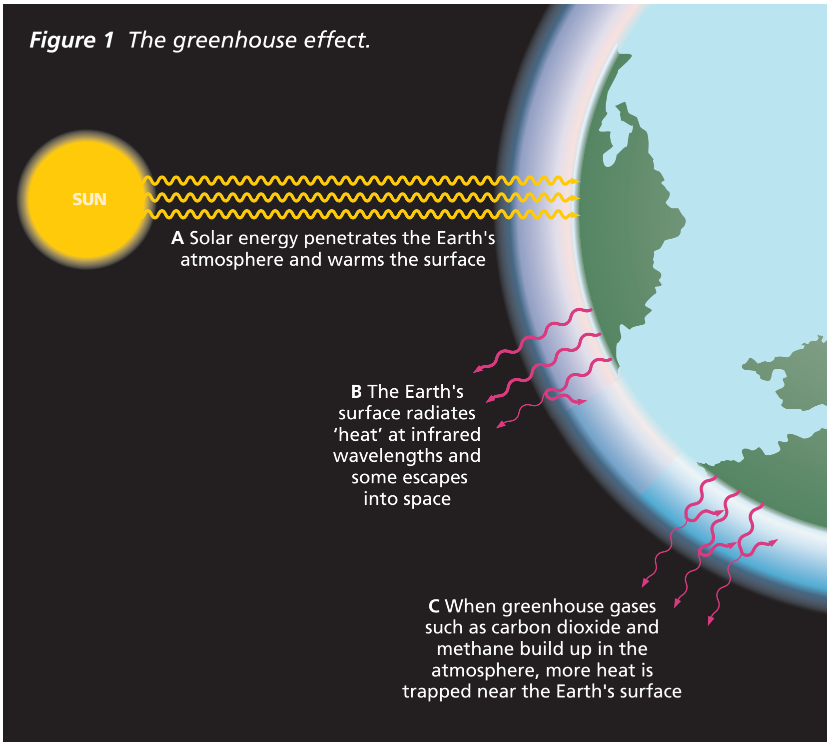


Figure 1 *The greenhouse effect.*

If you holidayed in Europe last summer you might have noticed that several countries have schemes to reduce rubbish burning by recycling more plastics, metallised containers and compostable waste. What is happening in your area?

wavelength from the original solar radiation. However, in our atmosphere there are a number of **greenhouse gases**, of which carbon dioxide is one. These have the ability to absorb energy of the wavelength that is being radiated by the Earth. They cannot absorb it indefinitely though, and they in their turn release it as radiation — some back towards Earth and some to space.

The overall effect is that the greenhouse gases trap heat energy in the Earth's atmosphere (Figure 1). This is known as the **greenhouse effect**, and is no bad thing for life on Earth. Without this warming effect it is estimated that the average temperature on Earth would be about 30°C colder.

An atoll in the Pacific. As sea levels rise with global warming islands like this will be submerged.

Douglas Faulkner/SPL

GOING UP

The fact that carbon dioxide levels are increasing is not in doubt. Carbon dioxide levels measured at the top of a mountain in Hawaii show a steady rise each year (Figure 2). The saw-tooth shape of the graph indicates an annual decrease due to carbon dioxide removal by **photosynthesis** in the growing season. However, the overall trend is upwards. Most scientists agree that increasing carbon dioxide in the atmosphere is causing **global warming**. Global temperatures have risen by 0.3–0.6°C since 1860 (and the Industrial Revolution), while the mean sea level has risen by 10–25 cm. It is hard to know what would have happened if all the carbon dioxide had not been released, but the United Nations (UN) believes that the changes observed are not due to natural variations.

WHAT CAN BE DONE?

In 1995 politicians from around the world met in Kyoto, Japan, and agreed to limit their countries' emissions of carbon dioxide. There has been progress in the UK towards reducing emissions. New cars are given a carbon dioxide emissions figure, in grammes per kilometre (gCO_2/km) and it is cheaper to tax a car that releases less carbon dioxide. There are plans to generate more of our electricity using wind farms, so that power stations burn less fossil fuels. However, other industrialised countries, notably the US, Australia and Canada, have made little progress in reducing emissions.

IS THIS ENOUGH?

Even if all countries met their reduction targets, we would still be releasing vast quantities of carbon dioxide. The UN predicts that by 2100 mean global temperatures could rise by 2°C, although worst estimates predict 5.5°C. To put this in context, a 1°C rise in temperature this century would be a greater rise than in any century in the past 10 000 years. Clearly 2°C would be extraordinary.

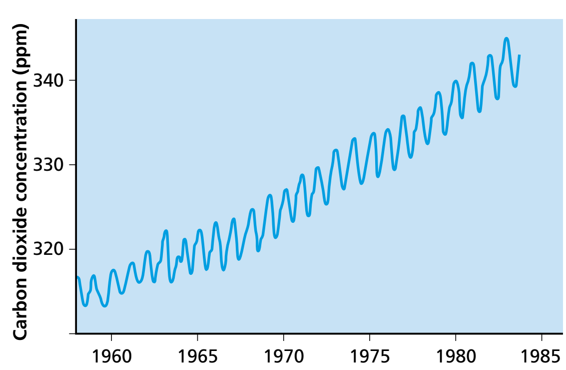


Figure 2 *Levels of atmospheric carbon dioxide measured at Mauna Loa, Hawaii.*

As a result of this, mean sea levels could rise by as much as 50 cm. This will mostly be due to expansion of the water as it warms up, but melting of ice sheets on land, such as those in Antarctica and Greenland, will contribute. It seems that some form of climate change is inevitable and its severity depends on our ability to reduce emissions.

TRAPPING CARBON DIOXIDE

Scientists at the University of Sheffield and the British Geological Survey (both funded by the Natural Environment Research Council) are looking at ways of removing carbon dioxide from the atmosphere. The most obvious process to look at is photosynthesis. Is it possible to plant enough trees to absorb the carbon dioxide being produced? The conclusion from scientists at the University of Sheffield is simple — planting more vegetation will not combat rising carbon dioxide levels. To absorb the carbon dioxide from just one large power station would need a forest the size of central England!

Scientists from the British Geological Survey (BGS) are focusing on an alternative way of storing carbon dioxide for a long time. They have discovered that it is possible to store it underground in porous rock. The gas is pumped underground where the pressure puts it into a supercritical state. The gas molecules are much closer together than they would normally be, and so the gas takes up less space.

The scientists have found that porous rock filled with salt water is the best place to store carbon dioxide. The water has been locked up for thousands of years and so it is very stable, and so salty it is unlikely to be of use. In the rock below the North Sea alone there is space for 800 billion tonnes of carbon dioxide, which is sufficient for all the carbon dioxide from Europe's power stations for 800 years.

STATOIL

The oil company Statoil has already begun storage of carbon dioxide by this method. The gas it extracts from the North Sea for use as fuel contains about 9% carbon dioxide. This has to be reduced to about 2.5% before it can be sold. In the past, the carbon dioxide removed from the gas would have been released into the atmosphere. Now it is injected back 800 m under the sea bed (Figure 3). One million tonnes of carbon dioxide per year have been injected since 1996. The BGS scientists are monitoring the long-term safety of this project.

Storage in disused oil and gas fields is one way of dealing with carbon dioxide. The inset shows the Sleipner platform and the bridge connecting it to the treatment platform where carbon dioxide is removed and compressed for injection.

Richard Folwell/SPL

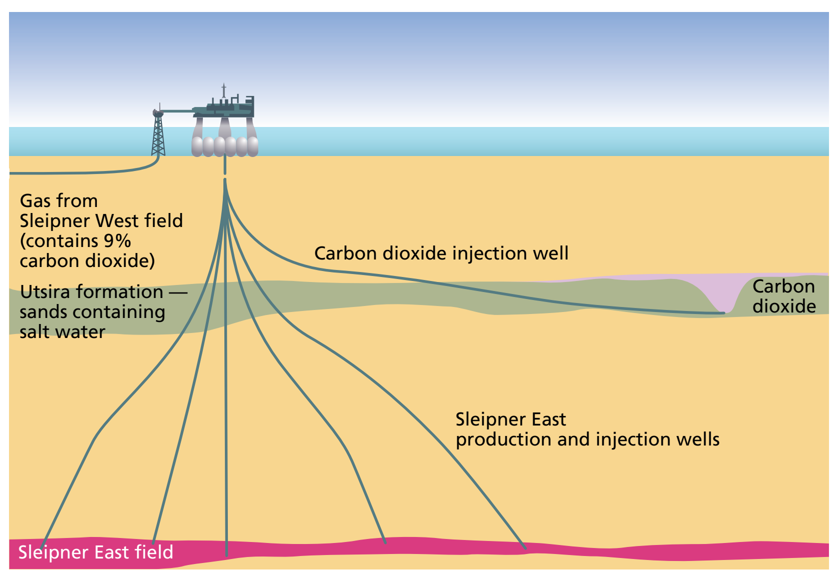


Figure 3 *Storage of carbon dioxide in the Sleipner oil field.*

Storage in disused oil and gas fields is an appealing way of dealing with carbon dioxide. Oil is, of course, formed underground. If we can extract it, use the energy and return the damaging emissions safely back underground then we will really be on the road to meeting our energy requirements while limiting the environmental impact.

You should know that plants take up carbon dioxide from the atmosphere and, with water and light energy, produce sugars, in the process of photosynthesis.

WEBSITES

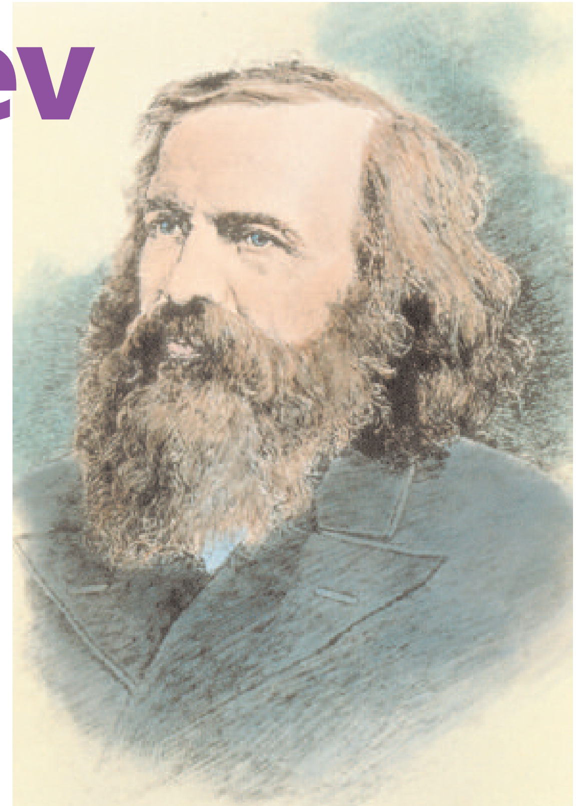
- Find out more about the oilfield where carbon dioxide is being pumped underground at **http://www.ieagreen.org.uk/sacs2.htm**
- Calculate your carbon dioxide emissions at **http://www.facefoundation.nl/Eng/frameset1dE.html**

Andy Dickenson *teaches science at King Charles I School, Kidderminster.*

A LIFE in science

Mendeleev

Mendeleev is well known as the originator of the periodic table we use today. But who was he, and did he have other achievements?



SPL

Dmitri Ivanovich Mendeleev was born on 7 February 1834 in Tobolsk, Siberia. He was the youngest of 14 children. His father was the headmaster of the local school and died when Dmitri was still quite young. His mother, Maria, needed to support the family and became the manager of a glass factory in Aremziansk. Dmitri spent many hours in the factory learning about the chemistry of glass and the art of glass blowing.

Dmitri studied hard at school and entered the science teacher-training course at the Pedagogical Institute at St Petersburg in the autumn of 1850. After spells of teaching at Simferopol, he returned to St Petersburg to complete his master's thesis on *Research and Theories on Expansion of Substances due to Heat*. Between 1859 and 1861 he travelled abroad, studying the density of gases with Regnault in Paris and spectroscopy with Kirchhoff in Heidelberg. In Heidelberg he became friendly with A. P. Borodin — a chemist who was later to become famous as a composer.

● Look at a modern periodic table. Iodine and tellurium are not in order of increasing atomic mass. Why is this? Are there any other pairs of elements that are arranged like this?

● Which gas did Kirchhoff discover on the surface of the Sun using spectroscopy before it was discovered on Earth?

Figure 1 *Mendeleev's first periodic table.*

Lithium	Sodium	Potassium
Beryllium	Magnesium	Calcium
Boron	Aluminium	?
Carbon	Silicon	Titanium
Nitrogen	Phosphorus	Vanadium
Oxygen	Sulphur	
Fluorine	Chlorine	

Figure 2 *Mendeleev's periodic table of 1869.*

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104.4	Pt = 197.4
			Fe = 56	Ru = 104.4	Ir = 198
			Ni = Co = 59	Pl = 106.5	Os = 199
H = 1			Cu = 63.4	Ag = 108	Hg = 200
	Be = 9.4	Mg = 24	Zn = 65.2	Cd = 112	
	B = 11	Al = 27.4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210
	O = 16	S = 32	Se = 79.4	Te = 128?	
	F = 19	Cl = 35.5	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85.4	Cs = 133	Tl = 204
		Ca = 40	Sr = 87.6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75.6	Th = 118?		

MENDELEEV AS TEACHER

When Mendeleev returned to Russia he settled down to research and teaching at St Petersburg. He became Professor of Chemistry, first at the technological institute and then in 1866 at the university. He was made a doctor of science. Mendeleev was a good teacher — his lectures were always crowded and even on trains and buses people would gather round him to hear his views on politics and social inequality. In 1890 Mendeleev resigned from the university — his political views did not match those of the minister of education. His final lecture was broken up by police who feared he might lead the students in an uprising.

IN LATER LIFE

Mendeleev published well over 250 writings in his lifetime — on science and also on his beliefs. His two textbooks, *Organic Chemistry* and *Principles of Chemistry*, rapidly became standard classroom texts. His research dealt mainly with agricultural chemistry, oil refining and mineral recovery. In 1887 he attempted to observe a solar eclipse from a hot air balloon. As he had not learnt how to control or land the balloon this proved rather perilous! In his lifetime Mendeleev received numerous awards and

Group / Series	O	I	II	III	IV	V	VI	VII	VIII
1		Hydrogen H 1.008	—	—	—	—	—	—	
2	Helium He 4.0	Lithium Li 7.03	Beryllium Be 9.1	Boron B 11.0	Carbon C 12.0	Nitrogen N 14.04	Oxygen O 16.00	Fluorine F 19.0	
3	Neon Ne 19.9	Sodium Na 23.05	Magnesium Mg 24.3	Aluminium Al 27.0	Silicon Si 28.4	Phosphorus P 31.0	Sulphur S 32.06	Chlorine Cl 35.45	
4	Argon Ar 38	Potassium K 39.1	Calcium Ca 40.1	Scandium Sc 44.1	Titanium Ti 48.1	Vanadium V 51.4	Chromium Cr 52.1	Manganese Mn 55.0	Iron Fe 55.9; Cobalt Co 59; Nickel N 59 (Cu)
5		Copper Cu 63.6	Zinc Zn 65.4	Gallium Ga 70.0	Germanium Ge 72.3	Arsenic As 75	Selenium Se 79	Bromine Br 79.95	
6	Krypton Kr 81.8	Rubidium Rb 85.4	Strontium Sr 87.6	Yttrium Y 89.0	Zirconium Zr 90.6	Niobium Nb 94.0	Molybdenum Mo 96.0	—	Ruthenium Ru 101.7; Rhodium Rh 103.0; Palladium Pd 106.5 (Ag)
7		Silver Ag 107.9	Cadmium Cd 112.4	Indium In 114.0	Tin Sn 119.0	Antimony Sb 120.0	Tellurium Te 127	Iodine I 127	
8	Xenon Xe 128	Caesium Cs 132.9	Barium Ba 137.4	Lanthanum La 139	Cerium Ce 140	—	—	—	— — —
9	—	—	—	—	—		—	—	
10	—	—	—	Ytterbium Yb 173	—	Tantalum Ta 183	Tungsten W 184	—	Osmium Os 191; Indium Ir 193; Platinum Pt 194.9 (Au)
11		Gold Au 197.2	Mercury Hg 200.0	Thallium Tl 204.1	Lead Pb 206.9	Bismuth Bi 208	—	—	
12	—	—	Radium Rd 224	—	Thorium Th 232	—	Uranium U 239		

***Figure 3** Mendeleev's periodic table of 1905.*

honorary degrees from around the world and was widely respected.

He died peacefully on 20 January 1907 aged 73.

THE PERIODIC TABLE

Mendeleev's most famous achievement was the organisation of the elements into a workable periodic table that could be used to predict their properties. His first scientific paper about this was written when he was 35. He was an avid collector of facts about the elements and maintained long correspondences with scientists all over the world.

Mendeleev began by arranging the elements in a logical order of increasing atomic mass, and placing those elements with similar properties next to each other. He realised that he might have to leave gaps as not all the elements had been discovered. His first attempt is shown in Figure 1.

In his book *Principles of Chemistry*, published in 1869, he had expanded the list to cover many more elements, as shown in Figure 2. Note that he was not afraid to assign masses to elements which he was certain existed but which had not been discovered. Indeed he was so confident about his table that he predicted the properties of ten unknown elements — and was later proved correct in eight cases. It was the predictability of the table that won him international renown.

By 1905 Mendeleev's periodic table had acquired a few more elements and had placed the periods horizontally and the groups vertically, but it still resembled his earlier versions (Figure 3). It is essentially a version of this table that we use today — an arrangement which has stood the test of time!

David Moore teaches chemistry at St Edward's School in Oxford and is an editor of CATALYST.

- **Why did Mendeleev attempt to observe the eclipse from a balloon?**

ANSWERS TO ELEMENT WORDSEARCH, PAGE 3

actinium
aluminium
americium
antimony
argon
arsenic
boron
bromine
cadmium
calcium
carbon
chlorine
erbium
fermium
gold
hafnium

holmium
iodine
iron
lanthanum
lead
lithium
magnesium
manganese
mendelevium
mercury
molybdenum
neon
nickel
osmium
oxygen
palladium

radium
radon
rhodium
silver
tantalum
terbium
thallium
tin
tungsten
uranium
vanadium
xenon
ytterbium
yttrium
zinc
zirconium

SUSANNA DUNACHIE AND ANNE MOORE

A vaccine for

A female *Anopheles* mosquito feeding on human blood.

Martin Dohrn/SPL

GCSE key words
Antibody
Vaccine
Pathogen
Genetic engineering

Malaria is one of the world's top ten diseases. Vaccines protect us against many dangerous diseases but there isn't yet an effective anti-malarial vaccine. In this article Susanna Dunachie and Anne Moore explain how they and other scientists in the Malaria Vaccine Group at Oxford are trying to overcome some very difficult problems using a new approach to vaccines.

Every year more than 2 million people die from malaria, including many young African children. Western travellers risk catching the disease when they visit countries that have malaria.

WHAT IS MALARIA?

Malaria is a disease in which the patient suffers high fevers, headaches, muscle aches and weakness. In severe cases it causes kidney failure, loss of consciousness and anaemia, and it is often fatal.

The disease is caused by several species of a single-celled parasitic organism, *Plasmodium*, which spends part of its life in *Anopheles* mosquitoes. The parasite is passed to humans when a female mosquito bites them. Figure 1 shows how the parasite

Vaccines are usually used against disease-causing microorganisms.

A **pathogen** is an organism that causes a disease.

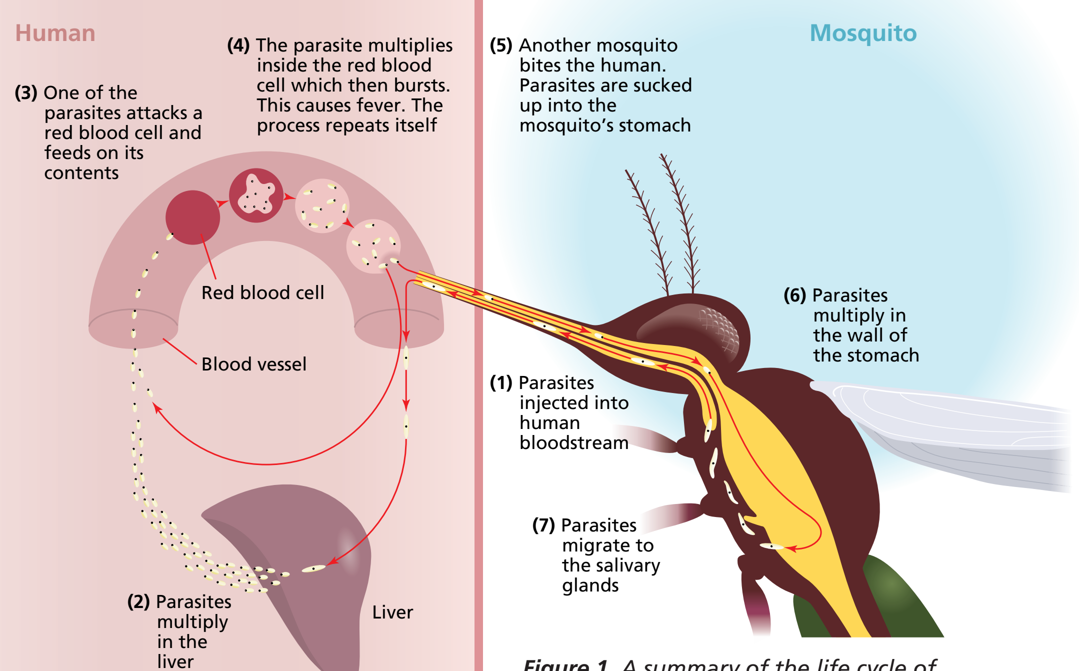


Figure 1 *A summary of the life cycle of the malaria parasite.*

malaria?

invades liver cells. Here the parasites multiply, then spill out into the bloodstream to cause illness.

The malaria problem is getting worse because the mosquitoes that transmit malaria are becoming resistant to insecticides, and the parasites are also increasingly resistant to anti-malarial drugs.

VACCINE SCIENCE

People naturally acquire immunity to an infection when they contract the illness and develop an immune response to it. The immune system can then fight off the same disease if it encounters it again. Vaccination mimics this process — the vaccine stimulates the immune system to generate a protective response against that pathogen if the individual is re-exposed to it.

The immune system responds to chemicals called **antigens** found in the disease-causing organism. A vaccine contains antigens from a specific disease-causing organism. It may contain whole pathogens which have been killed, weakened or inactivated, or fragments of the pathogen.

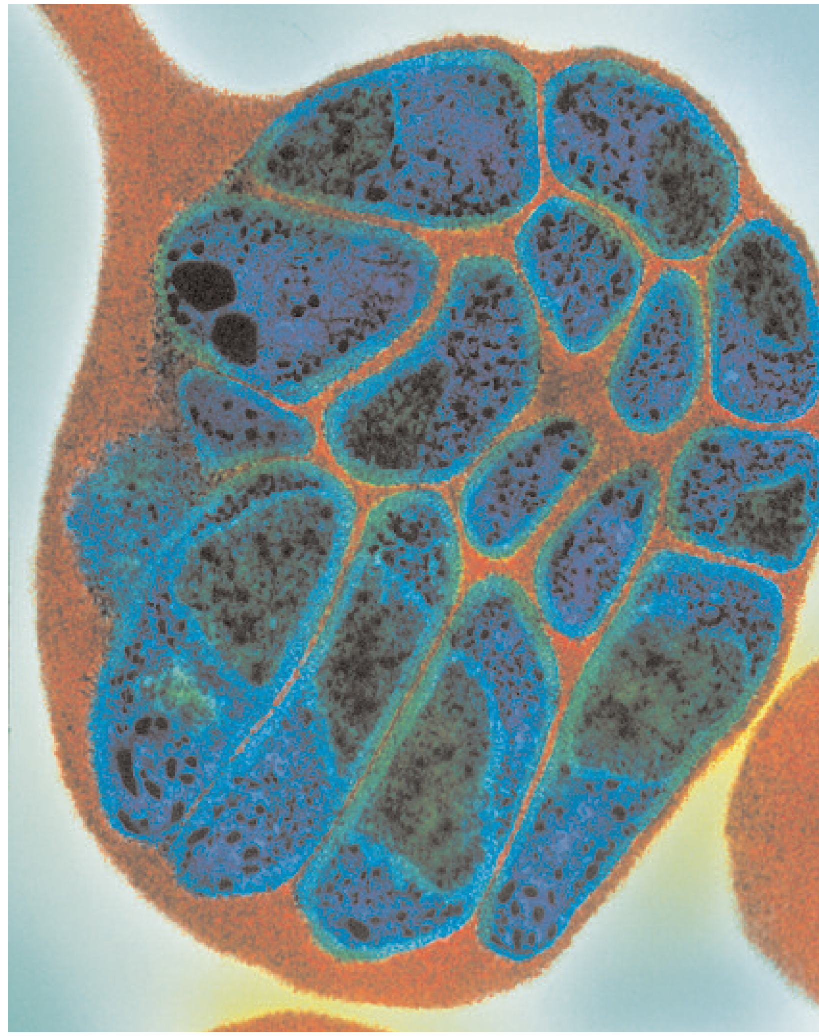
The malaria parasite can be weakened using radiation, but it is impractical to do this on a large scale because producing the parasites requires complicated rearing of mosquitoes. Another method for making a malaria vaccine is required.

The immune system responds to pathogens in several different ways. Traditionally vaccines have been designed to provoke white blood cells called **B-lymphocytes** to make **antibodies**. These tag onto invading pathogens in body fluids, marking them for destruction by white blood cells and making it difficult for them to cause disease. However, because the malaria parasite spends a lot of its life cycle hiding inside human liver cells, antibodies alone may not be protective against malaria.

More recent approaches aim to use a different group of white cells called **T-lymphocytes** (T-cells). These normally monitor the surfaces of cells in the body and can detect cells that have foreign surface antigens — such as virus-infected cells and cancerous cells — as well as those infected with malaria parasites. The T-cells then kill them directly or help the immune response to remove the cells from the body.

VACCINES AGAINST MALARIA

The Malaria Vaccine Group at Oxford University has been working on a vaccine against malaria for 15 years. Led by Professor Adrian Hill, our group



Moredun Scientific Ltd/SPL

Coloured electron micrograph of a human red blood cell infected with malaria parasites (blue) which have made this part of the cell swell.

Table 1 *Some diseases which still have no effective vaccine*

Disease	Estimated annual deaths	Estimated annual cases
Malaria	1 086 000	300–500 million
Schistosomiasis	14 000	not available
Worm infestation	16 000	not available
Diarrhoea	2 213 000	~ 4100 million
Respiratory disease	4 039 000	~ 362 million
HIV/AIDS	2 673 000	~ 2 million

Source: *World Health Report 2000*, World Health Organization.

aims to design vaccines that will induce potent T-cell responses against the liver stage of malaria infection. These T-cells recognise malaria antigens on the surface of infected liver cells and destroy them, so preventing both infection in the blood and transmission to new people.

We are currently developing three different types of vaccine. The first is based on **DNA**. It uses a small loop of DNA called a **plasmid**, which contains genes for malaria antigens. Plasmids, which were first described in bacteria, are used in genetic engineering to transfer genes into new cells. They are able to get human cells to translate genes into

Sir Ronald Ross, a doctor in the Indian Medical Service, found malaria parasites inside mosquitoes, showing their role in the spread of the disease.

Right: A child in Somalia suffering from malaria.

Every 30 seconds a child somewhere in the world dies of malaria.

There are nearly 2000 cases a year of people returning to Britain from abroad with malaria.

Mosquitoes spread not only malaria but also yellow fever and elephantiasis.

antigens because the plasmid also contains a signal to make products from the added DNA.

The other two vaccines contain weakened viruses that have been **genetically modified**. MVA (modified vaccinia virus ankara) and FP9 (fowlpox strain 9) viruses are harmless to humans but carry the same malaria antigen as the DNA vaccine. The viruses infect cells, which then produce malaria antigens on their surfaces. T-cells become sensitised to these malaria antigens and attack cells carrying them — including any liver cells infected by the parasite.

PRIME-BOOST VACCINATION

Each of these vaccines produces a weak immune response, but if they are given one after the other the immune response is much stronger and can protect against parasite infection. The theory is that one vaccine **primes** the immune system and the second vaccine **boosts** this response. The DNA and FP9 vaccines are good at priming the immune system and the MVA vaccine is excellent at boosting the response.

This discovery is significant for both human and veterinary medicine. It may be possible to develop vaccines of this new prime-boost type to prevent or treat diseases such as HIV, tuberculosis and viral hepatitis, and some cancers.

Right: A human volunteer being bitten by mosquitoes in the Oxford vaccine trials.

Vaccines are the only way to totally eradicate infectious diseases.

HUMAN CLINICAL TRIALS

The Malaria Vaccine Group has conducted human clinical trials using various combinations of the DNA, MVA and FP9 vaccines. Trials are first carried out in the UK and, if the vaccines are safe and produce significant immune responses, small-scale studies are done in The Gambia in west Africa (where malaria is a major problem), before going on to large-scale field trials. Many different doses and strategies have now been tested in Oxford. The response to vaccination is measured by counting T-cell responses in the volunteers' blood. We are also researching the molecular mechanisms of how these vaccines function.

INFECTING VOLUNTEERS WITH MALARIA

It is important to see if a vaccinated person is protected against malaria. We infect volunteers using a safe, well-established procedure with a strain of malaria that can be treated by drugs. Each volunteer is bitten by five infected mosquitoes and we make sure that the mosquitoes have fed (they become swollen with blood). The volunteers then have blood

WEBSITES

The website of our Malaria Vaccine Group in Oxford **http://www.malaria-vaccines.org.uk**

The website of the Malaria Vaccine Initiative, in Maryland, USA **http://www.malariavaccines.org**

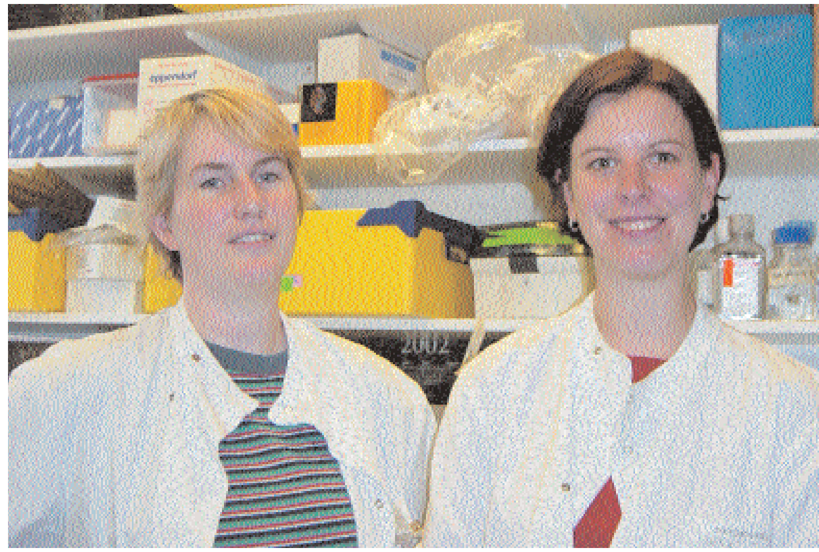
The World Health Organization website **http://www.who.int/en**

The Wellcome Trust's malaria website **http://www.wellcome.ac.uk/malaria**

samples taken twice daily and these are examined for the presence of malaria parasites. If a single parasite is seen the volunteer is immediately treated with chloroquine, a drug which kills the parasites. This type of malaria (*Plasmodium falciparum*) cannot recur after successful treatment, so the individual is cured.

RESULTS OF CLINICAL TRIALS

The trials have shown that vaccinated volunteers have significant immune responses in their blood and, more excitingly, some are completely protected against malaria. Large-scale field studies involving hundreds of people are currently underway in The Gambia. We hope that this scientific research will eventually enable malaria in Africa to be controlled.



Malaria Vaccine Group

Susanna Dunachie (right) and Anne Moore of the Malaria Vaccine Group.

Susanna Dunachie *is a medical doctor running the vaccine and challenge trials in healthy volunteers in Oxford.* ***Anne Moore*** *is a senior immunologist researching the immune mechanisms that make the vaccines work.*

The work of the Malaria Vaccine Group is funded by the Wellcome Trust and the Malaria Vaccine Initiative.

Shake that LED!

TRY this

Here's how to light up an LED (light emitting diode) without a battery, using your own wrist-power.

You will need:

- an LED — low-current ones are best;
- copper wire — about 50 m of thin, enamelled wire;
- a small, powerful magnet;
- an empty plastic 35 mm film container.

(If you have trouble finding any of these, ask your science teacher.)

WHAT TO DO

Wind a coil of wire around the film container. Keep the starting end of the wire free. (It helps if you fit the container with cardboard rings to contain the coil — see Figure 1.)

Scrape the insulation from the ends of the wire and solder on the LED.

Put the magnet in the container, put on the lid and shake it about.

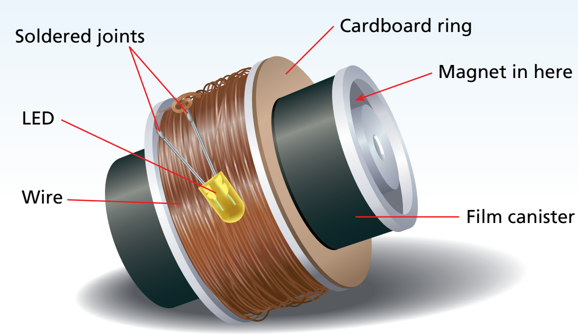


Figure 1
The end result.

HOW IT WORKS

You are generating an electric current by moving a magnet in a coil, just like in a bicycle dynamo. An induced current flows in the wire. When it flows in the right direction, it lights the LED.

Look out for an LED which lights up red or green, depending on the direction of the current. How do you think this will behave?

David Sang *writes textbooks and is an editor of* CATALYST.

This activity comes from the Creative Science Centre at Sussex University http://www.creative-science.org.uk

Thinktank

thinktank

Thinktank has ten galleries, a 200-seat theatre, education rooms, a café and shop. You enter Thinktank in the present day. The past is below you and the future above. Although there are many interesting activities in the present day sections, especially in medicine, we'll concentrate here on the past and the future.

● Log on to **www.thinktank.ac** to find out more.

THE PAST

Downstairs in the Making Things gallery you can explore the birth of the Industrial Revolution and how machines were developed, making anything from buttons and buckles to hairgrips and sweet wrappers.

Birmingham was a major hub of transport during the Industrial Revolution. In the Move It gallery you can see some of the remarkable machines that were built at the time. You can explore the evolution of the complex networks of canals, roads and railways that connected Birmingham to the rest of Britain, and hear stories from the people who made, used and ran them.

● Use a search engine to find out more about Matthew Boulton and James Watt.

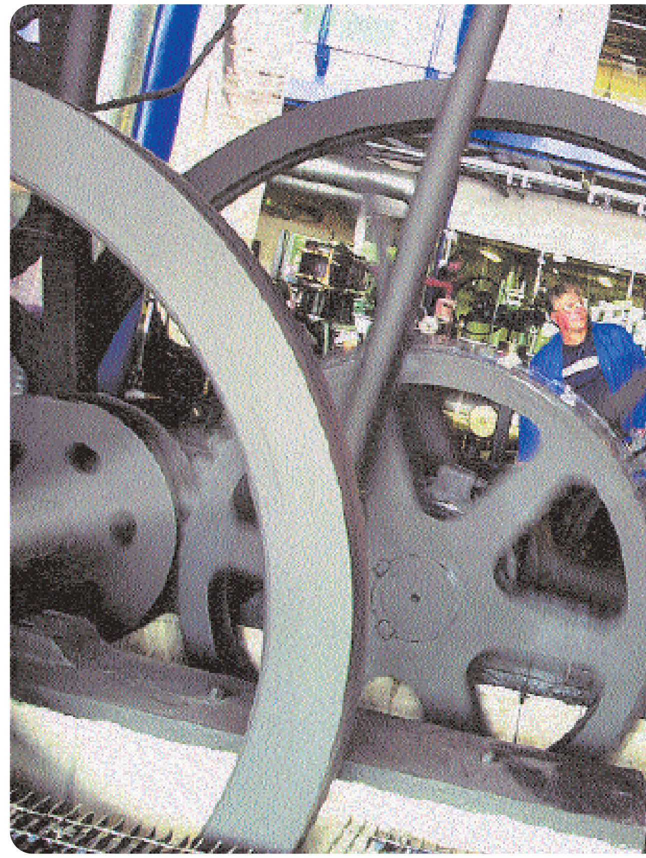
Steaming

One of the most comprehensive steam engine collections in the world is housed in the Power Up gallery — many of the engines are working. Scientists and engineers in Birmingham played a pioneering role in the development of steam power — it was here that businessman Matthew Boulton and engineer James Watt built the world's most efficient steam engine. Their partnership lasted 25 years. In the Boulton and Watt Object Theatre you can hear the story of how they met, how they built up an engineering business of world renown, and how this influenced the design of all future steam engines.

● Use a search engine to find out who belonged to the influential Lunar Society, which met in Birmingham.

There are ten working engines in Power Up, but pride of place goes to the Smethwick Engine, which is the oldest active steam engine in the world. It was designed by James Watt in 1778 and is a massive machine that pumps a tonne of water with every stroke. The most efficient and powerful steam engine of its time, it was built to pump water back up to the top of a canal's lock system, allowing many more boats to pass through a congested section.

There is also an IMAX cinema to visit at Millennium Point.



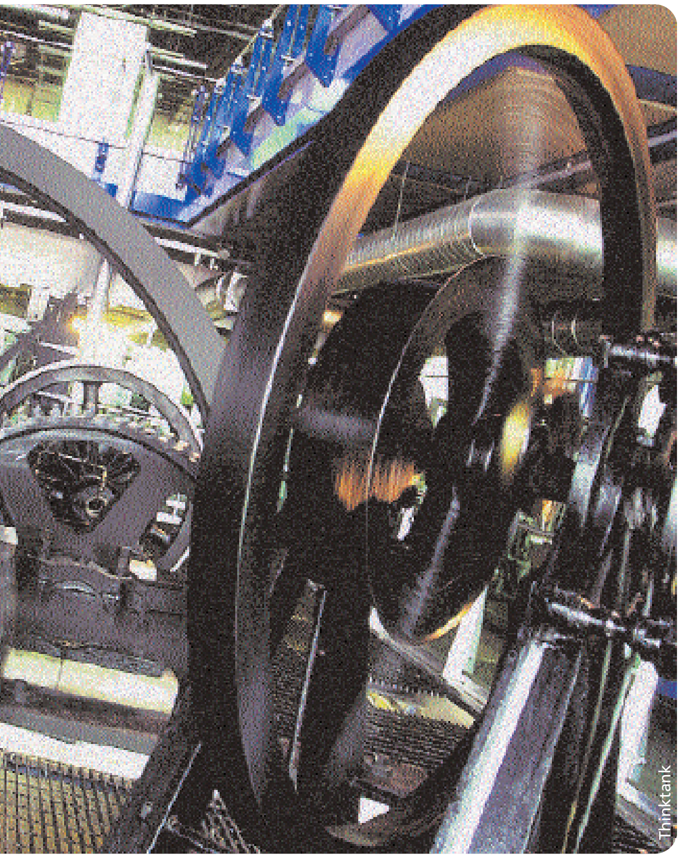
THE FUTURE

Science is changing all the time. In the Futures gallery six topics are presented. Four of them use touch screens which control much larger screens, creating a dramatic environment that enables you to unwrap further information, video clips or animations. There are sections entitled Superbodies, Sensors, Bodychecks and Design and Materials in this format.

Superbodies

As just one example, in Superbodies you can find out about Peter Houghton. He is an active man who enjoys strenuous exercise, but he is kept alive by a titanium pump inserted into his heart — the Jarvik 2000. Small batteries supply the energy for the heart

Thinktank, the Birmingham museum of science and discovery, sets out to explore the way in which innovation in science and technology underpins our lives. There is much here of interest to GCSE students — not just science but history too.



and Peter can increase and decrease his heart rate with a switch, depending on what he is doing. One day, thanks to the help of the Jarvik pump , Peter's own heart may once again be strong enough to work on its own.

Spacemappers

Also in Futures is Spacemappers, which has stunning imagery of the Earth and the Sun from the SOHO satellite and the Hubble space telescope. Three screens are spaced around a broad dome, high up above a large open space, and you can control images from a console set on the opposite side of the space. You seem to be in a bubble of sound and cannot hear anything of the commentary from the other two screens. Computers here reboot themselves when they crash — sadly not true of some machines in the present day sections of Thinktank.

Last but not least, there is a Robotics section. Making a powerful industrial robot mimic your drum playing is great fun.

VISITING

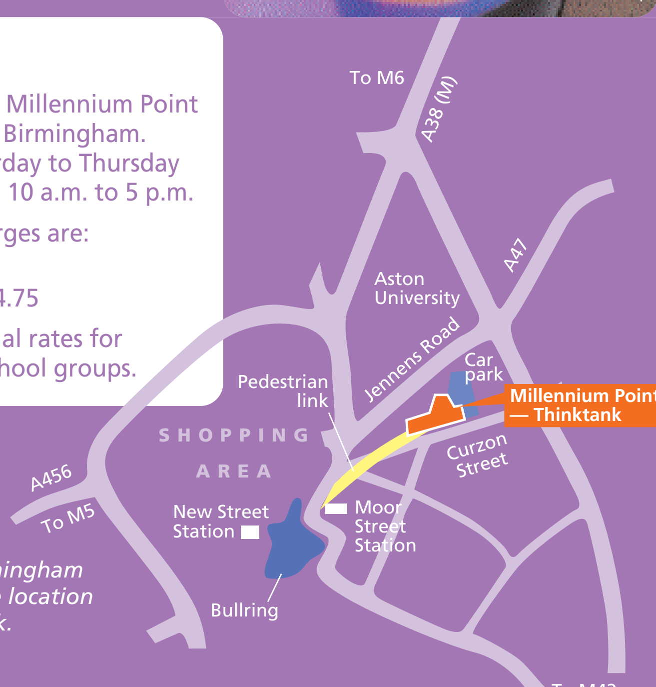
Thinktank is at Millennium Point in the heart of Birmingham.
It is open Saturday to Thursday (closed Friday), 10 a.m. to 5 p.m.

Admission charges are:

Adults: £6.75

Under 16s: £4.75

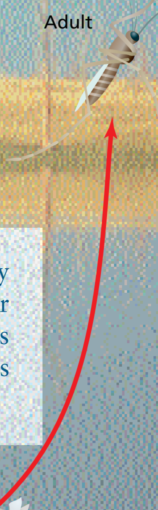
There are special rates for families and school groups.



Map of Birmingham showing the location of Thinktank.

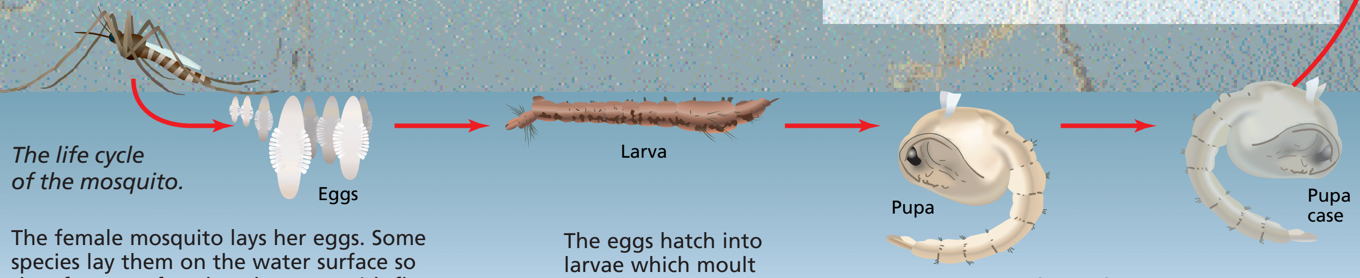
Controlling mosquitoes

Many diseases are spread by mosquitoes. Once scientists realised this they looked for means to reduce mosquito numbers. Adult mosquitoes can be killed using insecticides, but other ways have been found to control them, based on an understanding of their life cycle.



Oil sprayed on water surfaces prevents the larvae and pupae from breathing through their breathing tubes. It might be mixed with an insecticide.

The insecticide DDT was used extensively against adult mosquitoes but is no longer used because it accumulates in food chains and can affect other animals. Alternatives are available.



The life cycle of the mosquito.

The female mosquito lays her eggs. Some species lay them on the water surface so they form a raft; others lay eggs with floats.

The eggs hatch into larvae which moult four times before forming a pupa.

*This is an outline of the life cycle. The Wellcome Trust's website (**www.welcome.ac.uk/malaria**) has a detailed animation of the different stages.*

A mosquito net in use in Vietnam.

Sean Sprague/Panos Pictures

Stocking water bodies with fish that eat mosquito larvae and pupae might help but many mosquitoes breed in small volumes of water, such as hollows in trees or temporary puddles.

Draining wetlands removes the breeding area for many species of mosquito.

Mosquito nets prevent mosquitoes from reaching people at night.

Many of the methods described have serious disadvantages and consequences for other organisms.

The species of mosquito that spreads malaria does occur in Britain, but it is not normally infected. Being bitten is still painful!