Catalyst

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Inherited material

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Catalyst

The front cover shows a scanning electron micrograph of two chromosomes which have just replicated during mitosis (Andrew Syred/SPL).

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Contents

Questions about nitrogen

Nitrogen is all around us. It makes up 78% of the air we breathe. As the article on page 8 explains, it is a gas which doesn't take part readily in reactions. That's why it took a long time for scientists to identify it. In the eighteenth century it was clear that, when materials burned, they only used up about one-fifth of the air. What could the rest ('spent air') consist of?

This might seem a dull question, but those scientists persisted, and today we have a much greater understanding of nitrogen's role. It is a vital component of amino acids, without which there would be no proteins and probably no life.

But why 78%? With a few per cent more nitrogen in the atmosphere, living creatures would find it difficult to obtain enough oxygen. A few per cent less nitrogen, and the concentration of oxygen would be so high that fires would break out very easily.

David Sang

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David Brodie

Exploring Saturn


Topfoto

Above: *An artist's impression of* Cassini-Huygens *orbiting Saturn*

You're a long way from home. You've been asleep for 7 years during a journey with your sister, Cassini. *Now you have woken and you are alone, falling to a strange moon called Titan. You face a 2½ hour descent through cold orange smog. When you hit the surface below you'll either sink in a curious sea or be smashed by solid ground. Either way, your batteries will soon fail and all your systems will shut down for ever. It's tough being a robot space probe called* Huygens.

Huygens and *Cassini* are two spacecraft on a mission to explore Saturn and its moons. *Huygens* is planned to fall onto Titan, one of Saturn's moons. While it falls, it will gather all sorts of information. It is equipped with cameras of different sorts, chemical sensors and temperature sensors. *Huygens* has radio transmitters to send the information back up to *Cassini* which will remain in orbit round Saturn. *Cassini* will transmit the information back to Earth, and we'll find out much more about Titan.

Box 1 *Cassini-Huygens* science milestones

26 October 2004	Flyby of Titan
13 December	Flyby of Titan
15 December	Flyby of Dione
25 December	Release of *Huygens* probe
1 January 2005	Orbiter flyby of Iapetus
14 January	Descent of *Huygens* probe to surface of Titan
15 February	Flyby of Titan
17 February	Flyby of Enceladus
9 March	Flyby of Enceladus

Further flybys of Titan on: 31 March, 16 April, 22 August, 7 September, 28 October and 26 December 2005.

The rings of Saturn

The *Cassini-Huygens* mission is named after two scientists, one Italian and one Dutch, who worked more than 300 years ago. With their telescopes, a brand new technology of the time, they were able to see more than others had seen before.

Each instrument on *Cassini-Huygens* is managed by a principal investigator. Two of these are from the UK: Dr Michele Dougherty from Imperial College London and Professor John Zarnecki of the Open University. Watch out for them on television!

GCSE key words
Gravity
Orbits
Satellites
Sensing

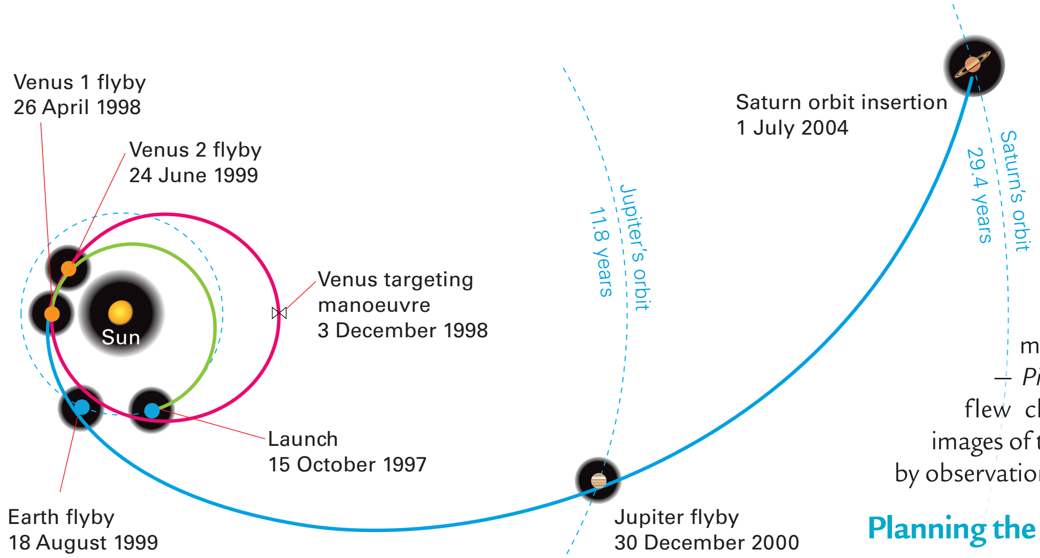


Figure 1
The journey to Saturn

In the 1650s Christiaan Huygens made his own telescope specially for the study of Saturn. He suggested that the shapes others had already seen around Saturn were a solid ring. He even found a moon of Saturn, which we call Titan. Giovanni Cassini discovered two more moons in the 1670s – Iapetus and Rhea. A few years later he found a dark line dividing the ring into two halves – inner and outer. We call it the Cassini division.

Debate over the nature of the rings went on for 300 years. Some people believed the rings were solid, others that they were made up of fragments. There was no way of knowing which was true. In the middle of the nineteenth century the great Scottish mathematical physicist, James Clerk Maxwell, did some complex maths which suggested that solid rings could not exist. They'd break up into fragments under the effects of gravity and their own motion. But it wasn't until the space missions of the late twentieth century – *Pioneer 11*, *Voyager 1* and *Voyager 2* – flew close to Saturn and radioed back images of the rings that the debate was resolved by observation. The rings are made of fragments.

Below: *An artist's impression of the* Huygens *probe landing on Titan. It's purpose is to investigate the atmosphere and it may not survive the landing*

Planning the mission

The *Pioneer* and *Voyager* missions provided some answers, but there are still a lot of questions. Is the weather on Saturn like the weather on Earth? What is Saturn like under its outer layers of clouds? How does the planet's magnetism affect its atmosphere? Why are the rings so complicated? Why and how do they change? Are the chemicals in Titan's atmosphere like the chemicals of life on Earth? Does Titan have solid continents and liquid seas? What are Saturn's other moons made of apart from ice? Questions, questions.

The *Cassini-Huygens* mission has been planned to provide some answers. It's a truly international project – a collaboration between European and American scientists who will share their work and their ideas for years to come. They decided to send a two-part spacecraft. At the end of 2004 *Huygens* will separate from *Cassini*, and begin its tumble to Titan, arriving in January 2005. For 4 more years the *Cassini* orbiter will stay in orbit round Saturn.

The journey to Saturn

When we look at it from Earth, Saturn is just a bright dot in the sky. How do you launch a spacecraft and get it to arrive at that dot? With careful planning!

Box 2 Unknown Titan

We already know that Titan's atmosphere is mostly nitrogen, just like the Earth's. And the Hubble Space Telescope detected infrared radiation from Titan's surface. The radiation was patchy, so the surface could be patchy. Perhaps some is solid and some is liquid.

The temperature on Titan is about 180°C below the freezing point of water. Any water there will be frozen. But there seem to be ever-changing clouds of methane. It is possible that beneath the clouds and haze there are lakes of ethane. The chemistry of these clouds and lakes could be complicated enough to form some of the chemical building blocks of life – the things that we are all made of. *Cassini* and *Huygens* will find out more.

Box 3 Unknown Saturn

Saturn is a ball of gas, mostly hydrogen and helium with traces of water, methane and ammonia, becoming denser towards its centre. It probably has a deep rocky core surrounded by a layer of liquid metallic hydrogen. There are other uncertainties, like the cause of the colours in the planet's clouds.

Saturn's magnetic field is not understood very well either. The *Cassini* orbiter will study the field, to find out more so that we can compare it with Earth's magnetism. The gravity of the moons pulls on the fragments of the rings. Some of the moons even seem to 'shepherd' fragments to create patterns in the rings. *Cassini* will provide information to help us understand whether the rings themselves were once a moon that shattered into fragments long, long before there were people to look at the planet and wonder.

The *Cassini-Huygens* mission was launched in 1997, and went into orbit round Saturn in July 2004. It didn't just have to escape from the Earth's gravity, but had a long, long trek away from the Sun. All that time, the Sun's gravity was pulling it towards the centre of the solar system.

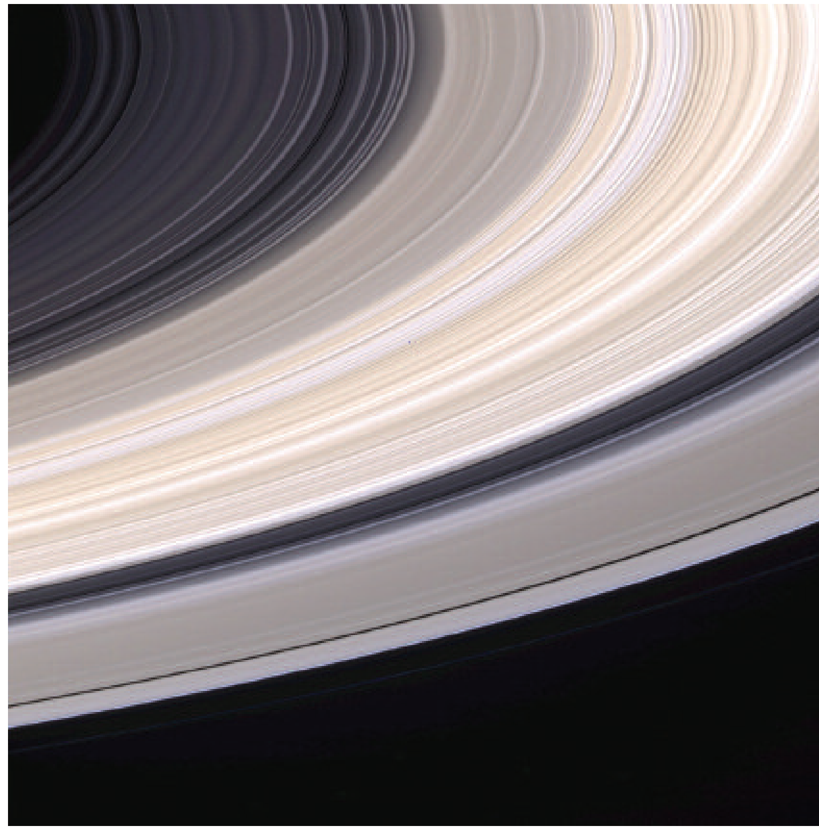
To give the spacecraft enough energy to overcome that inward pull, the planners decided to steal a little energy from the motions of other planets. So they sent it off in the 'wrong' direction — inwards through the solar system to the orbit of Venus. It flew past Venus and took energy from its motion, thanks to the gravitational pull of the planet. Then it did it again, faster than before. It came hurtling back towards the Earth, and in 1999 it flew past, taking a little energy from our orbital motion just as it had done from Venus.

Now it was going at a much higher speed than a launch rocket could ever have given it. And it flew onwards and outwards, but still not directly towards Saturn. It flew past Jupiter, and used the same energy-stealing trick once more, before heading out on the last part of its journey.

Cassini will orbit Saturn at a distance of about 1.5 million km, a similar distance to the radius of Titan's orbit, and well beyond the outer reaches of Saturn's rings.

Instruments and information

Some of the cameras on the two spacecraft can sense visible light, and some can sense other parts of the electromagnetic spectrum. *Cassini*'s imaging science subsystem, for example, has two digital cameras, one for wide-angle shots and one for details of small areas. But unlike your eyes, these cameras can also produce images from ultraviolet and infrared radiations. Meanwhile the composite infrared spectrometer detects infrared radiation emitted by Saturn's layers, rings and moons.



NASA/JPL/SSI/SPL

Above: *An image of Saturn's rings from the* Cassini *spacecraft, taken in June*

Box 4 Weblinks

The European Space Agency's website will give you up-to-date information on the progress of the mission: http://www.esa.int and click on the *Focus on...Cassini/Huygens* button once it is loaded.

SEDS is a student-run site; try searching it for images of Saturn and Titan — there are a lot! http://www.seds.org

A radar system will make maps of Titan as *Cassini* flies past, and other radio waves will travel through the atmosphere and the rings of Saturn to explore their structures. All the information will travel for more than an hour at the speed of light to sensitive radio antennae here on Earth.

Doing the science

More than 200 scientists around the world will work on the data that arrive at the radio antennae. They will be experts in different fields: atmospheric chemistry, weather systems, the unsolved questions of planetary magnetism, the complex dynamics of the motions of Saturn's many moons and the fragments of the rings. As they solve the riddles posed by the new information they will develop new ideas and new techniques. These will increase human understanding of our solar system, of the Earth and of ourselves.

David Brodie *has written many books and articles for school students.*

Improve your grade

Throwing marks

'Marvin should focus on improving the accuracy of his answers if he is to improve his grade.' What exactly does this mean? Read on.

If the examiners can't read your handwriting they won't be able to give you any marks.

You've worked hard on your revision. You've upgraded your notes, made concept maps, listed key facts and learnt them off by heart, and even got your Gran to test you. So why didn't you get as many marks as you thought you should in the exam? After all, you actually knew the answers to the questions, didn't you?

The answer lies in that one-liner in your end-of-year report — your answers lack **accuracy**. What does it mean? It means that you throw marks away. You don't do this deliberately — you simply don't realise how careful and specific you have to be to capture a mark. So let's take a look at ways that you might throw marks away.

Bad habits

You may lose a lot of marks through using casual thought and speech patterns, instead of scientific accuracy. Look at these examples:

You correctly calculate the velocity of a car travelling 400 metres in 20 seconds. The answer space has (m/s) as a unit. But it's about cars isn't it? You put the answer as mph — whoops you've lost 3 marks all at once. I know we talk to our mates about cars doing 50 mph but this is a science exam — we use SI units — and now your answer is mathematically wrong.

Q Explain what is meant by braking distance…

A *It is the time you take to stop your car after you have put your foot on the brake.*

This isn't a conversation. Why are you talking about *time* when you mean *distance*? The question is about distance, and your answer should refer to metres travelled.

When you skim along a sentence you are looking for the crucial words that indicate its subject. You skip over the small words...so you read:

Q …which is not a conductor of electricity…

and you write about a conductor.

A variation on this is:

Q What else could affect the temperature?

You give something that was mentioned earlier in the question because it's still in the forefront of your mind. Examiners put these important words in **bold** to try to attract your attention to them. Read more slowly.

What was that you said?

It helps to tell the examiner what you are talking about. Examiners are not very good at mind reading. Here's a good example:

Q Compare electricity and gas as energy sources for the home.

A *It's cheaper.*

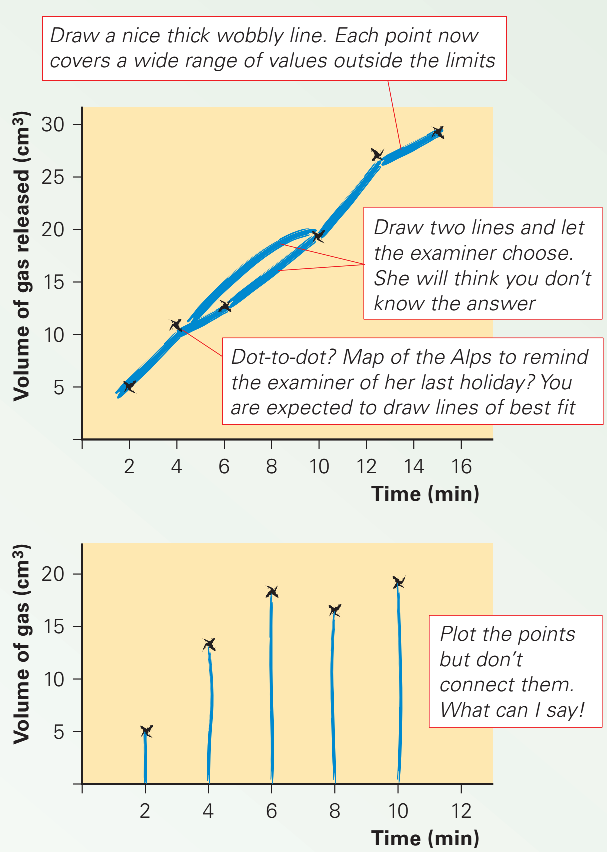
What's cheaper? Electricity? Gas? Cheaper than what? Than burning wood? Never start a sentence with 'it' or 'they'.

Throwing away graph and diagram marks

You can throw lots of marks away on badly drawn graphs. There are some crackers in Figure 1.

Diagrams are also great for making marks disappear. You can see some common mistakes in Figures 2 and 3.

Figure 1 *How not to draw graphs*



away

Ignoring the examiners

Examiners give you hints to stop you going off on the wrong track. Look at this question:

Q Give one reason why the population could have risen.

A *There might have been more food available, and fewer predators.*

The question asks for one reason. Some people like to show off their knowledge. Others don't know which bits are important. Both waste writing time by giving information that is not needed.

You don't get extra marks for extra answers. If one of your alternatives is wrong you'll lose the mark because the examiner will assume you don't know which is right.

Ignoring the mark allocation leads to trouble too. This question carries 4 marks:

Q Explain how fertiliser sprayed on crops can affect life in water.

A *Fertiliser drains in and it kills them.*

What does it kill? The answer has the right idea but no scientific details. Four marks means the examiner wants you to give four points from about six possibilities, such as:

- fertiliser dissolving in fallen rain
- fertiliser in soil moisture leaches through soil and enters a stream

and so on.

Missing the mark scheme

Try to avoid being vague. Look at this answer:

Q Why do farmers use pesticides?

A *Pesticides stop insects harming crops.*

How do they do this? Does the pesticide make the crop taste or smell nasty? Has it a bright colour to frighten insects away? Or does it kill them? How do the insects harm the crops — stamp on them? Poo on them? Or eat them?

You can even lose marks by the *way* you write your answers. Use the conventional way of writing chemical equations instead of inventing your own.

For example look at this equation:

$$\text{C6H12O6 . O}^2 \longrightarrow \text{C+O2 + 2HO}$$

The balanced equation for respiration is actually written as:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

There are six errors in the example, but just one error can lose you the mark for the whole equation.

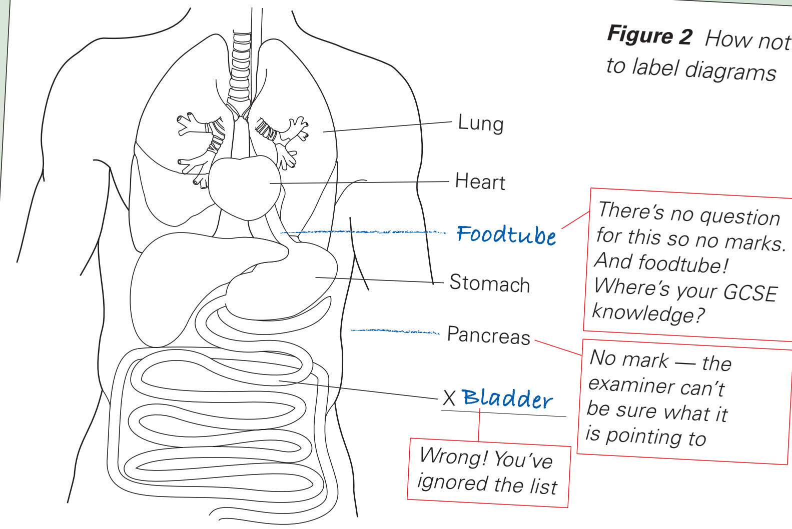


Figure 2 *How not to label diagrams*

Q Label organ X.
Choose from the list:
kidney
intestine
brain

Q Draw a line to label the pancreas.

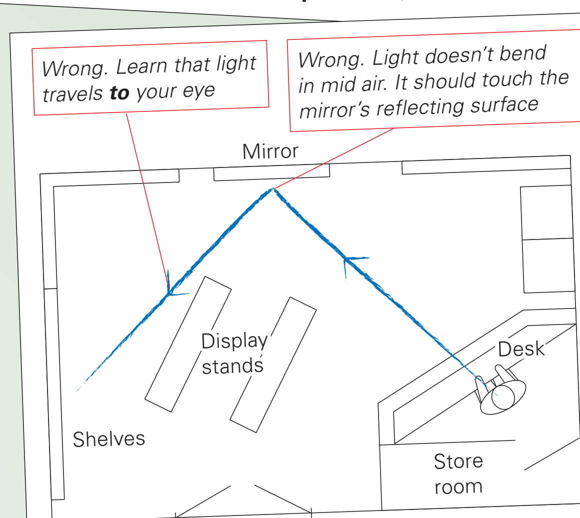


Figure 3 *Errors on a diagram*

Q Draw the path taken by light that enables the shop owner to see the shelves in the mirror.

Lastly, lots of students contradict themselves:

Q How will the changing wolf population affect the number of reindeer in the tundra region?

A *At first the wolves will eat the reindeer so their numbers will go up, but then there will not be enough food, so the reindeer will go up.*

Simply rephrasing the question and not adding anything yourself is not an answer.

The reindeer numbers are going up when the wolves eat them and when they are not eating them. Both cannot be right.

Go back over your last test paper and count how many marks you threw away. You could improve by a whole grade simply avoiding throwing marks away.

__Jane Taylor__ teaches biology and is an editor of CATALYST.

Twenty-first century plant hunter

Dan Luscombe is an assistant curator at Bedgebury National Pinetum, which has the largest collection of conifers on one site in the world. Part of Dan's job is to find new species to add to the collection.

Bedgebury Pinetum

Above: *Dan with the only parasitic conifer in the world,* Parasitaxus ustus, *in New Caledonia. It grows on the roots of another conifer*

Dan Luscombe left school after taking GCSEs, unsure about what he wanted to do. He joined a Youth Training Scheme and had a spell of work experience in a record shop. One of the training scheme's advisers then suggested the National Trust Careership scheme. This is a practical 3-year training programme for gardeners and countryside wardens.

Dan joined the scheme, studying part-time at Cannington College in Somerset while working as a gardener at a National Trust property. He became keenly interested in plants but was not sure that he wanted to continue as a gardener.

For a year or two Dan earned a living doing various jobs but eventually he took an access course in the humanities which would normally lead on to a degree. However at this point he decided to take up horticulture again. He enrolled on an HND at Bicton College in east Devon and it was here that his enthusiasm for conifers began to grow. In September 2000, directly after leaving Bicton, he gained a 1-year studentship and then a permanent job at Bedgebury.

• To find out about the National Trust Careership scheme visit: http://www.nationaltrust.org.uk/learningand discovery/learning/training/index.htm

Expeditions

Dan's first trip took him to New Zealand where he visited both the North and South Islands. On this expedition he was following in the footsteps of the famous eighteenth-century collectors Captain Cook and Sir Joseph Banks.

Even in remote parts of New Zealand the flora are quite well described. But this does not mean the plants are easy to find! Dan explained:

> Because our climate is generally colder than New Zealand the seed I collected had to come from trees that were already growing in the coldest parts of the islands, usually up in the mountains. That way they would have a chance of withstanding our cold winter frosts.

Dan compared his search with being asked to find a specific orchid in England and simply being given a map of the country. He said 'I did, however, have help from the rangers in the National Parks who were able to give me directions for finding particular conifer species in the mountains.'

Table 1 *Dan's expeditions*

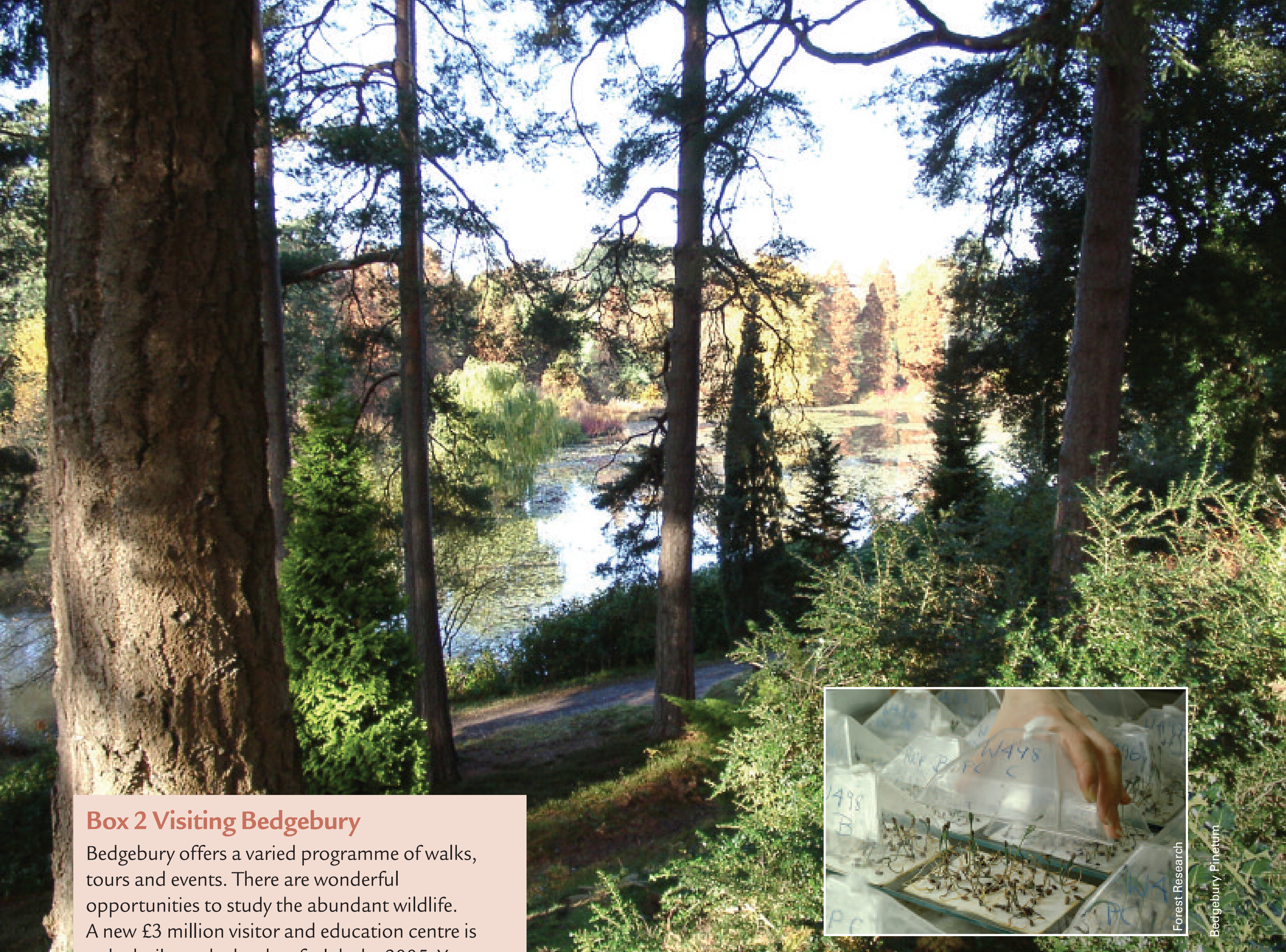
New Zealand and New Caledonia	March 2002
North Queensland, Australia (tropical rainforest)	April 2003
South Africa	October 2003
Melbourne and Tasmania, Australia	April–May 2004

Box 1 Plants on the move

Many eighteenth- and nineteenth-century plant hunters were intrepid people, enduring great hardships to find new plants. There were few restrictions on gathering and transporting plant material and some of their activities caused damage to plants and natural habitats.

In the second half of the twentieth century people became more concerned about conservation. Collecting is now strictly controlled and plant collectors have to apply in advance for permits from the government of the country they wish to visit. Things like indiscriminate bulb collecting from the wild are banned. Dan mainly gathers seeds, although he has sometimes brought back dried specimens for herbariums. Collecting only seed also reduces the risk of unwittingly transferring plant diseases around the world.

A pinetum is a collection of conifers or cone-bearing trees.



Above: *Bedgebury in autumn* **Inset:** *Germinating seeds at Forest Research*

Box 2 Visiting Bedgebury

Bedgebury offers a varied programme of walks, tours and events. There are wonderful opportunities to study the abundant wildlife. A new £3 million visitor and education centre is to be built on the banks of a lake by 2005. You can find information about visiting Bedgebury on http://www.bedgeburypinetum.org.uk

Bedgebury Pinetum has now merged with Westonbirt Arboretum in Gloucestershire and they will in future be known as The National Arboretum.

I was also given the wonderful opportunity to study the unique flora on the island of New Caledonia, a place that could be described as the floral equivalent of the Galapagos Islands. There are 43 species of conifers (more species than in the whole of Europe) in an area the same size as Wales. Many of these are threatened with extinction in their native habitats.

During the trip Dan met with other botanical and conifer experts from around the world at the Araucariaceae Symposium, which provided an opportunity to bring together all the scientific work done on the monkey puzzle tree *Araucaria muelleri* for the first time.

Germinating the seeds

The cost of Dan's trips makes the seeds he brings home very valuable. They are sent to the Silviculture and Seed Research Branch of Forest Research at Alice Holt Lodge near Farnham. Here the germination facilities are excellent. They include X-ray equipment to check the condition of the embryo within the seed. When the seedlings are large enough they are transferred to the nursery at Bedgebury where they are grown on until they are well enough developed to be planted in the collection or transferred to other botanical gardens.

At the pinetum

Bedgebury National Pinetum is in the High Weald of Kent. It has valleys with streams, marshy land and drier ridges. Dan is responsible for planting new trees in the collection and has to decide where they are likely to do well. The experience he gains on expeditions is very useful here. Some new plants come from botanical gardens such as Kew and Edinburgh. Planting and keeping records is part of his everyday job. Besides his work with the collection Dan sometimes acts as a guide to the public, leading visitors on walks through the pinetum to discover the trees.

Janet Taylor *is a science teacher and has contributed to many websites and textbooks.*

A recent book, *The Plant Hunters: Two Hundred Years of Discovery and Adventure Around the World* by Toby Musgrave, Chris Gardner and Will Musgrave, tells the stories of earlier expeditions. It has beautiful illustrations.

- **If you are interested in nature and working outdoors find out about courses in agriculture, horticulture and forestry at local colleges. Log on to http://agrifor.ac.uk and search for these subjects along with 'education UK'.**

David Moore

Nitrogen notes

Above: *The orange-red, blue-green, blue-violet and deep violet shades of the aurora borealis are created as high-energy radiation from the Sun interacts with nitrogen molecules in the upper atmosphere*

Please note that the 'web pages' in this article do not exist on the internet.

GCSE key words
Nitrogen
Fertiliser
Fixation
Radioactivity

Nitrogen is all around us. What do we use nitrogen and its compounds for? Read the 'web pages' and find out!

Colourless, odourless, non-toxic and inert – nitrogen gas is everywhere and we couldn't live without it. Nitrogen makes up 78% of the Earth's atmosphere by volume, equivalent to approximately 4×10^{15} tonnes. It dilutes the oxygen in the atmosphere and therefore slows down respiration in plants and animals. It also slows down burning – fires would be much more fearsome if unreactive nitrogen were not present in the air to slow down the combustion oxidation reactions.

Nitrogen is in Group 5 of the periodic table. It exists in the gas form as diatomic molecules, N_2, bound by a strong covalent triple bond. It is the strength of this bond which accounts for nitrogen's relative stability. A lot of energy, 946 kJ/mol, is needed in order to break the bond and allow the molecule to react. Although nitrogen can be made to react with virtually every other element in the periodic table, high temperatures or a catalyst are usually needed. (Compare the bond strength of nitrogen with that of hydrogen, H_2 454 kJ/mol, or fluorine, F_2 159 kJ/mol.)

In the Earth's crust nitrogen is the 33rd most abundant element, mainly in the form of the minerals saltpetre (KNO_3) and Chile saltpetre ($NaNO_3$). Both are found throughout the world, often in arid areas, or in caverns and caves.

Nitrogen gas was first isolated in 1772 by a British doctor, Daniel Rutherford, although Cavendish, Priestley and Scheele were studying 'burnt or dephlogisticated air' at about the same time. The French chemist Lavoisier proposed that it was an element and named it 'azote' (the lazy one). The importance of nitrogen-containing compounds in the soil was proposed by Justus von Liebig in 1862, at a time when most scientists believed that plants obtained nitrogen directly from the air.

Nitrogen is extracted from the air by the fractional distillation of liquid air. Air is cooled until it liquefies. On warming slightly, nitrogen boils off first at –196 °C, before oxygen at –183 °C.

Compounds of nitrogen are used in fertilisers, dyes, anaesthetics, rocket fuel and explosives.

http://www.liquidnitrogen.catalyst.co.uk

Liquid nitrogen

Liquid nitrogen is used:

- as a coolant — for example in the superconductor industry
- for preserving living cells and tissues, including eggs and sperm for in vitro fertilisation or artificial insemination
- for freezing food; for cooling the container compartments of transport lorries; and even for freeze-branding cattle
- to provide an inert atmosphere: preventing fires when flushing oil pipelines and tanks; preventing oxidation during welding processes; making plate glass; manufacturing silicon chips; in crisp packets to help maintain 'freshness' by excluding oxygen
- in the process of annealing steel, in which heating makes the steel harder

Right: *A researcher removing frozen biological samples from storage in liquid nitrogen*

Tek Image/SPL

http://www.nitrogenfixation.catalyst.co.uk

Nitrogen fixation

Nitrogen **fixation** is the process whereby nitrogen from the air is converted into nitrogen compounds. About 150 million tonnes of nitrogen a year are fixed by bacteria and lightning, and about the same amount by industry.

- Nodules in the roots of **leguminous plants** such as peas, beans and clover contain bacteria called *Rhizobium*. These bacteria combine organic compounds from the plant with nitrogen from the air to produce nitrogen-containing compounds, such as amino acids, proteins and nucleic acids, that the plant needs.
- The high temperature of **lightning** allows nitrogen and oxygen in the air to combine and react, eventually forming nitrogen dioxide. This dissolves in rainwater and is washed into the soil, as a soluble form of nitrogen which plants can use.
- Whenever a crop is harvested, nitrogen-containing compounds are removed from the soil. To replace them, nitrogen-containing **fertilisers** need to be applied to the soil.

Biophoto Associates/SPL

Left: *Red nitrogen-fixing nodules on the roots of a black alder tree. They contain bacteria which take nitrogen from the air*

- **What other elements are important in fertilisers?**

- A common starting material for making fertilisers is ammonia, NH_3, which is made by the Haber Process. A mixture of nitrogen (from the air) and hydrogen (either from the petrochemical industry, or by reacting steam with natural gas) is passed over an iron-based catalyst at a temperature of about 450°C at 250 times atmospheric pressure. The gases react to form ammonia in a 17% yield.
- The ammonia can be converted to nitric acid by reacting it with oxygen and water using a catalyst (the Ostwald Process). When the nitric acid is reacted with more ammonia, it makes ammonium nitrate — a widely-used fertiliser commonly known as Nitram.

Recent research has shown that the quantity of nitrogen-containing fertilisers applied to crops between 1980 and 1990 was more than that applied over all previously recorded history. Excessive use of nitrogenous fertiliser may cause problems such as algal blooms in rivers — excess nitrates end up in soil water, groundwater and rivers, and this encourages the rapid growth of algae.

Pekka Parvainen/SPL

http://www.nitrogenatmosphere.catalyst.co.uk

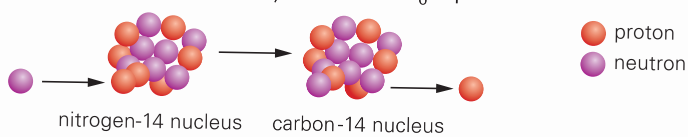

Smog over Los Angeles

David R. Frazier/SPL

Nitrogen in the atmosphere

Gases in the upper atmosphere are continually bombarded by cosmic rays. The energy of these knocks neutrons from some of the atoms. These neutrons can then knock a proton from the nucleus of some nitrogen atoms. In this way, carbon-14, which is radioactive, is created.

$$^{14}N_7 + n \longrightarrow {}^{14}C_6 + p$$



All living material contains a fixed proportion of this radioactive carbon. When the plant or animal dies, the radioactive carbon present gradually decays, with a half-life of about 5800 years, and is not replaced. The level of radioactive carbon remaining is therefore a measure of the age of the material, and this is the basis for carbon dating.

Nitrogen oxides in the atmosphere can lead to pollution. Smogs are produced when there is a build up of oxides of nitrogen (commonly known as NO_x) in the air in cities. The oxides are mainly produced from the reaction of nitrogen gas and oxygen gas being sparked together electrically within the confines of internal combustion engines.

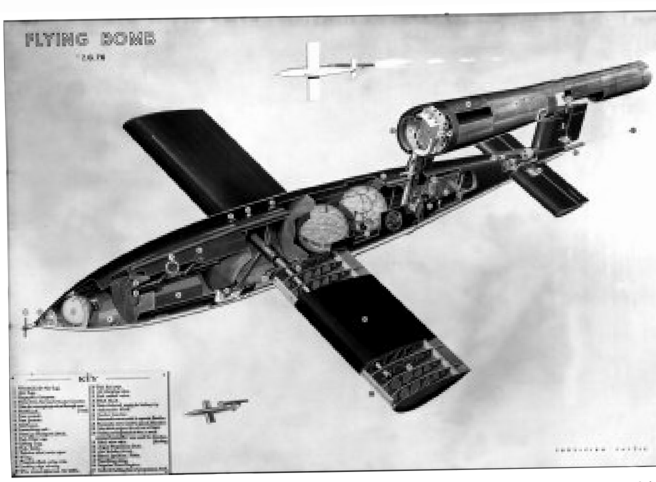
The bigger the value of the bond strength, the stronger the bond, and the more energy is needed to break it. So nitrogen with a strong triple bond is an unreactive gas.

http://www.nitrogencompounds.catalyst.co.uk

Nitrogen compounds

Some nitrogen compounds:

- **Urea**, $CO(NH_2)_2$, can be made from the reaction of ammonia with carbon dioxide under pressure. It is found in the urine of mammals and is widely used in fertilisers as a source of nitrogen.
- **Azo-compounds** are brightly coloured substances often used as dyes. They contain the –N=N– unit.
- Organic substances which contain the group $-NH_2$ are called **amines**. Two of these, found in rotting meat, are called putrescene, $H_2N(CH_2)_4NH_2$, and cadaverine, $H_2N(CH_2)_5NH_2$, and have appropriately awful smells!
- **Nitrous oxide**, N_2O, often called 'laughing gas', is a colourless gas which, mixed with oxygen, is used as an anaesthetic in dentistry and minor surgery.
- **Hydrazine**, N_2H_4, and compounds derived from it have found some use in the space programme as rocket fuels. The 'flying bombs' and V-2 rockets of the Second World War were powered by hydrazine.
- TNT, **trinitrotoluene**, is an explosive nitrogen compound.



Cut-away diagram of a flying bomb used in the Second World War

Topfoto

- Draw a 'dot and cross' diagram to show the bonding in a nitrogen molecule.

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

Inherited diseases

Nigel Collins

Each of us is the product of our genes, inherited from our parents, interacting with our environment. This environment is not just the physical one but also the social one, of our interactions with other people. How can the unique set of chromosomes and genes inherited from our parents cause problems?

Before considering the inherited diseases described in Boxes 1–3 overleaf, let's look at the basics of genetics. Inheritance can be considered either at the chromosome level or at the level of the DNA in the chromosomes, from which genes are made. Most people have 46 chromosomes, in 22 pairs plus either a pair of X chromosomes or a single X chromosome and a single Y chromosome.

Cell division

Throughout our lives these chromosomes are copied each time a cell divides to repair damage or add growth. Each new cell ends up with the full 46 chromosomes. This type of cell division is called **mitosis**.

Another type of cell division, called **meiosis**, occurs when sex cells are formed. In this type of cell division, occurring inside the ovaries or testes, the pairs of chromosomes split up and go separate ways into the sex cells produced. The pairs separate at random (Figure 1), so each sex cell contains a unique set of chromosomes and genes — a mixture of those the person originally received from each of their parents. Particular genes are positioned on particular chromosomes, and for convenience we number the chromosomes 1–22.

Things can go wrong during cell division. This may happen because of some fault in the genes carried on chromosomes, because of faulty copying, or it may be a chance event as chromosomes move around during cell division. Fortunately we have repair enzymes that can correct many faults. Other faults may occur when bits of genes (or sections of whole chromosomes) get broken off and attach themselves to other chromosomes. Sometimes pairs of chromosomes don't separate so we get cells with three copies of a chromosome or missing chromosomes.

The molecular level

Genes are made from DNA, which contains coded instructions for making proteins. Proteins are made out of long chains of amino acids, in some cases more than 100. Each protein contains a particular selection of amino acids from the 20 or so commonly available,

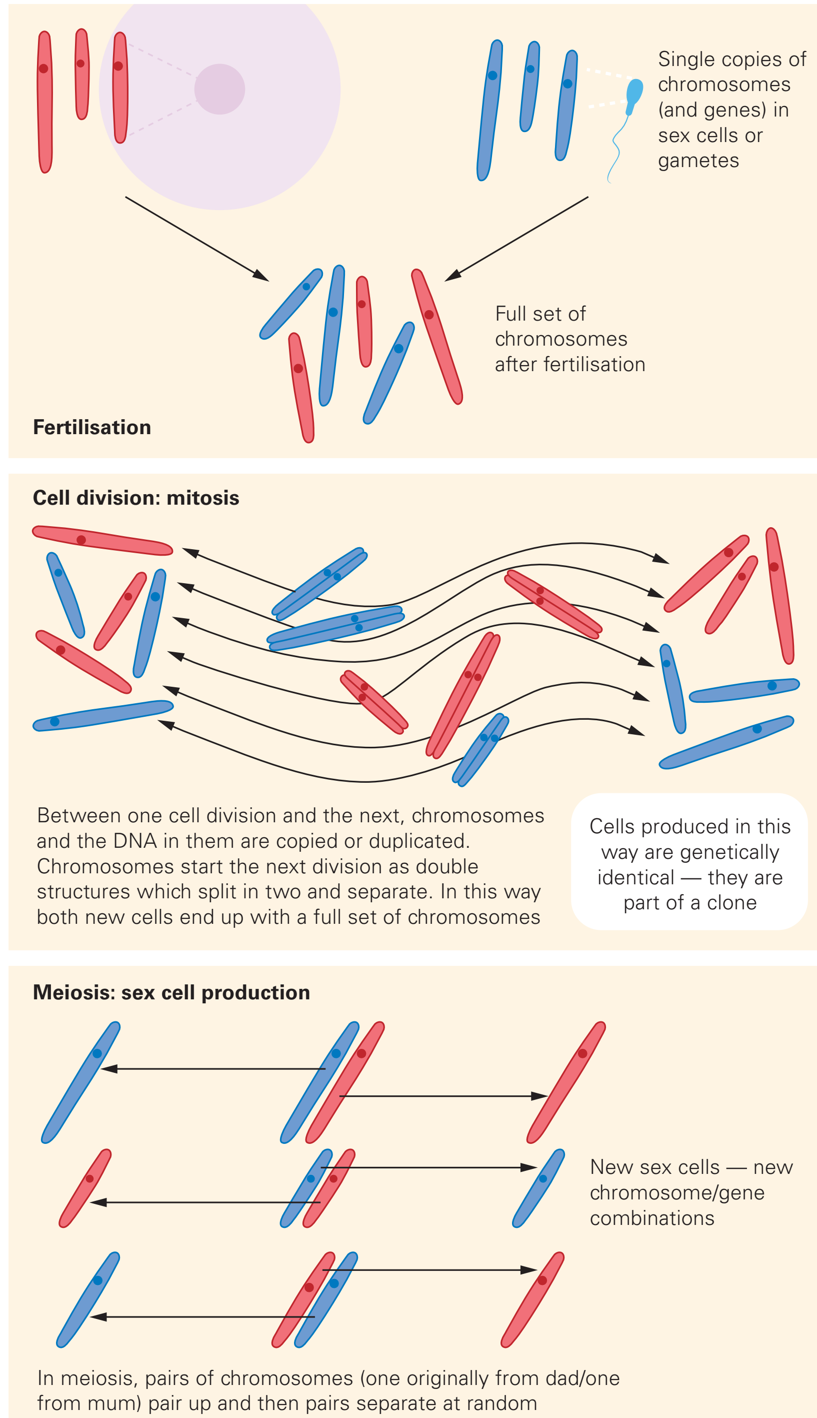
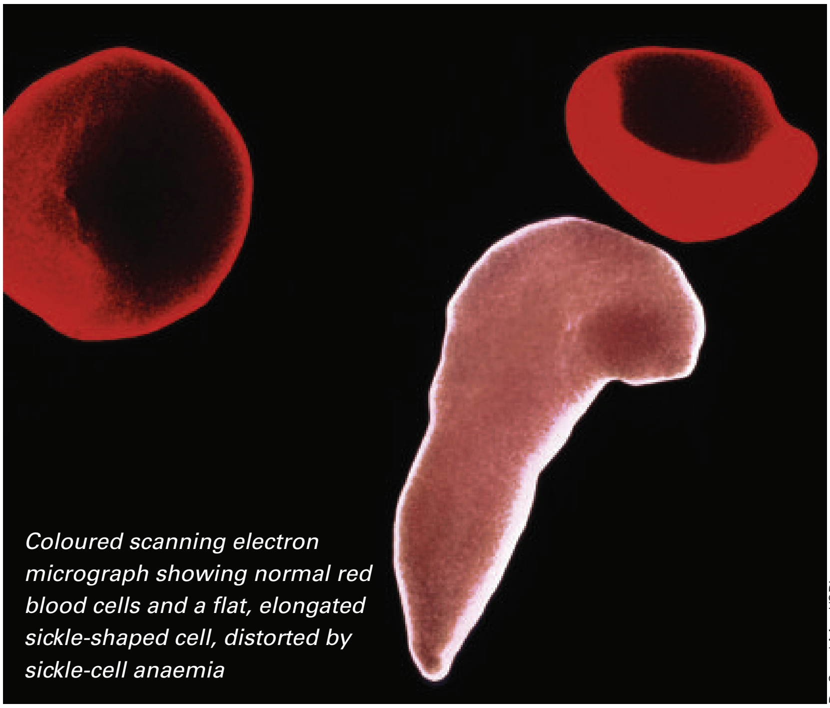


Figure 1 *Fertilisation, mitosis, meiosis and parental chromosomes*

Table 1 *Frequency of various inherited conditions*

Condition	Frequency per 10 000 births
Sickle-cell anaemia	1
Cystic fibrosis	4
Huntington's disease	5

GCSE key words
DNA
Chromosome
Sickle-cell anaemia
Mitosis
Meiosis
Cystic fibrosis



Coloured scanning electron micrograph showing normal red blood cells and a flat, elongated sickle-shaped cell, distorted by sickle-cell anaemia

Dr Gopal Murti/SPL

Box 1 Sickle-cell anaemia

People with sickle-cell anaemia have sickle haemoglobin (HbS) which is different from normal haemoglobin (HbA). Normal red blood cells can bend and flex easily. When sickle haemoglobin gives up its oxygen to the tissues (CATALYST Vol. 15, No. 1, page 9) the haemoglobin sticks together to form long rods inside the red blood cells. This makes the cells rigid and sickle-shaped. Because of their shape, sickled red blood cells can't squeeze through small blood capillaries. As a result the capillaries get blocked. This stops the oxygen from getting through to where it is needed and can lead to severe pain and damage to organs.

The mutation causing sickle-cell anaemia involves a change in one base in a triplet in a gene. As a result the amino acid valine is built into a β chain, instead of glutamic acid.

You can find out more about sickle cell at http://www.sicklecellsociety.org or at http://www.bbc.co.uk/health/awareness/sickle.shtml

arranged in a specific sequence. DNA contains a linear code for putting the right amino acids together in the right sequence. The unique sequence of amino acids in a protein helps to determine how the protein wraps itself up into a particular working shape – perhaps as an enzyme or a hormone, or perhaps a contractile muscle protein or the tough protein in fingernails.

The bases in DNA are:
A = adenine
C = cytosine
G = guanine
T = thymine

The coded instructions in DNA involve four **bases** – A, G ,C and T for short. These bases are strung along the DNA backbone in groups of three. Each group of three bases – or **triplet** – codes for a particular amino acid. AGC is the code for one called serine, CGT for alanine, GCA for a third called arginine and so on. Using four letters, in groups of three, in any order, provides 64 possible triplet combinations. With only 20 common amino acids to code for that is more than enough.

Box 2 Cystic fibrosis

Cystic fibrosis (CF) is the UK's most common life-threatening inherited disease and affects more than 7500 babies, children and young adults. One in 25 people in the UK carry the CF gene, usually without knowing it. People with CF have a build-up of mucus that is much thicker than normal, mainly in the lungs and digestive tract. As a result they suffer from a constant cough, an excessive appetite but failure to gain weight, bowel problems and repeated lung infections.

Some of these symptoms can be treated. Regular physiotherapy – tapping the chest – helps to loosen the mucus from the lungs. Enzymes taken with meals help with food digestion and antibiotics can protect against infections. At present there is no cure for CF, but the gene involved has been identified and doctors and scientists are working to find ways of repairing or replacing faulty alleles.

The gene codes for an important protein found in the cell membrane that affects the movement of salt into and out of cells. If too much salt is inside cells, water is pulled back from the mucus by osmosis, making the mucus more sticky. A genetic test can identify family members who may be unaffected carriers of the condition.

You can find out more about cystic fibrosis at http://www.cftrust.org.uk/index.jsp Click on *Living with cystic fibrosis*.

To look at an example, altogether there are 574 triplets which code for the 574 amino acids needed to make the complex protein haemoglobin. Each haemoglobin molecule contains two types of amino acid chains – α and β. The particular gene for making the α chain (146 amino acids) is on chromosome 11 and that for the β chain (141 amino acids) is on chromosome 16.

Mutation

Mutation involves a change in the inherited material . It applies to changes in both chromosomes and DNA.

Chromosome mutation

Some babies end up with an extra copy of a whole chromosome when chromosomes move during meiosis. This might be an extra chromosome 21, in which case the baby will show Down's syndrome. If it is an extra X chromosome the person will be XXY which means that they have Klinefelter's syndrome.

Sometimes different changes in the same chromosome have much the same effect. Where a small section of chromosome 15 is lost, or there is an extra chromosome 15, or bits of chromosome 15 have been switched and found on other chromosomes, the result is a condition known as Prader-Willi syndrome. Another condition, called cri-du-chat, involves loss of part of chromosome 5.

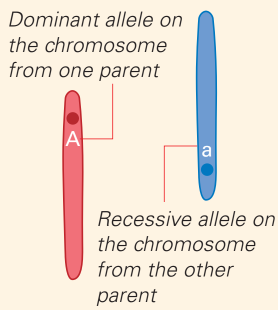
Box 3 Huntington's disease

In this disease the mutation has occurred in a gene on chromosome 4. This gene produces a protein called **huntingtin**. In some way — which is not yet understood — the faulty version of the huntingtin protein leads to nerve-cell damage in areas of the brain. This causes gradual physical, mental and emotional changes, which become more acute as time goes on. The actual cause of death is usually a secondary illness, such as pneumonia.

The symptoms of Huntington's disease tend to develop when people are between 30 and 50 years old, although they can start much earlier or much later.

You can find out more about Huntington's disease at http://www.hda.org.uk Click on *What is Huntington's disease* at the top of the page.

Genes come in different versions or **alleles**. **Dominant** alleles always result in a characteristic appearing while **recessive** alleles do not have an effect unless there is also recessive allele on the other chromosome (i.e. the trait is inherited from both parents).



A recessive disease

During meiosis the pairs of chromosomes separate into two sex cells, which then include either: A or: a

If two people are both carrying a recessive allele on one chromosome (e.g. the allele for cystic fibrosis or sickle-cell anaemia) the probability of what their offspring will inherit can be worked out using a simple table:

		Sperm	
		A or	a
Egg	A or	AA Normal	Aa Carrier for CF or sickle-cell
	a	Aa Carrier for CF or sickle-cell	aa Suffers CF or sickle-cell

- Draw a similar diagram for someone who is a carrier having children with someone who is not a carrier.

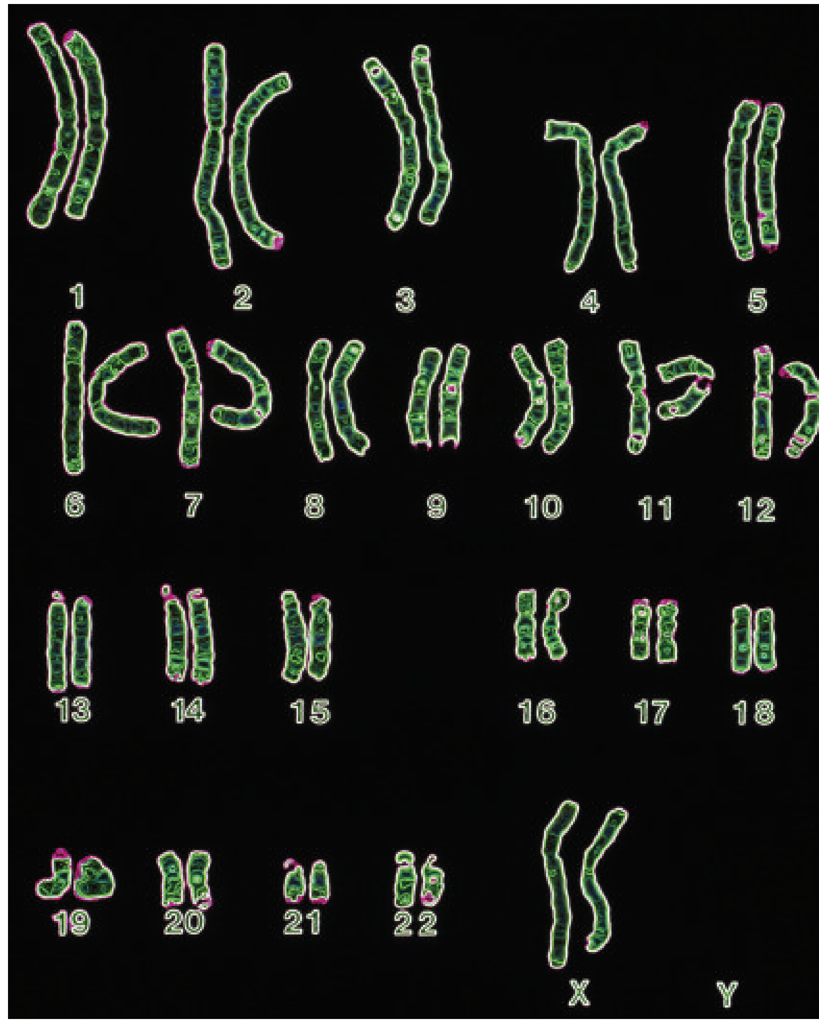
A dominant disease

If the disease is carried on a dominant allele, e.g. Huntington's disease, it is possible to be either AA or Aa and still suffer from it. If a person is Aa and the other parent is aa what is the chance of a child having the disease?

Figure 2 *How diseases are inherited*

DNA mutation

A mistake in the sequence of bases in DNA — a change in the **coding sequence** — will often lead to a protein being assembled incorrectly. The wrong amino acid may be added to the protein at one point or an amino acid might be missed out. For example, a single base change in the gene for haemoglobin, involving one change to the triplet coding for one particular amino acid, leads to a different amino acid being incorporated instead. As a result the mutant haemoglobin cannot wrap itself up into the proper working shape. This causes the condition sickle-cell anaemia (Box 1).



Clinical Cryogenetics/Addenbrookes/SPL

An enhanced light micrograph of a normal human female karyotype — the full complement of chromosomes in a woman

Inheritance of disease

Some features of an organism involve many genes, as well as complex interactions with the environment. However, a few characteristics, including some inherited diseases, are controlled by a single gene. Let's consider sickle-cell anaemia first. It turns out that the mutated version of the gene — the mutated allele — is **recessive**. In other words a person needs to inherit this particular allele from *both* parents if the disease is to show up (see Figure 2). Cystic fibrosis is another condition that is caused by to the action of a single gene (Box 2).

Another inherited disease that you may be aware of is Huntington's disease (Box 3). In contrast to sickle-cell anaemia and cystic fibrosis, the faulty allele leading to this disease is **dominant**.

- **You can find out about genetic disorders at the website of the Genetic Interest Group: http://www.gig.org.uk Click on *Education* for general information or on *membership of over 130 charities* in the text for links to other websites.**

- **Find out about Prader-Willi syndrome or cri-du-chat using the Genetic Interest Group website.**

Your future

Meteorology

The first weather broadcast on radio was made in 1922. Captions were shown on the television from 1936, and the first live television forecasts started in 1954.

To find out more about careers with the Met Office, go to http://www.metoffice.com/corporate/recruitment/index.html

The Royal Meteorological Society is at http://www.royal-met-soc.org.uk

Box 1 EMARC

The Environment Monitoring and Response Centre in Exeter is one of the Met Office services. It provides information and advice to anyone affected by environmental changes. One of its tasks is to help the government decide when cold weather payments should be issued to pensioners in the winter. EMARC also:

- provides a storm warning service
- advises when abnormally high tides are likely to breach sea defences
- monitors and runs computer models of water and air pollution to, for example, predict the path of an oil slick at sea or the direction of spread of air pollution from a fire, chemical leak or radioactive discharge
- monitors volcanic eruptions, for example so that aircraft can be diverted to avoid volcanic ash in the atmosphere, a great danger to jet engines
- offers advice in exceptional circumstances. During the recent foot-and-mouth outbreak EMARC was able to advise on the likely spread of the virus around the country using advanced modelling techniques

We've all seen the weather man or woman on the telly and weather reports in the newspapers — but how do you become someone who forecasts the weather?

In Britain the major source of information about the country's weather is the Meteorological or Met Office (**http://www.metoffice.com**). The Met Office has been supplying information about the weather and the natural environment for more than 140 years. It was originally formed to provide meteorological and sea current information to mariners.

The Met Office headquarters is in Exeter, along with its major research facilities, but there are over 900 forecasters and support staff at 80 locations around the UK. There is a network of observing sites, many of which are becoming automated. Two networks of forecasting offices are maintained — the first specialising in information for the armed forces, and the second focused on services to the media, industry and commerce.

Box 2 Training as a meteorologist

Steven Hadley is a meteorologist who is training to present the weather forecast on television. Here he tells his story:

It started in 1992 on holiday in Florida. Hurricane Andrew also paid a visit to southern Florida shortly after we arrived. Although we were safe, miles from the eye of the storm, seeing the destruction it caused really opened my eyes to what the weather can do.

Back home I saw my careers officer in the school library. She taught me how to pronounce 'meteorologist', and told me I'd need good A-levels in physics and maths to become one. So I grafted hard for my A-levels, and went on to a meteorology degree course at the University of Reading.

It was quite intensive but really interesting. For 3 years I studied a split of physics, maths and meteorology, and even opted to learn basic Spanish in the second year. You can find out more about my course at ***http://www.met.reading.ac.uk***

I decided to apply for the Met Office Forecaster Training Programme, and with a good degree behind me, I got in. I spent 6 months training at the Met Office College, which is now based in Exeter. Then to Newquay, Cornwall, where I worked on an RAF base for 6 months. My duties involved briefing trainee helicopter crew on current and forecast weather conditions around southwest England and Wales. I also prepared forecasts for places much further afield, depending on what the RAF was doing at the time.

Steven Hadley/Met Office

Steven Hadley practising presenting the weather forecast in the television studio. The blue background allows the graphics to be added behind the weather forecaster when you see the broadcast — the finished product is visible on the monitor to Steven's left

After qualifying I worked in London for 3 years with the Met Office. The forecasts I prepared were generally for energy companies, the Environment Agency, and even the Wimbledon tennis tournament.

Nowadays I'm working in Leeds, where I create weather graphics for television broadcasts on a daily basis and advise weather presenters on the forecast, as well as training to have a go in front the cameras myself!

Careers at the Met Office

There is a wide variety of jobs in meteorology. Scientists research weather and environmental information and deliver it to the Met Office's customers. Work might be based on:

- improving the numerical models used to forecast the weather
- investigating climate change and how this is influenced by the oceans
- developing communications, remote sensing and computing resources

If you are also good at computing then there is the opportunity to work on internet and extranet development as well as developing software.

In order to obtain a job at the Met Office you need five good GCSE grades, or equivalent, one of which must be in English language; good A-levels in maths and/or physics; and a degree in mathematics, the physical sciences, computer science or meteorology. Most importantly you must have an interest in meteorology. Training is given to all new staff and experienced research meteorologists can earn £33 000.

David Moore *teaches at St Edward's School and is an editor of* C*ATALYST*.

Topfoto

A winter storm floods Marine Drive in Scarborough. It is the responsibility of the Met Office to predict extreme events like this

Reviews

Watching wildlife

Corel

Have you felt inspired by Bill Oddie to watch warblers or swim with seals? Many animals move away when people are about. You stand a better chance of seeing them in places where experts have set up facilities or can guide you to see the animals in their natural habitat. Last summer I sampled three wildlife-watching trips on the west coast of Scotland, home to a quarter of the world's population of grey seals.

Box 1 Prices and websites

For a family of four:

Otter haven
free

Calum's Seal Trips
£20, no see-no fee
(http://www.calums-sealtrips.com)

Seaprobe Atlantis
£49
(http://www.seaprobeatlantis.com)

Otter haven

First I visited a wild otter haven at Kylerhea on the Sound of Sleat. An easy 800 metres down a track leads you to a hide with identification guides, binoculars and a sightings log. In 20 minutes we spotted seals, oyster-catchers, shags and other seabirds but, like the other visitors that day, no otters. Just a few days earlier Spanish tourists had seen five!

Seals in Loch Carron

On the mainland Calum's Seal Trips took us from Plockton into Loch Carron to observe seals. Around 300 harbour seals live in this loch and many were dozing in the sunshine on the offshore rocks. They are used to boats drifting close. The loch waters were still enough for us to spot orange starfish the size of dinner plates on the bottom, as well as crabs, sea urchins and great scallops. Commercial scallop and prawn fishing also takes place in the loch, with little conflict between fishermen and seals.

Underwater viewing

Seaprobe Atlantis is an unusual vessel — it has an underwater viewing chamber. Twelve of us cruised Loch Alsh, a marine conservation area. We had fantastic underwater views of shoals of moon jellyfish and occasional lion's mane jellyfish swimming by, as well as the sea life around a shipwreck and on the bottom of the sea loch. Above the water we saw seals, of course, a salmon farm and also close-up views of sea birds such as guillemots and razorbills. Sadly no otters again. And no luck with underwater views of the puffins or porpoises seen earlier that day.

Worthwhile? Yes, all of them.

Jane Taylor

Puzzle

Whatever the weather

Corel

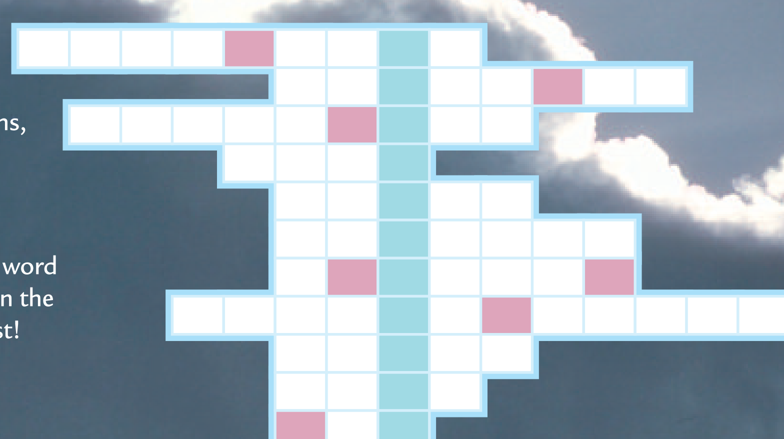
Fill in the grid on the right using words from the following list:

cloud, cumulonimbus, cirrus, stratus, high, low, pressure, barometer, thermometer, isobars, isotherms, front, rain, thunder, wind, hail, storm, drought, fog, mist, haze, meteorology, wet, dry

Some will not be needed!

All the horizontal words interlink to form one vertical word (shaded green) also on the list. Rearrange the letters in the red tinted boxes to form yet another word from the list!

Word from rearranged letters in red boxes:



(Answers on page 21)

David Sang

A view of London at night from the International Space Station, orbiting at a height of 360 km. You may be able to spot two large parks, just west of the city centre, and the M25 orbital motorway to the south. Heathrow and Gatwick airports are also brightly lit

NASA/SPL

Seeing stars

GCSE key words
Electromagnetic spectrum
Light pollution
Reflection
Refraction

Go outside on a dark night, and look up at the sky. What do you see? The Moon, stars, the odd planet? Or a dim light across the sky, making it difficult to discern anything of interest? Astronomers, amateur and professional, aren't happy about this. It's light pollution, and it makes it difficult for them to observe the night sky. But you don't have to be an astronomer to be affected.

'Over great cities, towns and even small villages, light pollution robs us, in the last millisecond of its journey, of light which may have travelled for hundreds, thousands or even millions of years to reach our planet.' Bob Mizon of the Campaign for Dark Skies.

You may have been on holiday to a place where the night sky is clear. The sight of thousands of stars can be a breathtaking experience. In such a place you may see the Milky Way, the broad band of stars which is our galaxy, or a comet.

In the UK such experiences are increasingly rare. Light pollution is caused by too much light, from street lighting and other sources, illuminating the night sky. Any dust or water droplets in the atmosphere reflect light back down to us, and this makes it harder to see the stars. Towns are much worse for light pollution than rural areas, but there is growing concern that the countryside is becoming more urbanised, with more lighting. The difference between town and country is decreasing.

Stars are faint objects. Bright moonlight is about one-millionth of the brightness of a summer's day, and stars are much fainter than that. To see faint objects, your eyes need to be accustomed to the dark. It takes a few seconds for the pupils to widen, to let in maximum light on a dark night. After a few minutes, the light-sensitive chemicals in the rod cells in your retina reach maximum sensitivity. But if the stars are lost in a faint haze of light pollution, you simply won't see them.

Floodlighting of sports grounds is one source of light pollution

Bob Mizon/CfDS


Frank Zullo/SPL

Above: *These street lights minimise light pollution. The mist in the air shows how all the light is directed downwards*

Astronomers up in arms

Astronomers are unhappy about light pollution, to say the least. It can interfere with their own observations, if they are looking at starlight in the visible part of the electromagnetic spectrum. In addition, it makes it difficult for amateur astronomers, most of whom live in towns, to make any observations at all.

This isn't just spoiling someone's hobby — amateur astronomers have always made important contributions to the development of astronomy. Earlier this year, Jay McNeil spotted a new star in the constellation of Orion. Using his 3-inch telescope, he had noticed a rare event — the birth of a new star. Within hours, the giant UK/US Gemini telescope, in Hawaii, was observing the same event. Professional astronomers value the part played by amateurs on occasions like this, and the two communities share information freely.

Light pollution is getting worse, despite growing awareness of the problem. In an attempt to turn back the tide, the British Astronomical Association has set up the Campaign for Dark Skies. Its head, Bob Mizon, explains why he thinks it's an important campaign:

> The night sky is by its very nature a 'site of special scientific interest' and an 'area of outstanding natural beauty'. It has been quietly and gradually taken away, over the last 50 years, from those dwelling in towns and urban fringe areas, throughout the developed world. Sky-glow and obtrusive wasted upward lighting also detract from the character of the night-time scene and are detrimental to local amenity, not just for astronomers, but for the public in general.

The campaign doesn't want to turn off all street-lights, but it does want to see more controlled lighting, with great reductions in the wasted light which spills upwards from poorly designed fittings.

Better lighting

Most street lighting in the UK makes use of sodium lamps, in which an electric current passes through a tube containing sodium vapour. The sodium atoms gain energy from the current and glow when they release it as light.

Low-pressure sodium lamps glow orange, the colour you may be familiar with from flame tests. Roughly 35% of street lights are low-pressure sodium. The remainder are nearly all high-pressure sodium, which give white light. These tend to waste more energy than the low-pressure variety.

A well-designed lamp will direct its light where it is needed. This can be done in a variety of ways.

- High-pressure sodium lamps usually have a reflector above the tube, to re-direct light downwards.
- Low-pressure sodium lamps make use of 'refractor optics' — light from the tube shines through a thick glass cover which acts as a lens, concentrating the light where it is needed.

The UK Highways Agency has a 'good practice' policy on street-lighting, to encourage local authorities to use energy-efficient, environmentally-friendly lighting (Figure 1). However, lights have a long life, and badly-designed lights may be around for a long time before they are changed.

At the same time, sources of light pollution are growing. More people are fitting 'security lights', and more public buildings are being floodlit. The skies are getting lighter.

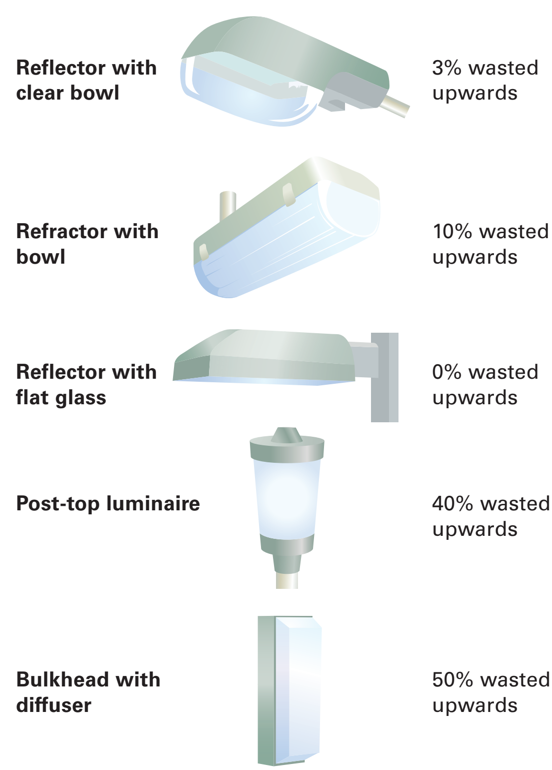


Figure 1 *Types of street light. Some waste as much as 50% of their light*

- **Try to imagine what it would be like if we lived on a planet where we could only see the Sun and Moon in the sky. Would we ever have discovered the true extent of the universe?**

- **There are many Sites of Special Scientific Interest (SSSIs) on the ground in Britain. Use a search engine to find out why a place is declared an SSSI.**

- **The first Area of Outstanding Natural Beauty was the Gower peninsula in south Wales. Where is the nearest one to your home?**

Box 1 Looking at the statistics

Case 1

Traders in Birmingham's Rag Market were worried about thefts. They installed new lighting in late 1983.

Figure 2 compares the numbers of thefts in the Rag Market with the numbers in two other markets nearby (the Open Market and the Market Hall). Unfortunately, the number of thefts in the Rag Market was already falling, so the data can't be said to show that lighting was effective.

Case 2

In Bristol, new lighting was introduced in some areas in the late 1980s. The upper line on Figure 3 shows the number of crimes on the relevant police beats over intervals of 6 months.

The control data are for other beats where no changes were made to the lighting. Can you see a pattern?

You might guess that there is a slight downward trend in the upper line, but a proper statistical analysis shows that this is insignificant. Paul Marchant says, 'The up-and-down variations are what is known as "noise". They are simply random variations from one year to the next, and don't show any convincing evidence for the effectiveness of increased street lighting in the fight against crime.'

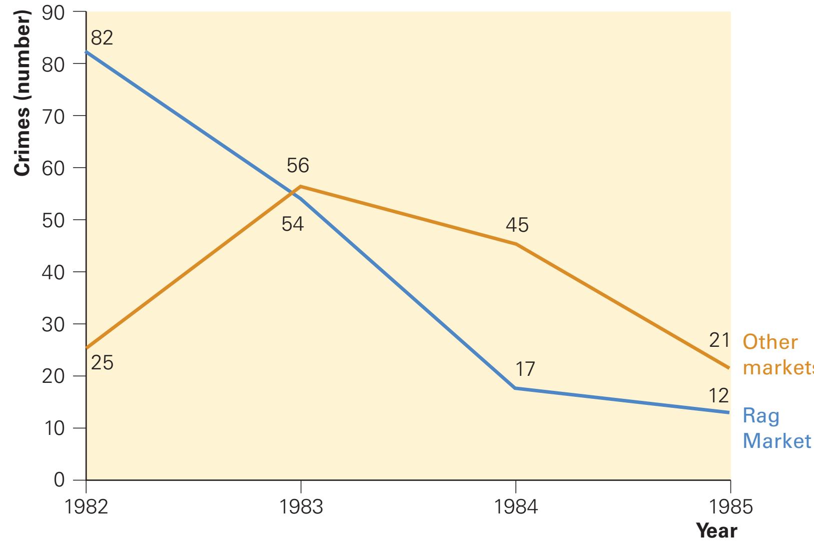


Figure 2 *Number of crimes in Birmingham markets. New lighting was introduced at Rag Market in late 1983*

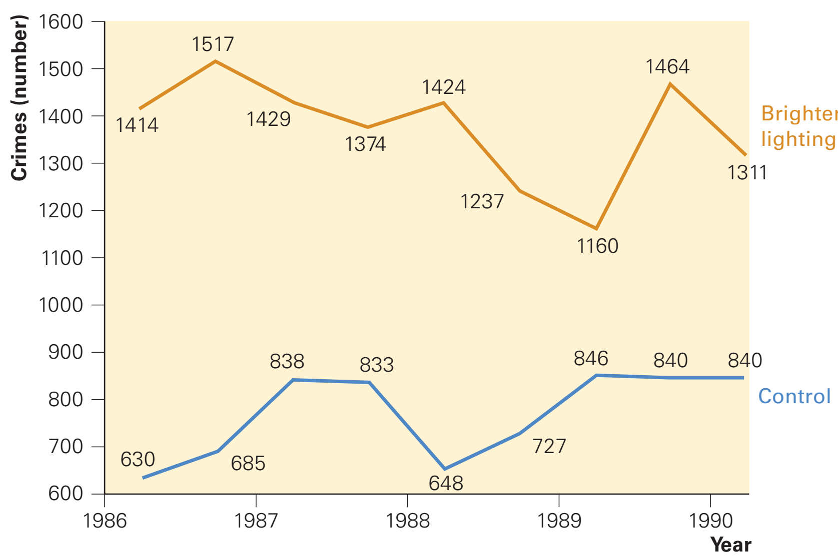


Figure 3 *Number of crimes reported (in 6-month periods). New lighting was introduced from July 1987 to March 1989*

Keeping crime at bay

People are increasingly fearful of crime. They worry that their houses may be broken into, or that they will be mugged in the street at night. So they fit exterior lights in their gardens, and local authorities increase the level of street lighting as a deterrent to crime. It seems sensible, doesn't it?

Not necessarily, according to Paul Marchant, a statistician at Leeds Metropolitan University, and an amateur astronomer:

> It may seem obvious that crime will go down with better lighting. However, we do not have the evidence to prove it.
>
> Most crimes are committed during the day. At night, burglars need light, too. In some parts of the USA, schools have turned off their lighting at night, and they get less vandalism.
>
> The light fittings which many people attach to their homes are too bright; the glare they give off makes it difficult to see what is going on in the shadows. Try replacing a 150 W lamp with a 15 W one and you'll see the difference.

Paul is not convinced by the data used to argue for more lighting (see Box 1). 'There haven't been any scientifically-designed studies into the effects of increased lighting. Meanwhile light pollution has substantial environmental consequences. If any decision is taken to increase lighting, it needs to be taken on the best possible evidence.'

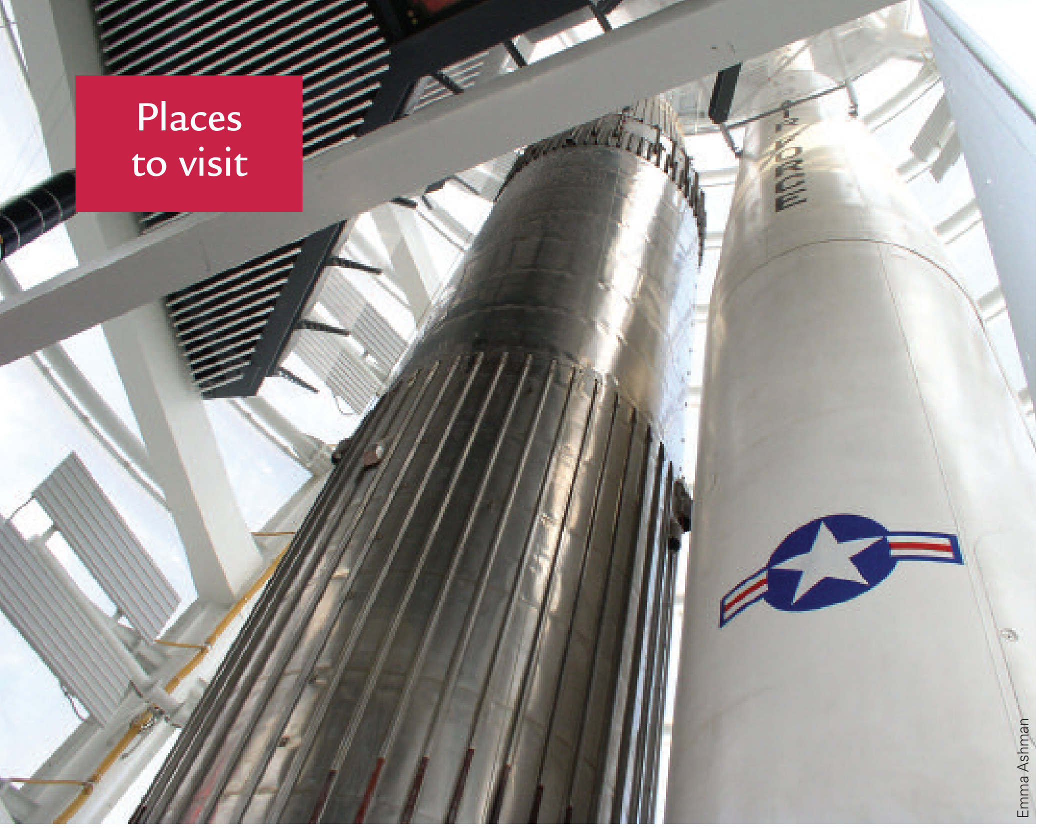
Darker nights

Astronomers make use of all regions of the electromagnetic spectrum to study the skies. They have agreements with governments not to permit the use of certain wavelengths for radio communications, so that radio telescopes don't suffer from interference. At the same time, the evidence is that light pollution has increased over the last 10 years, and our view of the stars is fading fast.

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

The Campaign for Dark Skies is run by the British Astronomical Association: http://www.dark-skies.org/main.shtm

- **The Campaign to Protect Rural England is concerned about light pollution. Go to http://www.cpre.org.uk/campaigns and click on *Light pollution* where you can download maps for your area for 1993 and 2003.**



Emma Ashman

Leicester is home to the UK's National Space Centre. It is three centres in one: a collection of interactive galleries, an education centre, and home to many of the UK's space research scientists.

The galleries are open to the public. They allow you to find out about space travel, the planets and stars, whether there might be intelligent life out there, and even what it would be like to journey through a wormhole in space.

Here we tell you a bit about what it's like to go on a school trip to the Challenger Centre, and to work in the space science labs.

The National Space

Box 1 A visit for students

To celebrate National Science Week, a trip to the National Space Centre in Leicester was organised for students at King Charles I School, Kidderminster. Katherine Jones and Kelly Knight, two year 10 students who took part, describe their visit.

We began by exploring some of the museum exhibits which included climbing to the top of the Apollo *rocket tower, filming a television weather forecast (much harder than it looks!), finding out how much you would weigh on Jupiter and much more. We then headed to the Space Theatre to view a short film about Mars and the future of space exploration. This was no ordinary theatre however, as the film was projected onto the domed ceiling above (if you have been to the Planetarium in London, you will have a experienced a theatre just like this).*

After a quick lunch we set off for our 'Mission to Mars'. This was the bit we had all been waiting for. Our voyage began in the Challenger Learning Centre (the only one outside North America) founded by the families of the Challenger *space-shuttle crew who died in 1986. The objective of the simulation was to*

> *relieve a crew who have been living and working on Mars for 2 years and to send probes to the two Martian moons. The crew on Mars had been living in a small self-contained environment for 2 years and were ready to return to Earth. Probes were to be launched to either or both of the two Martian moons Phobos and Deimos, which may contain minerals needed to sustain life for future crews.*

The centre was split into two sectors, one simulating Mission Control and the other simulating conditions onboard the spaceship. The only way the two sectors could interact was through a communication and data officer, which tested our patience and ability to write concise and understandable instructions. Teamwork was vital for our mission to succeed. After a few close shaves (like nearly running out of oxygen and turning off the autopilot accidentally) the mission was a triumph and everyone returned home safely.

Emma Ashman

Mission to Mars

Box 2 Work experience

Heather Audley, a pupil at Sutton Coldfield Grammar School for Girls, arranged an unusual work experience placement when she was in year 10. Here she describes her 2-week placement at Leicester University's Space Research Centre. Heather is now studying science A-levels.


Jane Taylor

Leicester University took part in the Beagle 2 *mission to Mars, and while I was on work experience at the centre I was able to work with the team who were developing the PAW (position adjustable workbench), the part of the lander that contained all the scientific instrumentation.*

For a large portion of the first week I was working in the centre's clean rooms, where the Beagle 2 *lander's electrical model was being tested for short circuits. As a result of this I was asked to design a part that would prevent the short circuits. The design I came up with was considered and taken through to the next stage in the design process!*

*Another test I was able to take part in was the shock testing at the Rutherford Appleton Laboratory in Oxfordshire. This test made sure that components of the lander wouldn't fall off during take-off or landing. On a more mathematical level I did some distance calculations that were used to ensure that the people constructing both the satellite (*Mars Express*) and the* Beagle 2 *lander were not exposed to lethal doses of radiation from one of the spectrometers — luckily, these calculations were checked!*

At Leicester, I also worked on the ground-test model, which was used to test the manoeuvres planned for Beagle 2. *These tests were to ensure that the computer information gave the correct movement on* Beagle 2.

The control centre for the Beagle 2 *was at the National Space Centre, and on Christmas Day 2003 I was present at the control centre when* Beagle *was due to land. This experience gave me an amazing insight into the space industry and the major role played by the UK in space research.*

Centre, Leicester

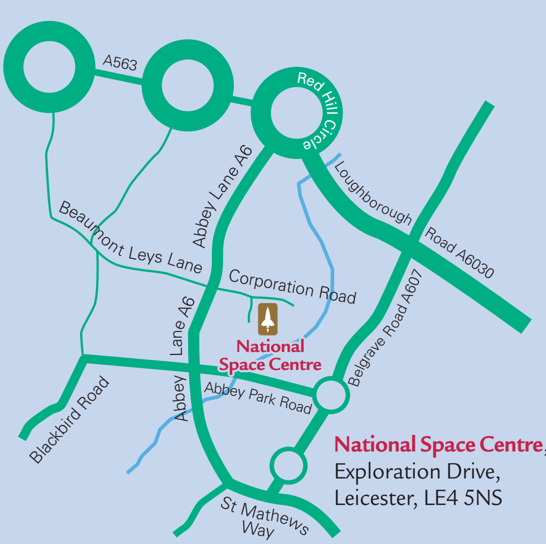
Box 3 Visiting information

The Space Centre is open as follows:

School terms: 10–5 Tuesday to Friday; 10–6 Saturday and Sunday

School holidays: 12–6 Monday; 10–6 Tuesday to Sunday

Admission costs £8.95 for adults and £6.95 for children, with concessions for families and pre-booked groups



National Space Centre, Exploration Drive, Leicester, LE4 5NS


Emma Ashman

The Space Centre website is at http://www.nssc.co.uk

Left: *Students at work in the Space Centre*

Answers to Whatever the weather, page 16

I	S	O	T	H	E	R	M	S						
					P	R	E	S	S	U	R	E		
	B	A	R	O	M	E	T	E	R					
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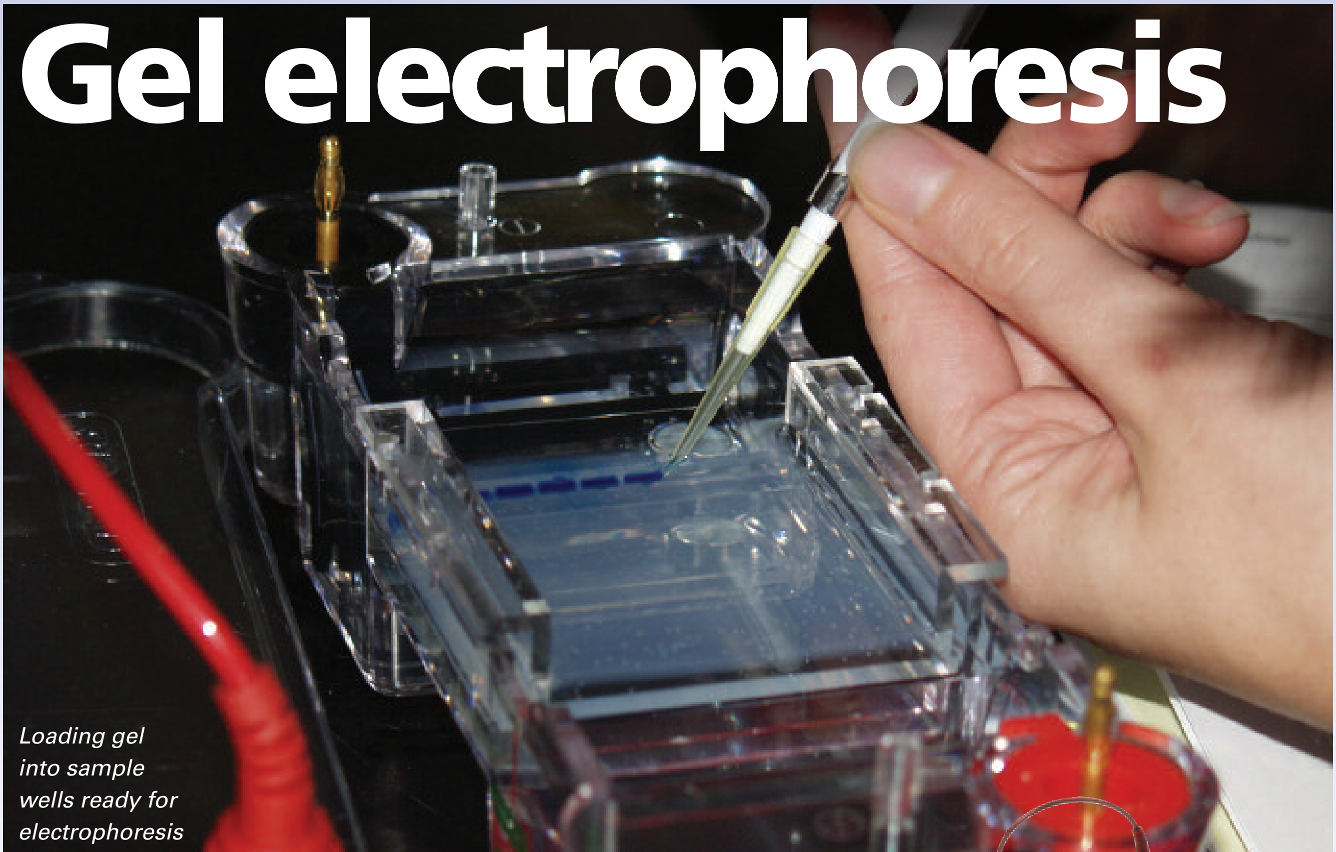
Gel electrophoresis



Loading gel into sample wells ready for electrophoresis

BBSRC/University of Edinburgh

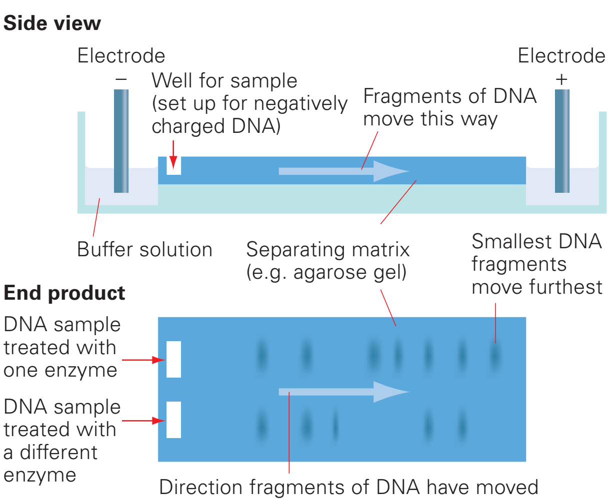
Gel electrophoresis is used to separate big molecules, in particular nucleic acids and proteins. To learn more about the structure and function of large molecules such as DNA and proteins, they can be broken up into smaller fragments, using enzymes.The molecules are separated on the basis of size and on the electrical charge they carry, as well as other properties.

Look at the diagram. The electrical current from one electrode repels the molecules while the other electrode attracts them, depending upon the electrical charge they carry. DNA fragments usually carry a negative charge and so move towards the positive electrode. The gel material acts as a 'molecular sieve', separating the molecules or fragments of molecules by size.

The final positions of the separated molecules, relative to one another in the gel sheet, can be shown up by staining.

Gel electrophoresis is an important tool in molecular biology and is of great value in many aspects of genetic manipulation and study. These include DNA fingerprinting, the Human Genome Project and genetic engineering. The process is so sensitive that it is possible to separate and identify protein molecules that differ by as little as a single amino acid.

The process of electrophoresis



The end product: agarose gel sheet with bands from treating DNA with different restriction enzymes. Bands are revealed by staining or using UV light

Bio-Rad Laboratories

A small-scale electrophoresis tank, with wells for buffer solution at each end

Front cover *The background of the front cover photo shows the results of separating fragments of DNA by electrophoresis. In this case there were a great many wells, filled at the start with fragments of DNA that had been tagged with a radioactive marker. Following electrophoresis each spot on the gel was picked out by laying photographic film over the gel and developing it. The radioactive fragments of DNA fogged the film above the spots where they occurred.*