Catalyst

GCSE Science Review

Volume 16
Number 4
April 2006

Exploring Venus

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Catalyst

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The front cover shows a false-colour radar map of the west hemisphere of Venus (NASA/SPL).

Contents

The end is nigh?

It's April, and the end of the school year is in sight. That probably means tests and exams, so we have included some suggestions on how to revise on pages 4–5.

At the end of the nineteenth century, many physicists believed that the end of scientific discovery was nigh — the mysteries of mechanics, electromagnetism and thermodynamics had been sorted out, and only a little tidying up remained. Then, in 1905, along came Albert Einstein with his three dramatic theories. On pages 14–16, you can read about how twentieth-century physics turned conventional ideas on their head.

In fact, there's always something new around the corner — that's what makes science exciting. Take the photo on the front cover. It's a radar map of Venus, a planet about which we will learn a lot more soon, thanks to Venus Express (see pages 8–10).

David Sang

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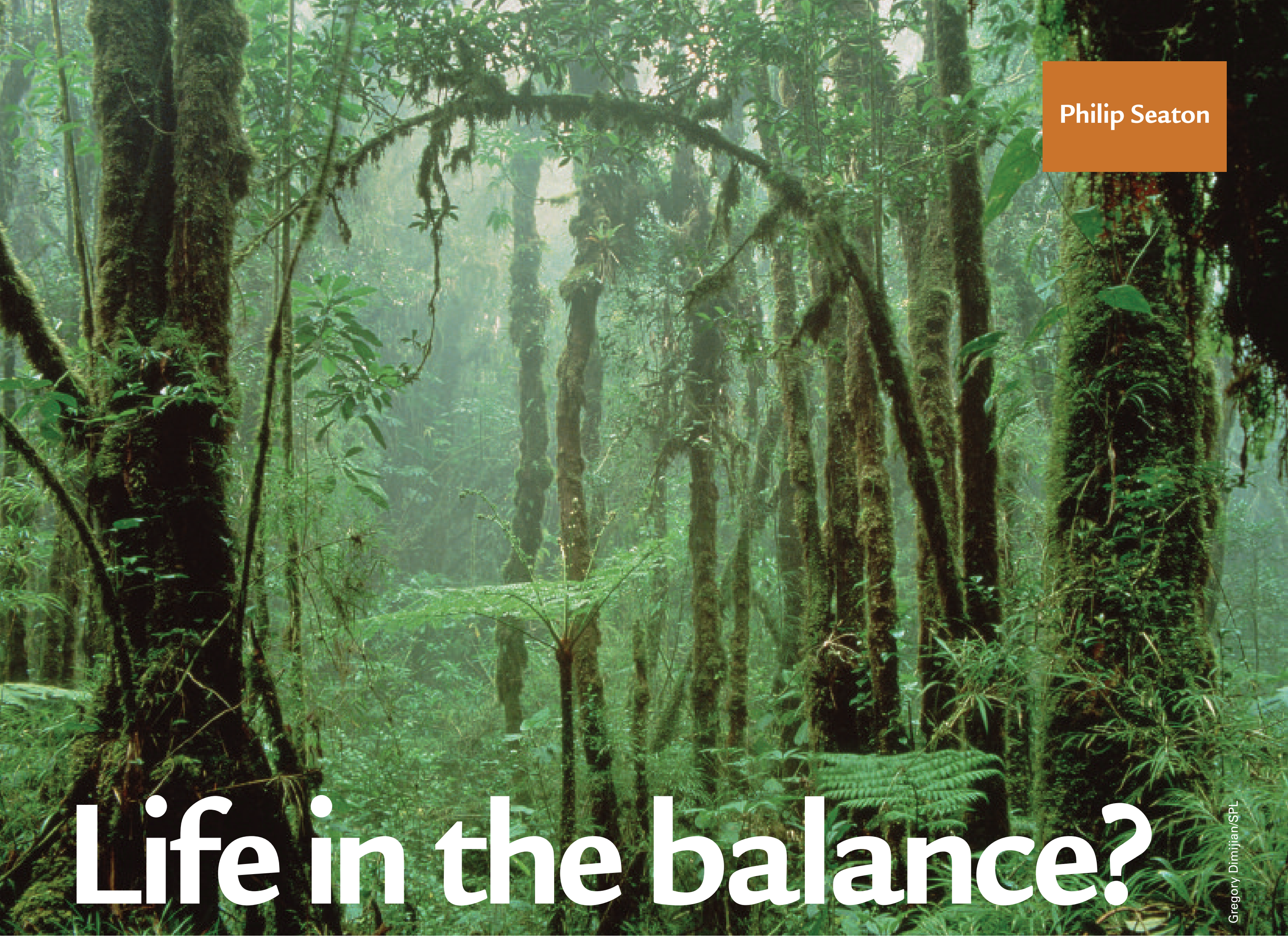
ISSN 0958-3629

Publishing Editor: Catherine Tate.
Design and artwork: Gary Kilpatrick.
Reproduction by De Montfort Repro, Leicester.
Printed by Raithby, Lawrence and Company, Leicester.
Printed on paper sourced from managed, sustainable forests.

Philip Seaton

Life in the balance?



Gregory Dimijian/SPL

Much of our planet's biodiversity appears to be teetering on the brink of a man-made extinction crisis. Scientists have suggested that, unless urgent action is taken now, many species will disappear in the next 50 years. This article looks at some of the issues involved.

The main reasons for this crisis are well documented. The world's tropical forests are disappearing at an alarming rate, both due to logging for the timber trade (much of it illegal) and to land conversion to agriculture. Vast tracts of lowland forest have been converted to banana, oil palm or pineapple plantations. Large areas of the Amazon Basin are currently being converted to soya cultivation or pasture for cattle ranching.

What is not always appreciated is that many of the world's temperate forests face a similar threat. Increased logging is taking place in the far east of Russia, for example, and clear felling is continuing along stretches of the northwestern coast of North America.

The potentially harmful effects of global warming are of increasing concern. As average temperatures rise, habitats may change and become unsuitable for their resident plants and animals. To survive, many need to **migrate** to more suitable areas, but **habitat fragmentation** means that such species may literally have nowhere else to go.

The island of Mauritius is a tropical paradise. Most visitors do not realise that only around 1% of its original forest remains. The lush green forest canopy is largely made up of introduced exotic species — guava and privet. Invasion by exotic species is an increasing menace to natural populations. Of course, Mauritius was once home to the dodo, tragically extinct within less than 100 years of its discovery in 1598.

Sadly, examples of illegal and unsustainable hunting of animals for local trade and consumption, as well as for the international market, are easy to find. In China there is an illegal market in snow leopard skins and bones. The bones are used in traditional medicines, as are the gall bladders of bears. In parts of Africa where there is a shortage of protein, there is a thriving bush meat trade, including such wild animals as chimpanzees.

GCSE key words

Human impact on the environment
Deforestation
Global warming

Habitat fragmentation: after clearing the natural vegetation in an area, small fragments of the original landscape are sometimes allowed to remain. Unfortunately, the number of species able to survive in such small parcels of land declines rapidly.

Plant migration: unlike animals, plants have to remain rooted to the spot. Plant populations can, however, migrate over time through seed dispersal.

Figure 1 Mauritius and Madagascar are islands in the Indian Ocean

● To learn more about Orchid Conservation International go to its website (www.orchidconservation.org).

Angraecum longicalcar

Royal Botanic Gardens, Kew

Phil's colleague David Roberts from Kew locating the Angraecum longicalcar *in Madagascar*

Philip Seaton

Box 1 Case study: a Kew expedition to Madagascar

During our 11-hour drive to the Ranamofana National Preserve it was easy to believe that only 10% of Madagascar's natural forest remains. For most of the journey the countryside was a mosaic of rice paddies encircled by bare hillsides with their characteristic red soils which, from the air, can be seen bleeding into the surrounding Indian Ocean.

The lush humid forest of Ranamofana boasts a total of 20 lemur species, each living in a slightly different ecological niche. The highlight was finding the rare golden bamboo lemur. Only 100 individuals remain in the wild, 20 of which are currently protected, at Ranamofana.

In contrast, the Itremo Plateau was hot and dry. We were looking for plants of an endangered orchid, *Angraecum longicalcar*, which grows in full sun on marble outcrops. We soon discovered that the total population had declined to no more than 25 plants. The local herdsmen routinely burn the grassland, to stimulate the formation of fresh green shoots for their herds of zebu cattle. Alarmingly, part of the population of orchids had recently been accidentally burned. In addition, some of the remaining plants had been removed by collectors, and one of the outcrops was being mined for its marble. Truly, this is an orchid species on the edge.

Why should we care?

There are various reasons why we should be concerned. The first is an economic argument. Illegal logging threatens the livelihoods of many local communities that depend on forest resources for employment and income. Trees bind the soil together and, particularly on steep slopes, prevent it being washed away by rainfall.

Plants and animals are important sources of food, fibres and, potentially, undiscovered medicines.

At the heart of the matter is the fact that we depend on other species for our continued existence on this planet. They are part of the fabric of life, and food chains and food webs may begin to unravel as key organisms are removed.

Ultimately, after millions of years of evolution and coexistence, many people would argue that it is morally wrong to cause the extinction of plants and animals.

What is being done?

All of the above can make pretty depressing reading, but fortunately there appear to be an increasing number of people who care enough to be doing something, and more and more people are willing to pay to see wildlife in its natural habitat. The Central American country of Costa Rica, for example, derives more income from ecotourism than any other source. Here are just a few examples of the sorts of conservation activities and projects that are taking place around the world.

Mauritius kestrel

***In situ* conservation** involves conservation of plants and animals in their natural habitats. The Mauritius kestrel declined to just four wild individuals, but captive breeding and subsequent reintroduction has saved this beautiful bird from extinction.

African elephants

One of the successes of the conservation community has been the international agreement banning trade in ivory and its products, thereby halting the lucrative market for poached tusks, and the catastrophic decline in African elephant populations.

Box 2 Case study: cloud forests of Costa Rica

Cloud forests are among the richest habitats on Earth. Constantly bathed in rain and mist, the branches of the trees are draped in a dense carpet of orchids, bromeliads and ferns. As global temperatures rise so the cloud base moves up the mountain sides, and those plants and animals migrate up the mountains along with the changing conditions. Those that required the special conditions at the tops of the mountains have nowhere left to go.

A lady's slipper orchid

Lady's slipper orchid

It is not only plants and animals in exotic places that are at risk. In Britain our native lady's slipper orchid declined to one individual plant remaining in a secret location somewhere in Yorkshire, after the plants had been dug up by collectors. Artificial pollinations were carried out by staff at the Royal Botanic Gardens, Kew, the seeds germinated in the micropropagation unit, and a healthy population of seedlings was once again established in its natural habitat.

Sustainable development

***Ex situ* conservation** is conservation of material outside its natural habitat.

The key phrase in the vocabulary of today's conservationists is **sustainable development**. In Mexico many orchid species are used in religious festivals to decorate the altars. Not only are the flowers removed from the wild, but also sections of the plants, as this means that the flowers will remain fresh for a longer time. This leads to a decline in natural populations.

Projects are now being set up to store seed of these orchids for the future in germ banks, and laboratories are being established to raise orchids from seed for subsequent cultivation by the local people. The Millennium Seed Bank Project at Kew aims to conserve seeds representing 10% of the world's flora by 2010, concentrating particularly on semi-arid areas, where most people live on land on which agriculture is marginal.

***Philip Seaton** taught biology for more than 30 years. He now works full time in orchid conservation. He is secretary to the Orchid Specialist Group of the IUCN/SSC, the World Conservation Union, and Orchid Conservation International, a Registered Charity.*

The natural vegetation of much of Britain is woodland, but most forests were cleared for agriculture thousands of years ago.

- **The beautiful blue Brazilian parrot, Spix's macaw, was declared extinct in the wild in December 2000. In contrast, after an absence of more than 60 years, the ivory-billed woodpecker has recently been sighted in the ancient cypress swamps of Arkansas, USA. To learn more about both birds go to www.arkive.org/species**

- **To find out more about the Millennium Seed Bank Project visit the Kew website on www.kew.org.uk and click on Wakehurst Place.**

Improve your grade

Revision

It's that time of year again — exams. This Improve your Grade gives you important advice on when and how to revise.

Friends can be useful revision aids. When you work together you argue about topics. This makes you formulate your ideas and turn your thoughts into speech — which helps you remember them.

It's hard to get started revising because there is always something more urgent to do. Begin by making a revision timetable which covers the areas you need to revise. This will make you realise that there is a lot to do and that you need to start as soon as possible.

Don't leave learning topics until just before the exams. It makes your life difficult. Learn topics you covered early in your course well in advance and use the weeks before the exams for learning your most recent work and revision.

What should I revise?

You need a list of the topics in your GCSE specification. If your teacher hasn't given you one, check the correct title for your exam and go to your exam board website (Box 1). Download a copy of the specification. Now you are ready to get started.

The internet is a fantastic source of information, but you can waste a lot of time with useless sites so choose the key words for your search carefully.

Box 1 Examination board websites

AQA: www.aqa.org.uk
OCR: www.ocr.org.uk
Edexcel: www.edexcel.org.uk
Northern Ireland: www.ccea.org.uk
Scottish: www.sqa.org.uk
Welsh: www.wjec.co.uk

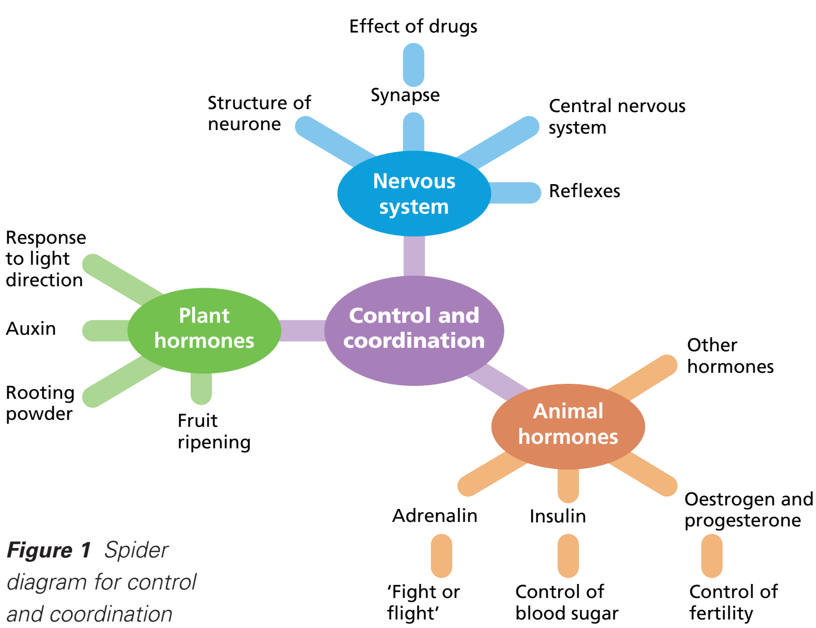


Figure 1 *Spider diagram for control and coordination*

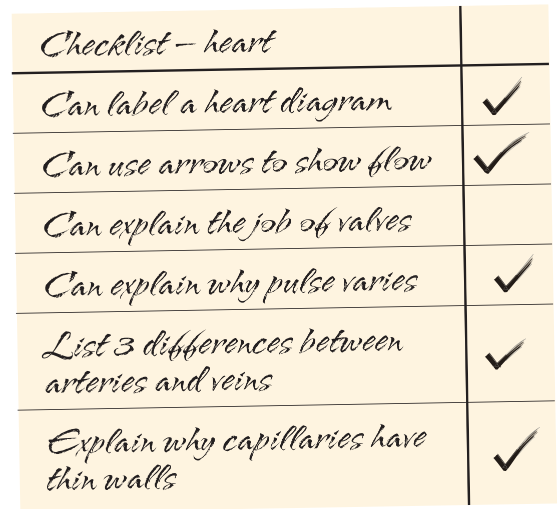


Figure 2 *Revision checklist*

It makes you feel good if you revise topics you like and got high marks for — when you test yourself you know it. Unfortunately, these areas aren't the ones you need to work on. You must identify your weak spots and start with them.

Use your target sheets and checklists (Figure 2) to help you prioritise revision topics. Look at the tests and assessments you have done during the year. Tick off the topics that you gained good marks for (*good* means all or most of the marks for the questions). You should be left with a list of areas you didn't do so well on — these are your first priority.

Break each topic down into bite-sized chunks that are easier to remember and focus on. For example, a biology module on control and coordination can be broken down into nerve cells, synapses, reflex arc, hormones, glands and plant hormones.

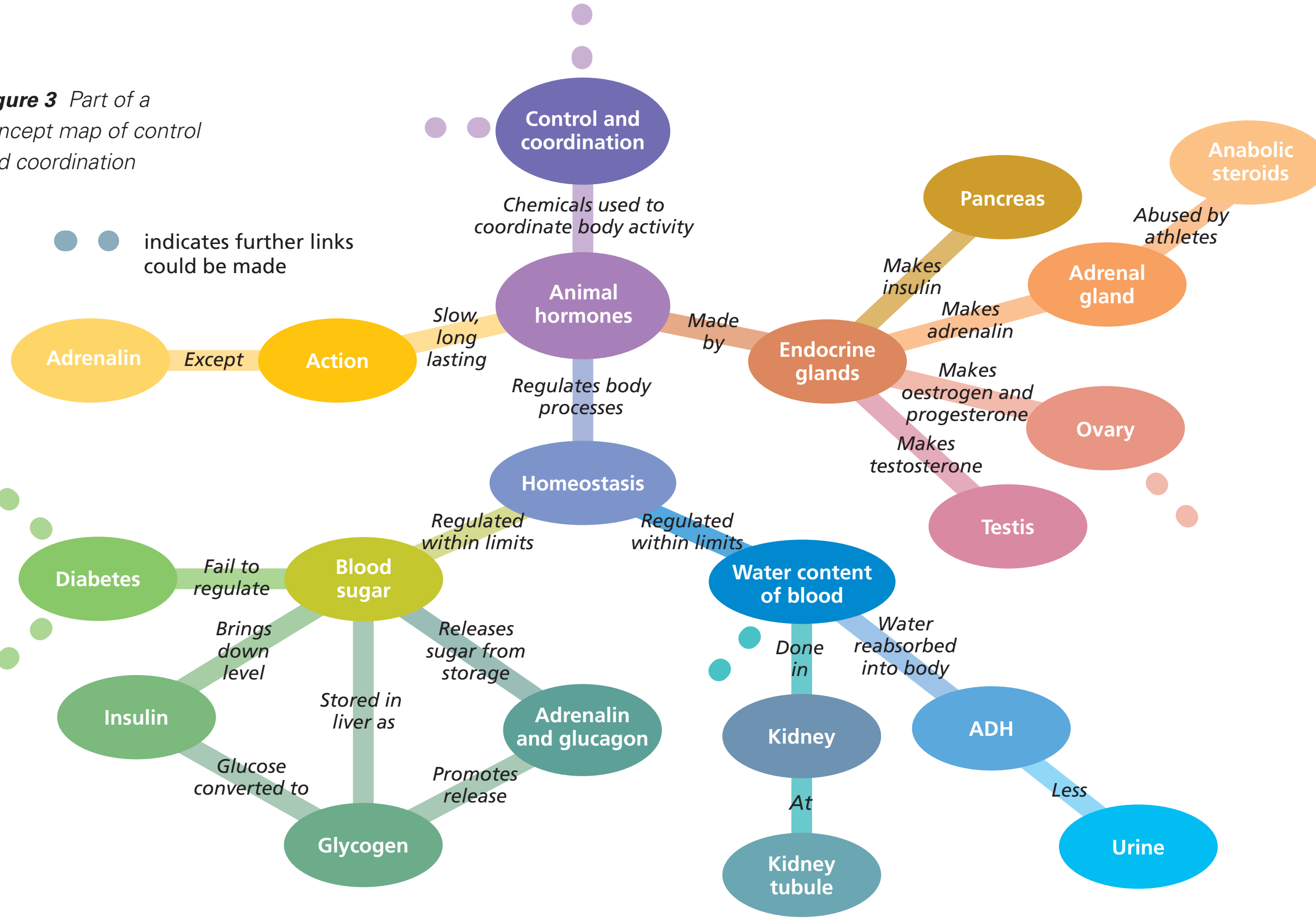
If you haven't got target sheets or tests, look through your books and files. Make a list of the areas you didn't do very well in and start with these.

Getting down to it

Look at your notes. Is there any unfinished work? Are there any gaps from when you were ill or playing for a team? You need to fill these gaps in your knowledge before you start to revise.

Use a range of sources for each topic. Begin with your notes and your textbook if you have one. Read more from a different book in the school library, a CD-ROM or a useful website such as **www.s-cool.co.uk**, and your back issues of Catalyst. The sources will overlap, but each presents the material in a different way — one of them will be right for you.

Figure 3 Part of a concept map of control and coordination



What's the best way to revise?

Different people learn best in different ways. Try a few techniques to find which suits you best. The worst way is just to sit and read your notes or a textbook — this won't help you to remember much. You need to be more active and make notes or draw diagrams, for example.

Revision notes

These are very useful. Many people write down key words and points as they read. No one else is going to read your notes so it's okay to scribble and use abbreviations. The best notes are:

- short
- limited to key points
- full of cues to help you recall the data

Diagrams

These are good if you find it easier to take in visual information. You can construct spider diagrams (Figure 1) and flow charts. Venn diagrams can be useful too. Try looking at the animations on a CD-ROM and drawing your own diagrams on a note pad.

The drawing and writing isn't important, it's the processing of information that you do while making the diagram or chart which makes you remember the information. Try turning a spider diagram into a concept map (Figure 3) by writing on the links between words — this will make you think about the relationships between topics.

Table 1 *Electromagnetic spectrum revision table*

	Type of wave	Frequency	Uses
1	Gamma rays	Highest	Treating cancer
2	X-rays	↓	Examining broken bones
3	Ultraviolet		Sterilising labs
4	Visible		Photography
5	Infrared		Heating
6	Microwaves		Communications
7	Radio waves	Lowest	Broadcasting

Tables

Making tables can help you learn too. Look at Table 1 about the electromagnetic spectrum. The table has memory cues: there are seven sections to remember, put in order from highest frequency to lowest.

Make a mnemonic of the initials GXUVIMR to help you remember it. For example: Giant Xylophones Upstage Very Important Musical Russians.

Finally

Don't forget to revise your practical activities: the reasons why you used particular materials and equipment, how you made your work a 'fair test' and how you explained the results scientifically.

You will also have done work on the development of scientific ideas in history; you might have to explain some of these in an exam too.

Jane Taylor *teaches biology and is an editor of* CATALYST.

It is never too early to start revising.

Kim Marshall-Brown

Cooler times ahead?

Right: *This image of people skating on the frozen Thames represents a potential, if highly unlikely, future scenario*

Scientists have found that the overturning circulation in the Atlantic Ocean, which maintains Europe's moderate climate, was weaker in 2004 by 30% relative to earlier estimates. What does this mean and what impact could it have on our climate?

Three scientists at the National Oceanography Centre (NOC) in Southampton — Harry Bryden, Hannah Longworth and Stuart Cunningham — published the above findings last December in the science journal *Nature*.

What is overturning circulation?

Warm water heated in the tropics heads northwards as the Gulf Stream. At latitude 45°N (level with Spain) it splits in two. One branch heads south back to the equator due to the Trade Winds and the Earth's rotation. This is what happens in the Pacific Ocean and it is called a **circulating current**. The other branch continues northwards past Britain and Norway and far north into the Arctic Ocean. Westerly winds pass over this warm water, pick up the heat and blow it over northwest Europe, which keeps our climate moderate.

When this water reaches the Arctic, it gets very cold. As ice forms (which is fresh water) the salt is left behind and this salty brine water becomes very dense, which causes it to sink. It sinks to the ocean floor and makes the return journey south, very cold and salty. As the water sinks it effectively pulls water from the south to flow northwards. This is called **overturning circulation**.

In the absence of overturning circulation in the northern Pacific Ocean, Alaska, which is on a similar latitude to the UK, is much colder in the winter than here.

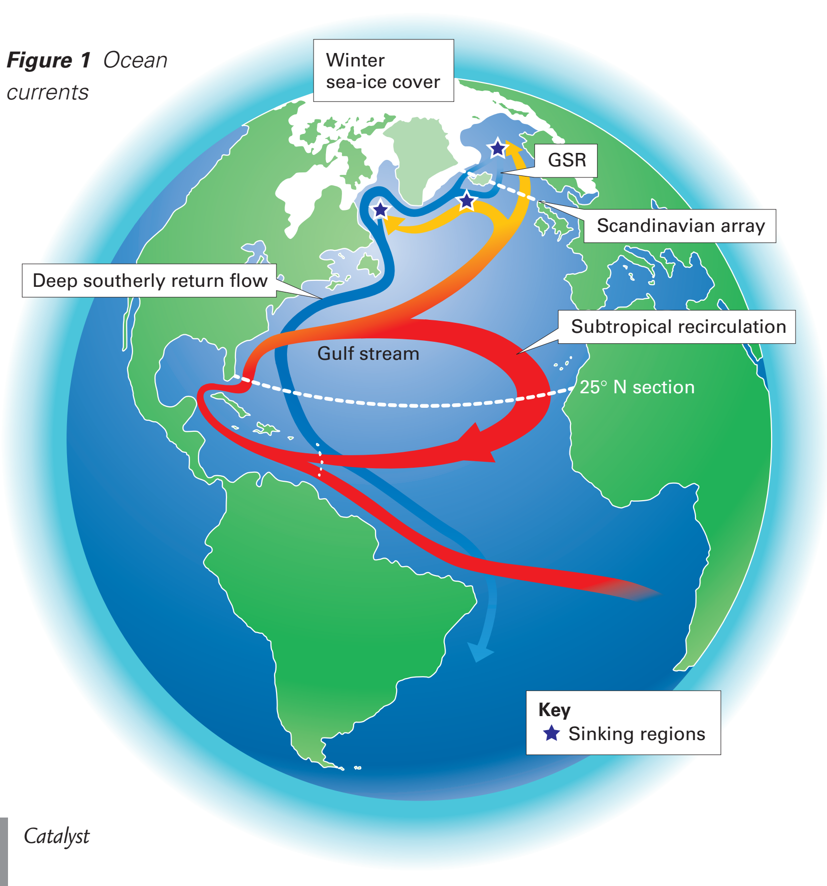


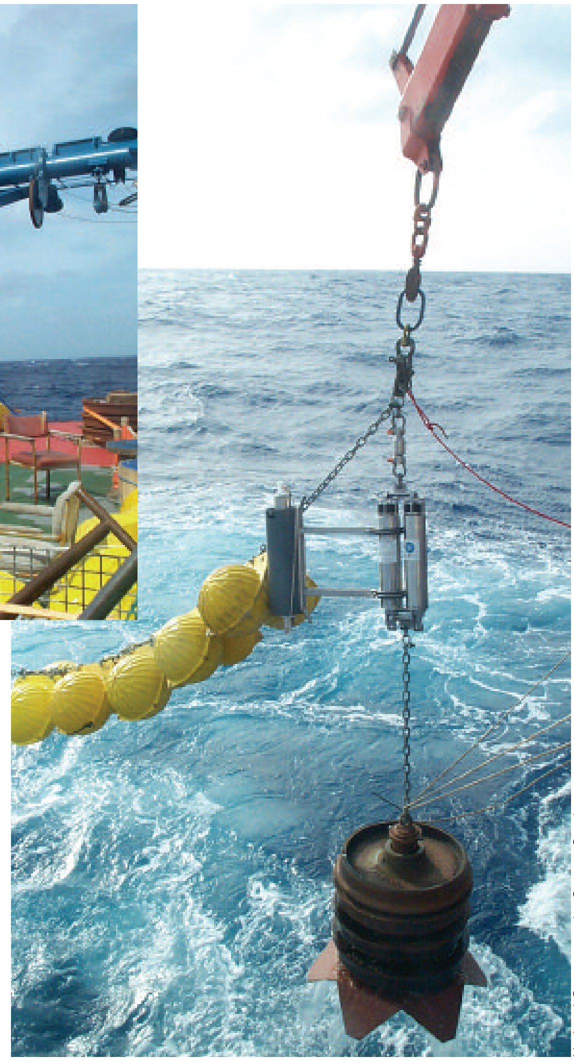
Figure 1 *Ocean currents*

The important news

It would seem that more of the Gulf Stream is going into the southward circulating branch, less is making its way north past our shores and less is returning to the tropics as deep, cold, salty water. This could be due to global warming creating fresher waters in the north through more rain and melting glaciers — a bit like the scenario in the film *The Day After Tomorrow* but nowhere near as fast!

How do scientists know this?

Scientists have been measuring the ocean as it flows across latitude 25°N which runs just below the Canary Islands, stretching from Miami to the Saharan coast of Africa. There have been five research cruises over the last 50 years, in 1957, 1981, 1992, 1998 and the last one in 2004. Until 1992 the figures recorded



National Oceanography Centre, Southampton

Clockwise from top left:

A mooring cable being played out

Redundant railway wheels set as anchors for the mooring on the sea bed

Glass floats in their protective covers (see the back page)

were pretty much the same. On this last cruise the figures showed that the flow had weakened by 30%.

This may be seasonal or just a blip; without constant measurements we cannot know for certain. Scientists decided to monitor the circulation and heat transport more closely by taking more frequent measurements of the temperature and salinity of the water and the speed at which it is moving.

Since 2004 scientists at the National Oceanography Centre, Southampton, led by Dr Stuart Cunningham, have deployed an array of instruments across the Atlantic Ocean at 25°N. The instruments measure current speeds, temperature and salinity continuously and record them on dataloggers. The instruments are tethered at different depths to a mooring that stretches from just under the water surface to the seafloor, involving around 5 km of cable in some areas of the ocean. Nine are sited across the Deep Western Boundary Current east of the Bahama Islands, four across the Mid-Atlantic Ridge and nine across the continental slope off the coast of Africa. The back page shows one of the moorings in more detail and explains how it works.

Scientists sailing on research vessels retrieve the data from the buoys once a year. The monitoring array involves close collaboration with American scientists at the University of Miami and National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorological Laboratory. The project is due to end in 2008, giving 4 years of continuous observation.

Climate predictions

Scientists can use computer models to investigate different climate conditions in the future (see CATALYST Vol. 15, No. 4). When they have run the model with the overturning circulation slowed down, the UK climate, particularly Scotland, gets much colder, by several degrees. This can be quite dramatic and the models suggest it could happen in a few decades rather than hundreds of years. The overturning circulation has turned off before, during the ice ages. We know this from looking at samples of sediment taken from the seafloor – the paleo-ocean record and ice cores.

Look out for reports from scientists at Southampton, as they collect and analyse the data coming in over the next 3 years!

Kim Marshall-Brown *is the editor of* Ocean Zone, *a quarterly newsletter published by the National Oceanography Centre, Southampton.*

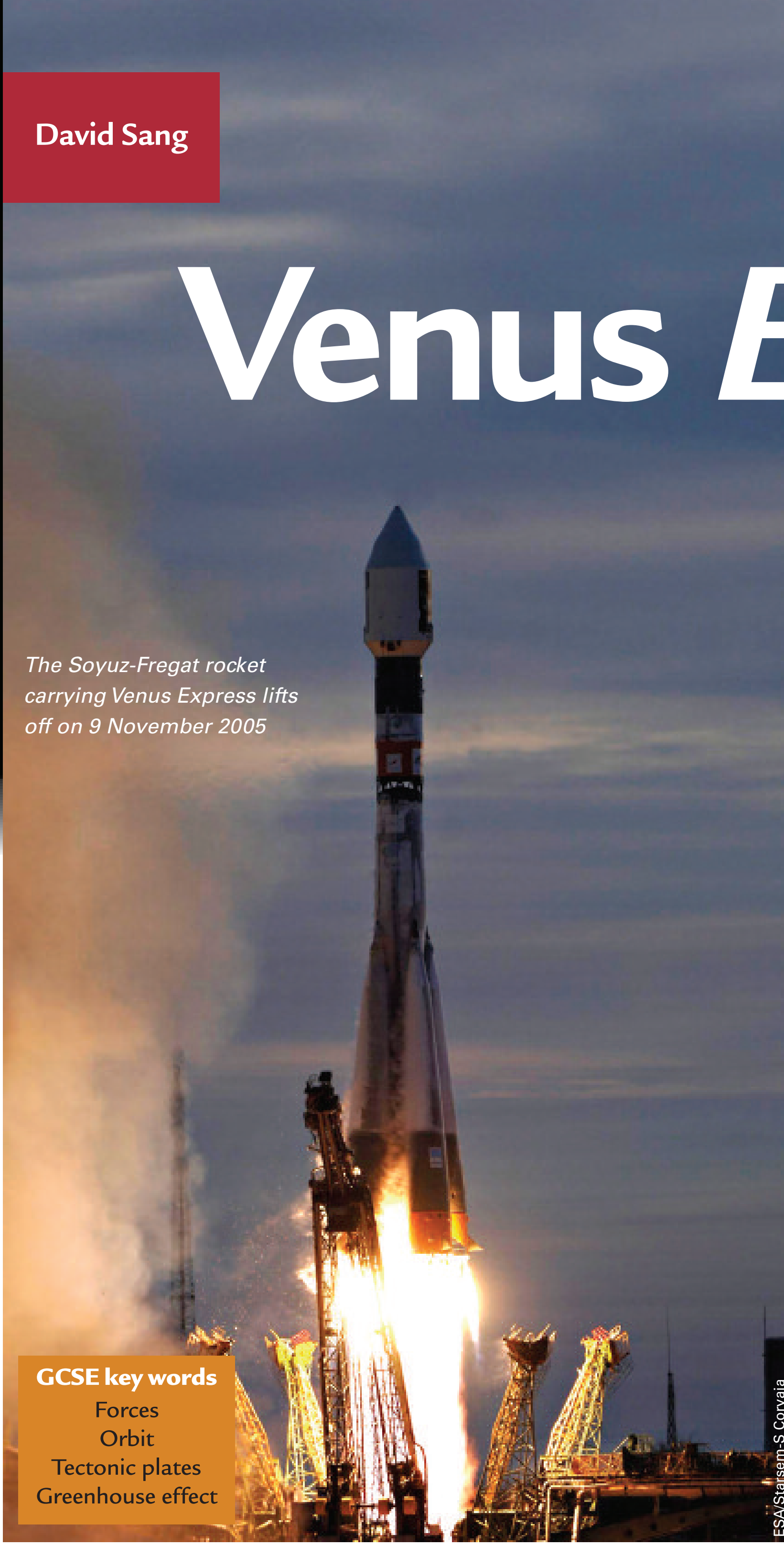
• **Find out more about the three scientists involved in the project in A Life in Science on pages 20–21.**

The work of scientists at the National Oceanography Centre is described on its website (www.noc.soton.ac.uk).

David Sang

Venus *Express*

The European Space Agency (ESA) is off on its travels once more — this time to Venus. What is to be gained from a visit to our cloudy neighbour, a planet which some astronomers describe as 'Earth's evil twin'?



The Soyuz-Fregat rocket carrying Venus Express lifts off on 9 November 2005

GCSE key words
Forces
Orbit
Tectonic plates
Greenhouse effect

Table 1 *Venus and Earth compared*

	Venus	Earth
Mass (kg)	4.87×10^{24}	5.98×10^{24}
Equatorial radius (km)	6052	6378
Average distance from Sun (km)	108 000 000	150 000 000
Year length (Earth days)	225	365
Rotation period (Earth days)	243	1
Mean surface temperature (°C)	465	15
Tilt of axis	178°	23.5°
Surface gravity (N/kg)	8.9	9.8

The Venus Express spacecraft was launched at 3.30 in the morning on 9 November last year. The mission is modelled on ESA's successful Mars Express mission (see CATALYST Vol. 14, No. 2). The term 'Express' refers to the speed with which the mission has been carried out, from first approval in 2002 to launch in 2005.

Journey into space

The trip to Venus lasts 153 days. For most of this time, the strongest force on the craft is the pull of the Sun's gravity. Once Venus Express is captured by Venus's own gravitational pull, the engineers at the control centre in Darmstadt, Germany, need 5 days to manoeuvre it into its operational orbit.

There is no lander on this craft; it is planned to follow an extended elliptical path around the planet (Figure 1). This takes it first within 250 km of the planet's surface, and then far out, 66 000 km into space, before it plunges back inwards once more. This is a polar orbit, giving the craft a view of the planet's entire surface as it rotates slowly below.

Venus is closer than Earth to the Sun, so the Sun's rays are twice as intense. This has important consequences:

- There is an abundant supply of energy for the spacecraft's solar panels, which generate its power.
- At the same time, there is a serious danger that the spacecraft could overheat, so it has built-in systems to remove excess heat and radiate it back out into space.

The spacecraft is something of a flying computer, with on-board systems which store data and process it, ready for transmission back to Earth.

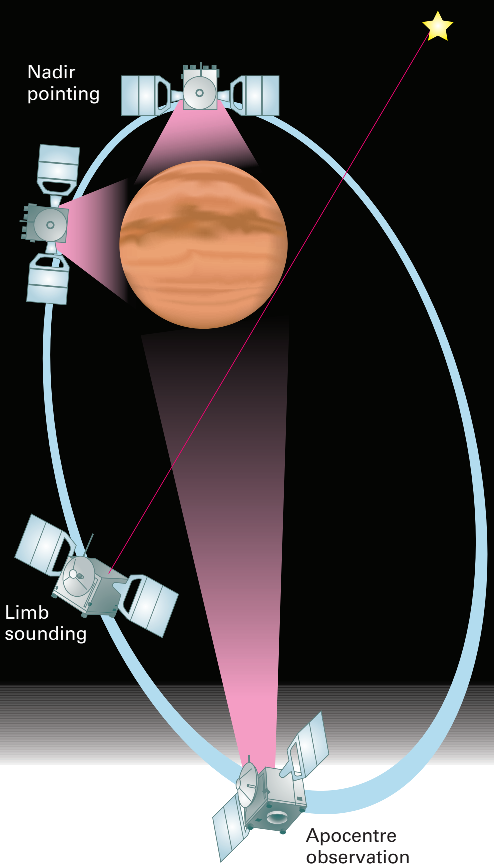
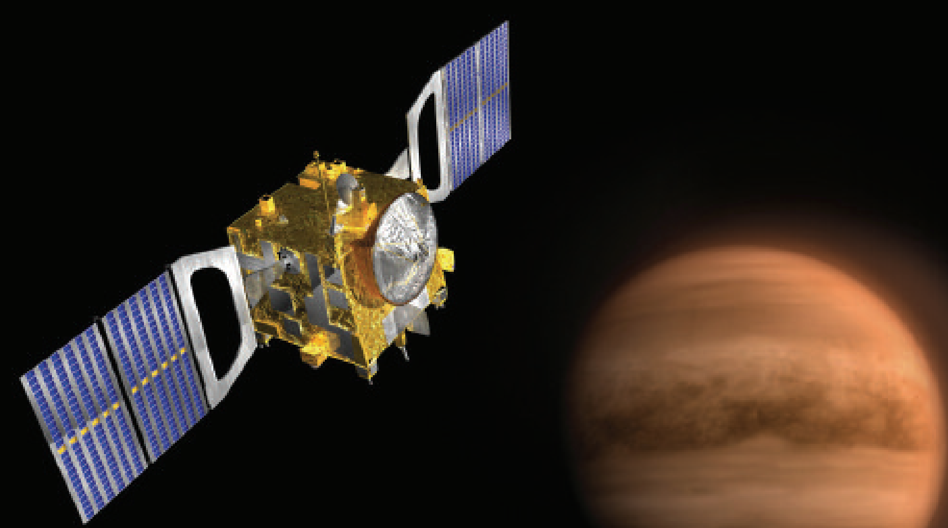


Figure 1 *As Venus Express orbits, the planet will rotate slowly beneath it, allowing all parts of the surface to be scanned. During the limb-sounding experiment, instruments gather starlight which has passed through the planet's atmosphere and analyse it to learn more about its physical and chemical properties*



Artists's impression of Venus Express orbiting Venus

ESA

Why visit Venus?

In many ways, Venus is comparable to Earth (see Table 1). It is a rocky planet, with similar size, mass and gravity. However, there are two major differences: Venus is much hotter than Earth and its atmosphere is very different from ours. These two facts are connected, and they explain why Venus is of interest to us earthlings.

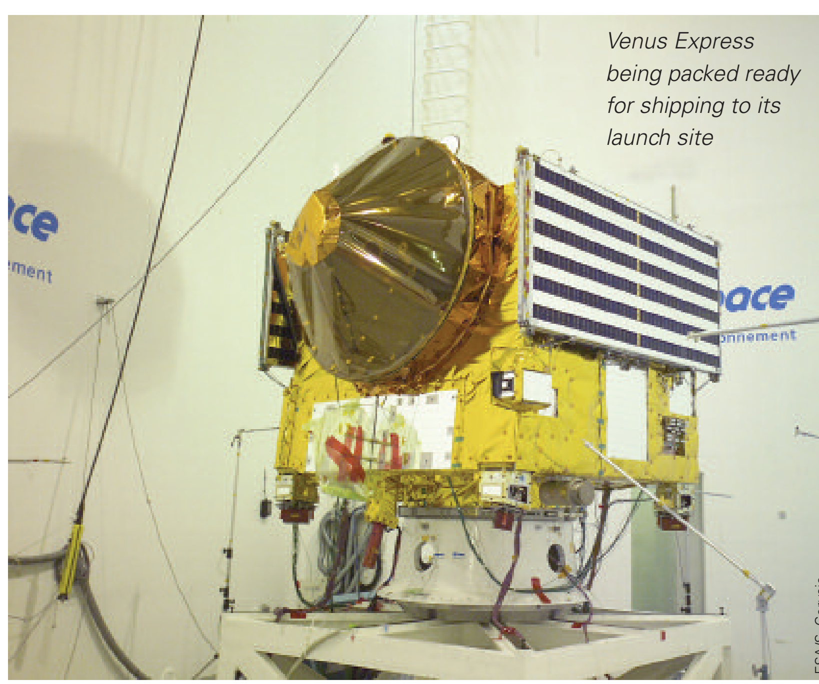
The atmosphere of Venus is dense (its pressure is about 90 atmospheres), and it is largely composed of carbon dioxide. This causes it to have a strong greenhouse effect; infrared radiation is trapped in the atmosphere, so that the surface temperature can rise as high as 500 °C. This gives Venus some very odd weather, with winds up to 250 km/h, lurid yellow clouds of sulphur and heavy falls of lead sulphide 'snow'.

Venus Express will orbit high above this murky world, using radar to detect the planet's surface through the dense cloud layer.

Understanding how Venus's atmosphere works may help scientists to predict how Earth will change as we pump increasing quantities of greenhouse gases into our own atmosphere. It may also give us ideas about the Earth's distant future. Dr Andrew Coates from UCL's Mullard Space Science Laboratory, who is one of the UK scientists involved in the mission, says:

> This is a wonderful mission of discovery – not only to find out why Earth's twin went wrong and to study its strange atmosphere now, but also to glimpse a possible future for the Earth. The extreme example of Venus will test models of our own atmosphere and humankind's contribution to greenhouse gases here. It

As well as Venus Express and Mars Express, ESA has the BepiColombo mission to Mercury, so it will have visited each of the rocky planets in the inner solar system. The final bill for the mission will be about 200 million euros – similar to the cost of making a blockbuster movie.



Venus Express being packed ready for shipping to its launch site

ESA/S. Corvaja

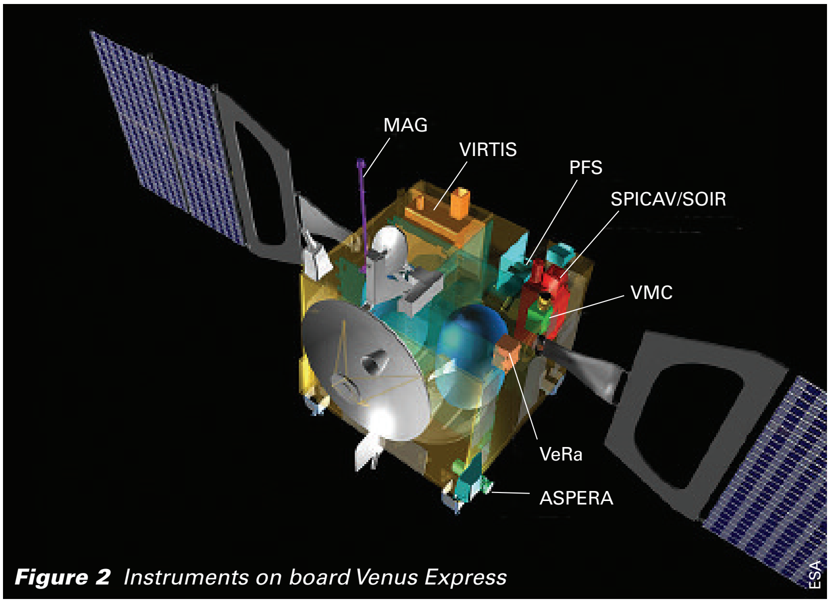


Figure 2 *Instruments on board Venus Express*

- **Follow Venus Express on the ESA website (www.esa.int/venus).**

will also give a preview of what it may be like in 2 billion years' time when the Sun has got brighter in its evolution along the main sequence of stars. At that time Earth will no longer be in the 'Goldilocks' zone and our planet may become more like what Venus is like now.

- **Explain why Venus is always observed at dawn or dusk, close to the Sun in the sky.**

Planetary pressure cooker

Venus, like Earth, is rocky, and shows signs of volcanic activity. Its surface is cratered like the Moon, but there is a difference — the oldest craters on Venus are no older than 500 million years, despite the fact that the planet is over 4000 million years old. It seems likely that the planet's entire surface was renewed 500 million years ago.

Earth has tectonic plates which move around and volcanoes which explode. These release any build-up of pressure beneath the crust. Venus seems to be different; its surface may be a single plate. As pressure builds up inside, a sudden outburst turns the whole thing over, creating a completely resurfaced planet.

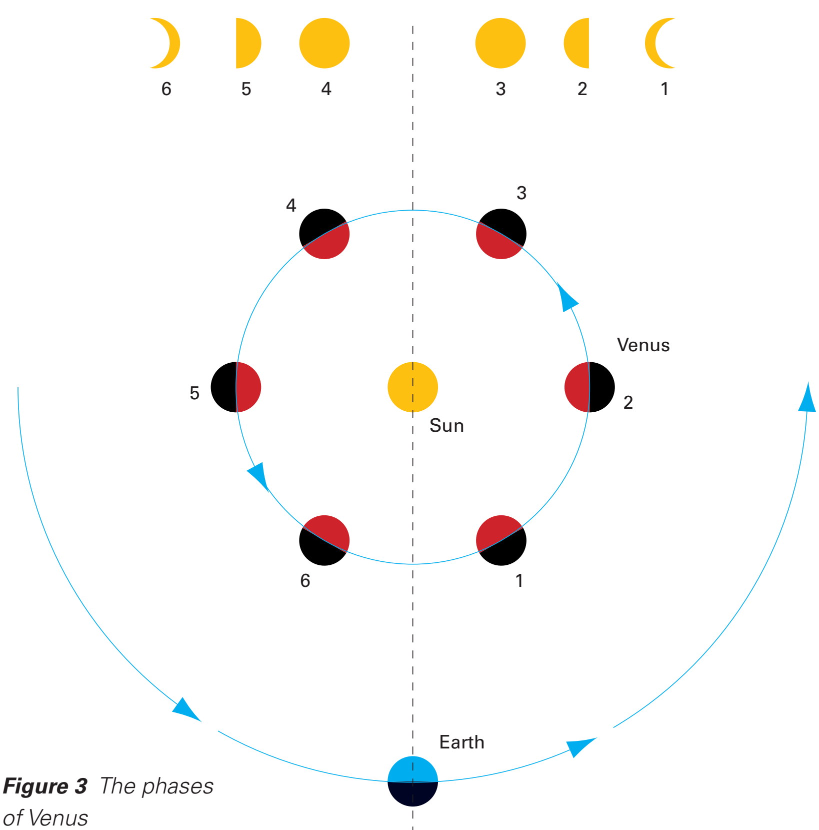


Figure 3 *The phases of Venus*

Instruments on board

The main structure of Venus Express was built by the Astrium company at Stevenage in Hertfordshire. It carries a number of instruments for studying the planet (Figure 2):

- MAG looks at the planet's magnetic field which does not come from inside the planet, but from its interaction with charged particles in the solar wind.
- VIRTIS uses ultraviolet, visible and infrared radiations to look at the planet's cloudy lower atmosphere.
- PFS measures temperatures and determines composition within the atmosphere.
- SPICAV/SOIR looks at the upper atmosphere.
- VMC is a camera that photographs clouds and the planet's surface.
- VeRa uses radio waves to study the ionosphere, an ionised layer high in the atmosphere.
- ASPERA looks at interactions between the solar wind and Venus's atmosphere, by collecting atoms and molecules leaving the planet.

To ensure that the craft is always pointing in the right direction, it has four pairs of thruster rockets, each of which provides a force of 10 N. It uses star trackers to check its orientation in space, and then fires the thrusters for just the time necessary to put it into the correct orientation.

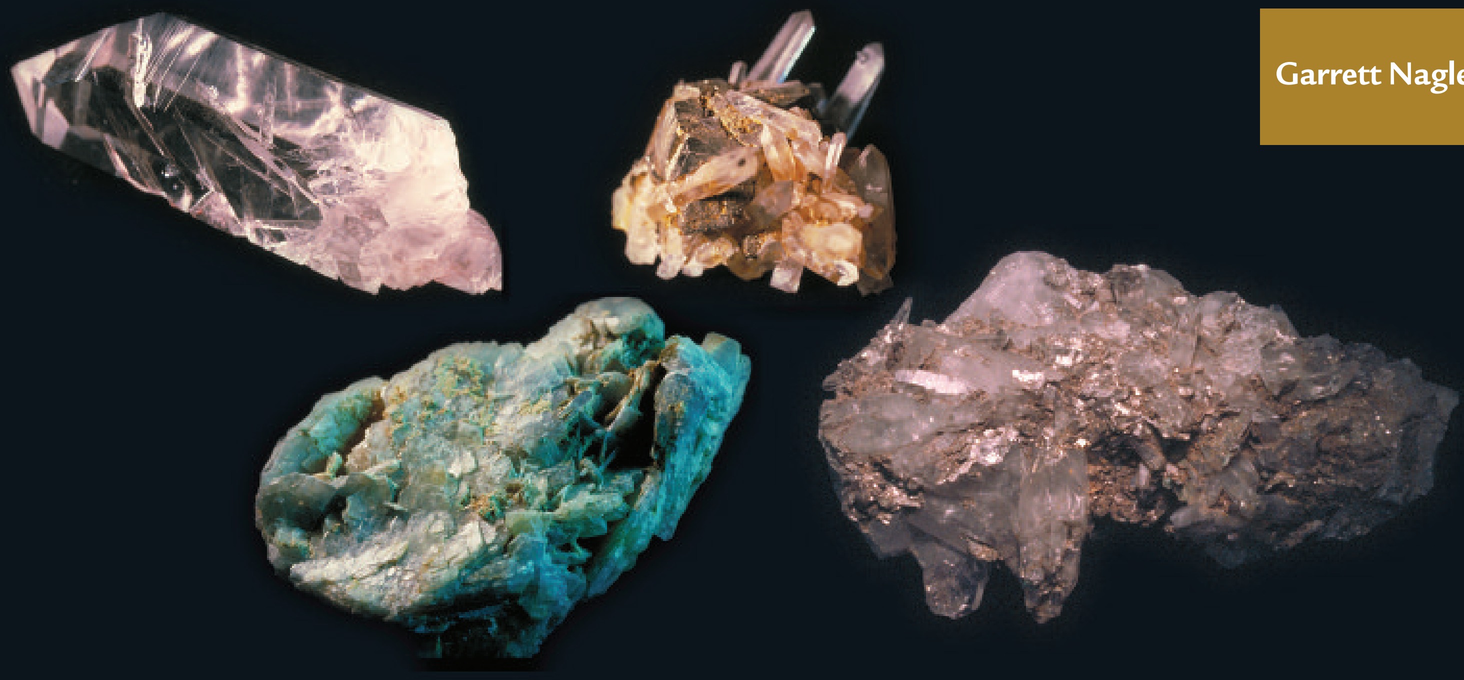
Venus viewed from Earth

Venus may be familiar to you as the 'evening star'; it appears as a bright, untwinkling speck of light in the western sky at dusk. At other times, it appears around dawn in the eastern sky, and is known as the 'morning star'. Seen through a telescope, it shows phases, just like the Moon. Its apparent size also changes, from small when it is full to large when it is just a slim crescent.

This can be explained by picturing Venus in its orbit around the Sun (Figure 3). When it is on the opposite side of the Sun to Earth, it looks smaller, but we can see the whole of its illuminated side. When its orbit brings it close to Earth, we see the unilluminated side of the planet. Four hundred years ago, these observations helped to convince Galileo that Venus orbited the Sun, rather than Earth.

***David Sang** writes textbooks and is an editor of* C*ATALYST*.

Garrett Nagle



Minerals and rock structure

Corel

The rock cycle is responsible for the formation of many different types of rocks and minerals. This article looks at the formation of minerals, their composition and their internal structure.

GCSE key words
Rocks
Silicates
Minerals
Diamond
Graphite

Of the 3700 minerals discovered so far, most are rare, sometimes merely a thin coating on a rock. Others, such as quartz, feldspars and calcite, are found worldwide. Some exist only as microscopic crystals; other crystals may weigh several tonnes.

Minerals are formed in a wide variety of environments. For example:

- opal forms from water percolating down near-surface joints between rocks
- gypsum forms from warm saline waters
- garnet forms at a temperature of 500°C in solid rocks 25 km below the surface
- olivine forms from magma at 1100°C, either on the surface or deep below the crust
- galena forms in veins from hydrothermal waters at depth

How do minerals form?

The whole Earth, apart from the liquid outer core and isolated patches of magma elsewhere, is made of minerals. The chemical constituents of the Earth are continually being reworked; virtually nothing new is being made.

Eight elements — oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium — make up 98% of the Earth's crust by weight. Oxygen is 47% of the crust by weight and 93% by volume. Some 20 or so mineral families make up 99% of the crust's mass. Whether a particular mineral grows or not depends on the appropriate elements being present in the right concentration under the right conditions (mainly temperature and pressure).

Chemical composition

A few minerals contain only one element, such as gold (Au) and diamond (C), but most are compounds, such as galena which is formed of lead (Pb) and sulphur (S). Figure 1 shows the most frequently found elements in the Earth's crust. It follows that minerals which contain mixes of these elements are common, whereas minerals formed of rare elements, such as diamond which is made from carbon, are rare. Thus, rocks containing silicon are common, while non-silicon containing rocks are much less common.

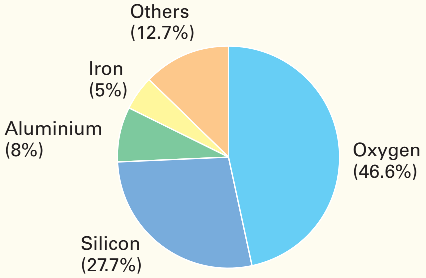


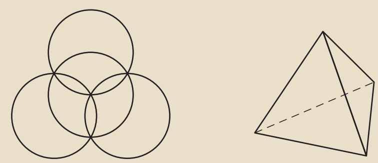
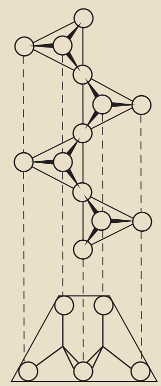
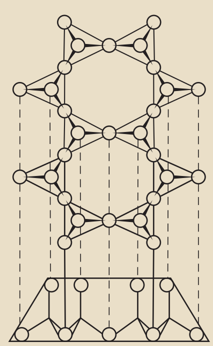
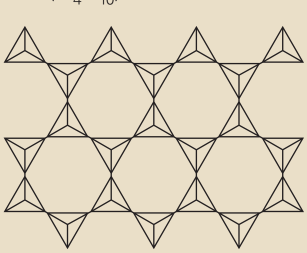
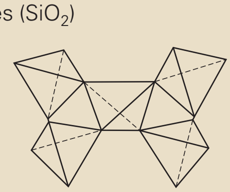
Figure 1 *Composition of the Earth's crust (mass)*

The oldest known mineral is zircon: 4300 million-year-old crystals of zircon were found in a sedimentary rock in Australia which derived from an earlier igneous rock.

Hydrothermal: minerals dissolved in superheated water under pressure.

Sedimentary: rocks made by the deposition of material under water which have subsequently been cemented together.

Figure 2 *Silicates*

Mineral types with examples of formula	**Structural type and silicate unit**
Olivines: e.g. Mg_2SiO_4 Garnets: e.g. $MgAl_2(SiO_4)_3$	Single tetrahedra $(SiO_4)^{4-}$  (a) Relative scale (b) Schematically
Pyroxenes: e.g. $Mg_2Si_2O_6$	Single chains $(Si_2O_6)^{4-}$ 
Amphiboles: e.g. $Ca_2Mg_5(Si_8O_{22})(OH)_2$	Double chains $(Si_4O_{11}\ (OH))^{7-}$ 
Micas: e.g. $KMg_3(AlSi_3O_{10})(OH)_2$ (also clay minerals)	Sheet silicates $(Si_4O_{10})^{4-}$ 
Quartz: SiO_2 Feldspar: e.g. $NaAlSi_3O_8$	Framework silicates (SiO_2) 

Physical properties

The physical properties of minerals depend on their chemical composition and structure. For example, graphite and diamond have the same composition but quite different structures and totally different properties. These properties reflect the conditions under which the diamond and graphite were formed. Diamond, which is formed under high pressure, is hard, whereas graphite, which is formed under low pressure, is soft.

Most rock forming minerals are silicates that can be bonded as isolated tetrahedras (olivines), chains (pyroxenes), double chains (amphiboles), sheets (micas) or frameworks (quartz) (see Figure 2).

Bonds in the crystals

Atoms in mineral crystals are held together by electrostatic bonding forces, which in about 90% of minerals are ionic or predominantly so. An ion is an atom that has become charged, either by the loss of an electron to become positively charged, or by gaining an electron to become negative.

Mineral hardness

The hardness of a mineral is usually measured on **Mohs' scale of hardness** (Table 1). Diamond is the hardest mineral, with a value of 10 on the scale, while talc, the softest mineral, has a value of 1.

A harder mineral can scratch a softer one but not the other way round. Hardness depends on the atomic structure of the mineral, and how densely the ions are packed within the structure. Diamond is far more tightly packed than graphite, although they have the same chemical composition (Figure 3). Similarly, within silicate rocks, micas have a hardness of 2 to 3 due to the atoms being loosely packed. In contrast, olivines with a hardness of 6.5 and quartz, hardness 7, are densely packed.

Figure 3 *Structure of (a) diamond and (b) graphite*

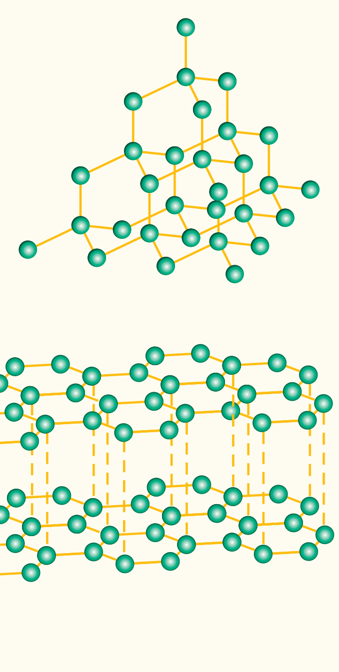


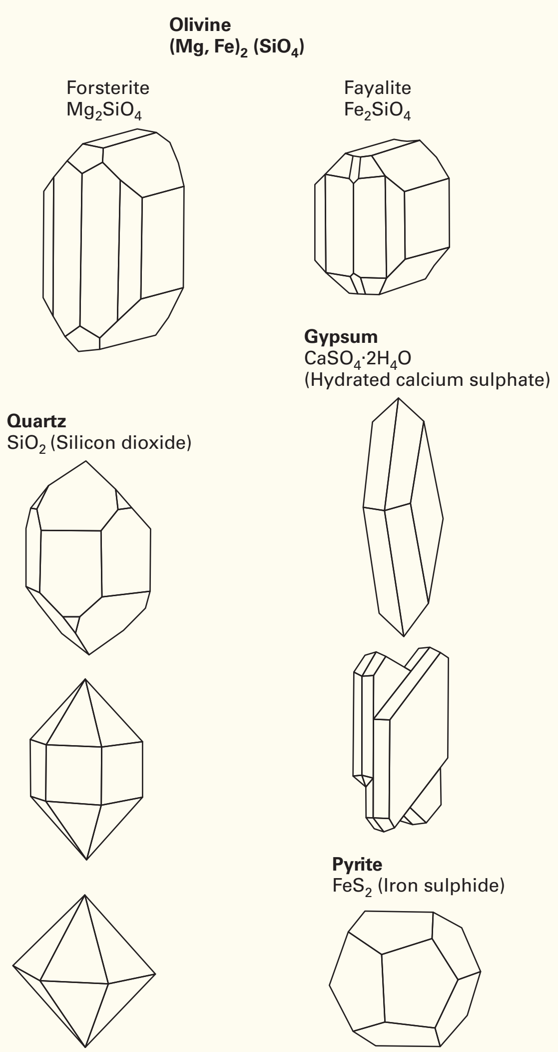
Table 1 *Mohs' scale of hardness*

	Hardness	Mineral	Examples
Hardest	10	Diamond	
	9	Corundum	
	8	Topaz	Steel file 7.5
	7	Quartz	
	6	Feldspar	Steel pin or penknife 5.5
	5	Apatite	
	4	Fluorite	Copper coin 3.5
	3	Calcite	Finger nail 2.5
	2	Gypsum	
Softest	1	Talc	

Cleavage

Cleavage is the way in which a mineral breaks along a distinct, well-defined plane of weakness. These lines of weakness are related to the internal atomic structure — in effect, they are lines of weakness in the chemical bonds between chains and layers of atoms. Micas have well-developed cleavage direction, and the mineral splits in thin sheets. The bonds between the sheets are weaker than the bonds within the sheets.

Figure 4 *Crystal forms of some common minerals*



Box 1 Silicates

About one third of all known minerals are silicates. They are the most important rock forming minerals. Many of them are rare but there are a few types — olivines, pyroxenes, amphiboles, micas, clay minerals, quartz and garnet — which are quite common, and these make up 95% of the Earth's crust.

Types of silicate minerals

Silicate minerals are classified according to their crystalline structure. The basic structure is one silica atom surrounded by and strongly bonded by four oxygen atoms (SiO_4).

- **Olivines** are a group of silicates that contain magnesium, iron and the silicate group with minor amounts of nickel, manganese and calcium. Olivine is common in basalts, dolerite and gabbro.
- **Pyroxenes** are chains of silicate (SiO_4) units. The chains are linked by cations, especially calcium, iron and magnesium.
- There are 30 or so types of **mica**, but only three are common — biotite, muscovite and phlogopite. Micas are sheet silicates. The forces between the sheets are weak and so the sheets can be split apart from one another easily. Mica is sometimes used to insulate electrical heating elements as it is not affected by heat. Formica was invented as a synthetic substitute for mica in electrical uses.

Crystal form

Crystal form refers to the shape of the crystals. This depends on the atomic structure of the elements involved (Figure 4). When there are many elements in a mineral, crystals may interfere with the growth of other crystals, so crystal structure is not always as straightforward as the theory suggests.

Graphite is soft because the layers of carbon atoms can slide over each other easily.

Colour and streak

Colour is one of the more obvious properties of a mineral although it can be affected by the impurities of a handful of atoms. Quartz (SiO_2) occurs in a range of colours including colourless (rock crystal), white, pink (rose quartz), black (smoky quartz) and purple (amethyst). Hardness and cleavage are not affected by colour. Gemstones such as ruby (red) and sapphire (blue) are variations of corundum (Al_2O_3). Streak is the colour of the mineral when powdered.

Diamond is hard since each carbon atom is strongly held to four others in a rigid three-dimensional network.

Relative density

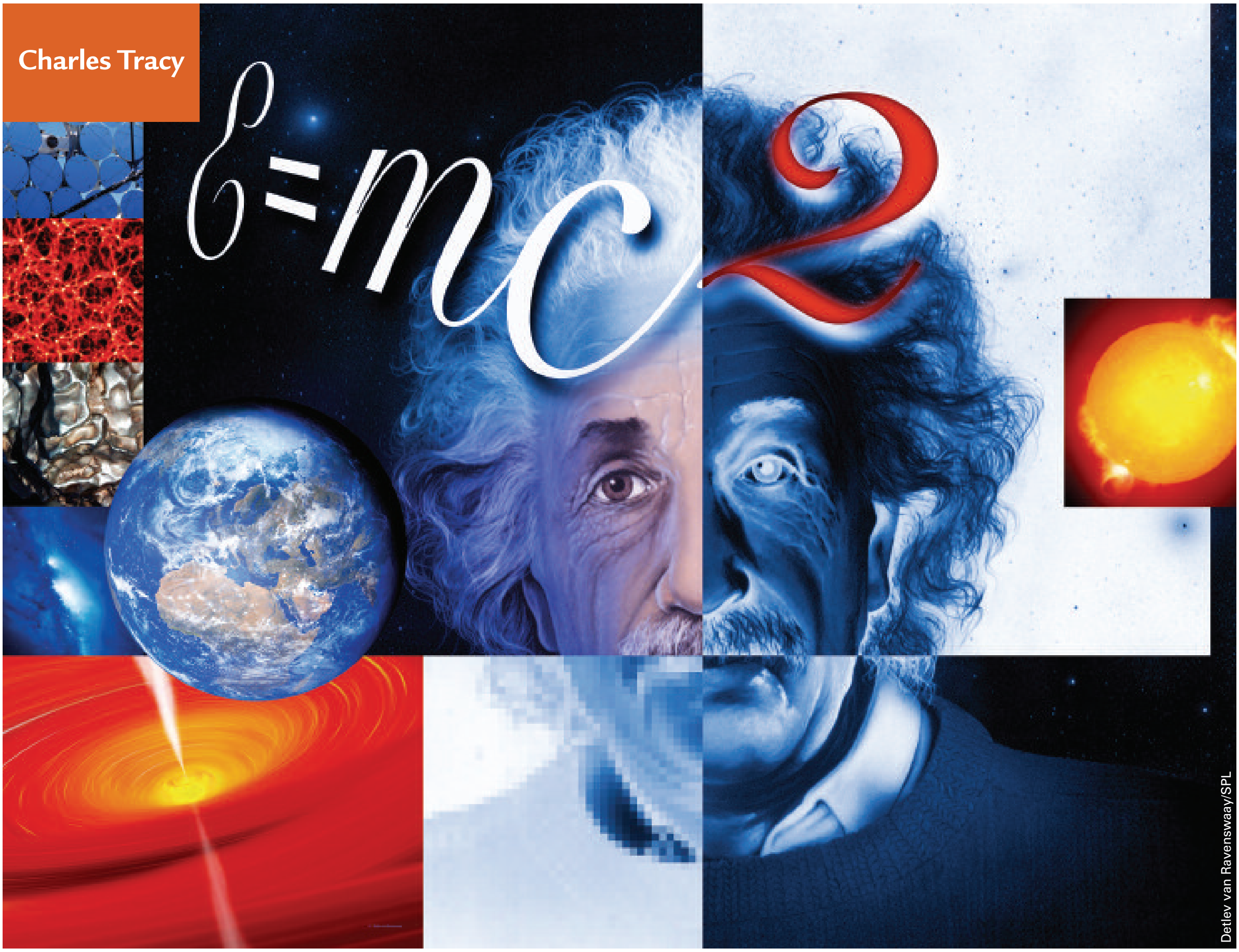
The relative density of a mineral is the ratio between its mass and that of an equal volume of water. Relative density depends on the atomic mass of the elements and how closely packed the atoms are. Diamond and graphite are both composed of carbon, but diamond has a high relative density (3.52) compared to graphite (2.3). Most minerals have a relative density of between 2.5 and 3.5, with the exception of minerals containing heavy metals such as barium (barite, barium sulphate $BaSO_4$, with a relative density of 4.5). Gold has a relative density of up to 19.3.

Positive ions are called cations. Negative ions are called anions.

- **Go to www.minersoc.org/pages/links/schools.html and follow the links to other useful mineralogy and geology websites.**

Garrett Nagle *teaches geography at St Edward's School in Oxford and is an author of many geography textbooks.*

Charles Tracy



Detlev van Ravenswaay/SPL

Physics connections

Last year we celebrated the International Year of Physics — also known as Einstein Year. In the century since Einstein's annus mirabilis *(see* CATALYST *Vol. 16, No. 1) there has been a revolution in the study of physics. This article explores the links between some of the architects of this revolution.*

GCSE key words
Gravity
Alpha particle scattering
Nuclear fission

Einstein did not become instantly famous in 1905; it took several years before he became a global icon. In 1915, while Europe was caught up in the First World War, **Einstein** broadened his special theory of relativity. His **general theory of relativity** predicted the effects of gravity on space, time and light. In particular, it described how space becomes distorted near a massive object such as a star, so that light follows a curved path rather than travelling in a straight line (Figure 1).

Its publication in wartime and the fact that it was written in German meant that few people read it. However, one person who did read it was the British astronomer **Arthur Eddington**. The story goes that it was Eddington who brought Einstein to the world's attention — though Einstein might have disagreed.

Eddington was a conscientious objector. As such, he should have spent the war in jail. Instead, he got official permission to prepare for a trip to observe a total eclipse of the Sun — a rare event. His intention was to verify Einstein's general theory of relativity. Einstein felt that no such verification was needed, but

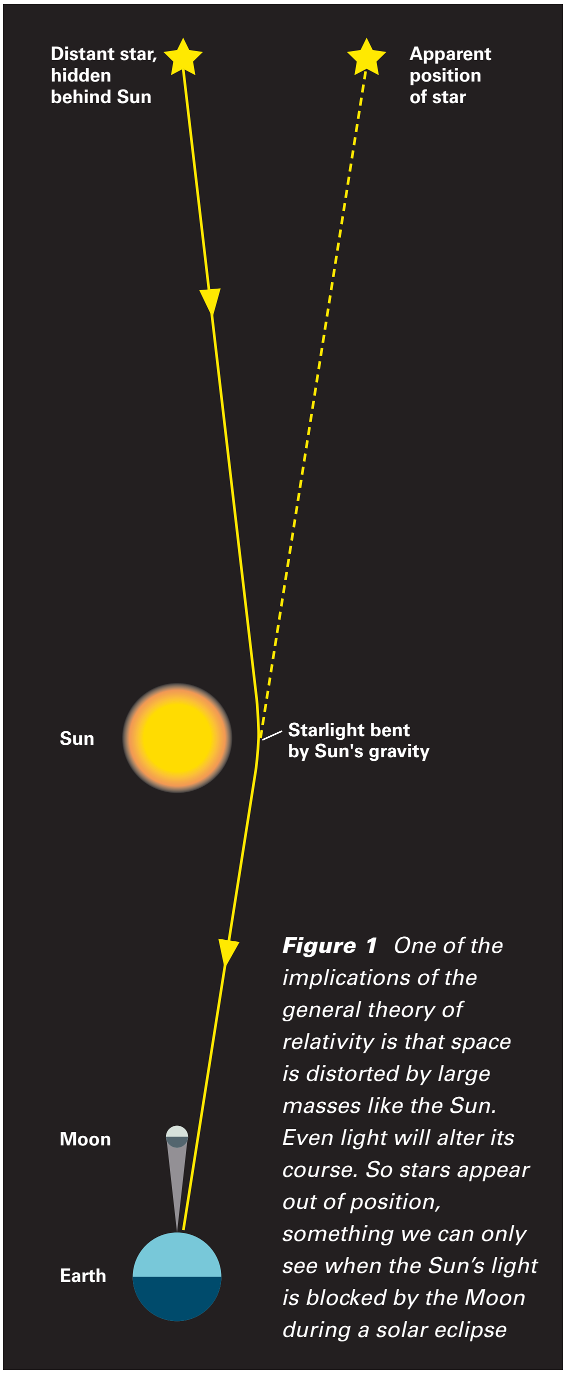


***Figure 1** One of the implications of the general theory of relativity is that space is distorted by large masses like the Sun. Even light will alter its course. So stars appear out of position, something we can only see when the Sun's light is blocked by the Moon during a solar eclipse*

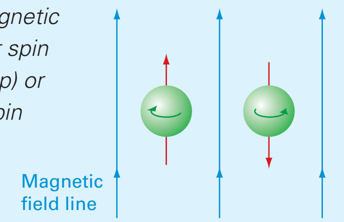
Eddington went ahead as planned in 1919. During the eclipse, Eddington measured the apparent shift in the positions of stars that were beyond the Sun, as their light rays were curved by its gravity. His results were in close agreement with Einstein's predictions.

The international press were captivated. One reporter suggested to Eddington that he was one of only three men who understood Einstein's theory. Eddington replied, possibly ironically: 'I am trying to think who the third person is.'

Predicting particles

That person could well have been **Satyendra Bose**, the Indian physicist who translated Einstein's paper on the general theory of relativity from German into English. In 1924, Bose devised a theory for photons

***Figure 2** An electron has spin. In a magnetic field, it can either spin clockwise (spin up) or anti-clockwise (spin down)*



and black body radiation. The theory came from a mistake he made in a lecture: while trying to show that theory could *not* predict the behaviour of photons, he accidentally showed that it *could*.

After some correspondence with Einstein, Bose developed a new type of statistics that described the behaviour of photons and similar particles. These particles, which have whole-number values (0, 1, 2 etc.) of a property called spin, are now known as **bosons** after Satyendra Bose.

Particles that are not bosons are called **fermions**. They have a spin of ½, 1 ½, 2 ½ and so on. This family of particles includes protons, neutrons and electrons (Figure 2), and takes its name from **Enrico Fermi**, the Italian American physicist who built the first **nuclear chain reactor** in a Chicago squash court in 1942. This was 4 years after he had escaped from the fascists at the time of his Nobel prize ceremony. After collecting his prize – for work on creating radioactive isotopes through neutron bombardment – Fermi slipped out of the Stockholm Institute and made good his escape.

Physics and facism

Another scientist who fled the fascists was **Niels Bohr**. Bohr stayed in his native Denmark for 3 years of the Nazi occupation. But, in 1942, he escaped via Sweden to England in the empty bomb rack of a British plane. He made his way to America and joined Fermi and others in the Manhattan Project, building America's **atomic bomb**.

Before he left, Bohr had had a secret meeting with his former pupil, the German physicist **Werner Heisenberg**. In the 1920s, Heisenberg had developed a mathematical method to describe the behaviour of atoms. This was one of the foundations of quantum mechanics, the basis of much of today's physics. Later, during the Second World War, he was a member of the **Uranium Club** – the German group trying to develop a fission weapon. In 1941, he travelled to Copenhagen to meet his old friend Bohr and they went for a stroll after dinner. Their discussion remains a mystery. Did Heisenberg pass information to Bohr, or did he try to enlist Bohr's help with the Uranium Club? We may never know for sure.

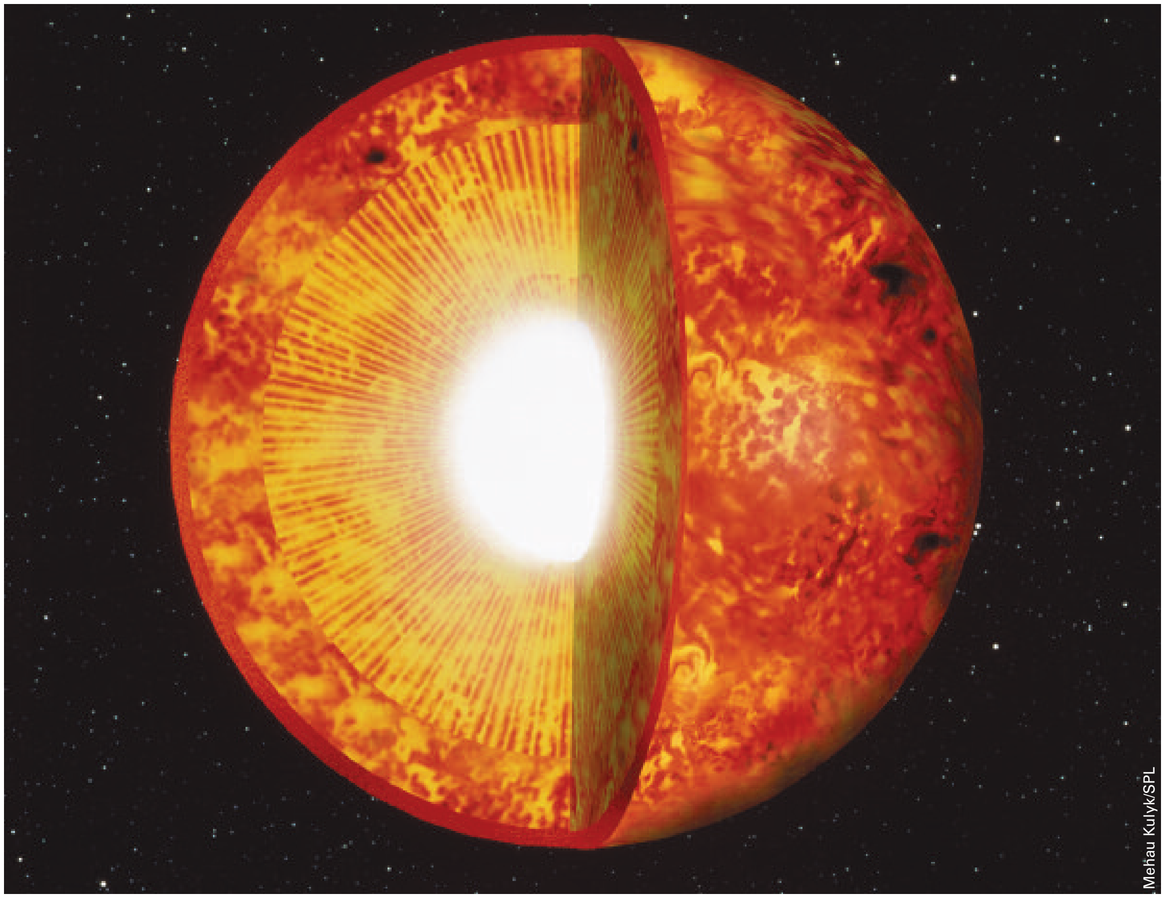
The Uranium Club also included the German physicist **Hans Geiger**. During the Second World War, Geiger was an enthusiastic Nazi. This was totally at odds with the vehemently anti-fascist views of his

Photons are the particles which carry the energy of electromagnetic radiation. Einstein used the idea of photons to explain the photoelectric effect.

In his *annus mirabilis*, Einstein published three papers. Their contents initiated modern cosmology and quantum mechanics – the foundations of modern physics.

Classical mechanics, developed by Newton and others, is used to describe large-scale phenomena. It does not work on the scale of atoms – quantum mechanics must be used instead. It is the basis of semiconductors and therefore much of our technological world.

Right: *Computer graphic of the interior of the Sun. Scientists now know that the Sun is a massive nuclear fusion reactor*



The Hot Big Bang theory, generally accepted by scientists today, says that the universe exploded into existence, emerging from a single point, about 14 billion years ago.

former tutor, **Ernest Rutherford**, for whom he had performed the famous alpha particle scattering experiments during 1908. In 1933, Rutherford had set up the Academic Assistance Club to help Jewish scholars escape the rising hatred in Germany.

Another of Rutherford's students, **James Chadwick**, could have used some help in the previous war. Chadwick left Manchester in 1914 to work with Geiger in Berlin. Unfortunately for him, the assassination of Archduke Ferdinand on 28 June 1914 led to the outbreak of the First World War. He was trapped in Germany and spent 4 years interned in the stables of a German racecourse. On his return home, he joined Rutherford at the Cavendish Laboratory in Cambridge where his work led to the discovery of the **neutron** in 1932.

The age of the Sun

The following year, the Russian physicist, **George Gamow**, escaped a different tyranny by defecting from Stalin's Soviet Union to America. Gamow worked on many things (including the genetic code), but is renowned for his description of the **Hot Big Bang**. The paper, which he wrote with his student **Ralph Alpher**, was published in 1948. When he heard that **Hans Bethe** was in town, Gamow could not resist a little radiation joke: he asked Bethe to add his name to the paper which became the Alpher, Bethe, Gamow (α,β,γ) paper.

Hans Bethe is best remembered for developing a theory that describes the nuclear processes inside the Sun. His theory explained, at last, how the Sun could stay so hot and have lasted so long — 4.5 billion years, long enough for life to evolve on Earth. Only 50 years earlier, **William Thomson** (**Lord Kelvin**) had estimated the age of the Sun as about 20 million years — 200 times too small.

Kelvin had described the Sun as an incandescent rock that had gained all its energy from ancient meteor impacts. Somewhat boldly, in 1900 he had stated that: 'There is nothing new to be discovered in physics now. All that remains is more and more precise measurement.' Had Kelvin waited 5 years — for Einstein's influential papers — he might have been more cautious.

Physics, past and future

Hans Bethe died in 2005, the year in which we celebrated 100 years of astute, committed and often brave people who made the century of physics. Their stories are as much about human endeavour, strength and frailty as of laboratories and brassware. The physics they have developed would be unrecognisable to Kelvin. Physics is still changing. Who knows what will happen in the next 100 years?

Charles Tracy *is a schools adviser in Hertfordshire and develops physics teaching resources.*

• Visit www.physics.org/evolution/evolution.asp for an animated history of physics.

Predator and prey

This is a good time of year to see predators such as waterboatmen in action and think about the way they deal with their prey.

Waterboatmen feed on a range of invertebrates in ponds, lakes and even water butts. They swim on their backs, using their third pair of oar-like legs. Their other two pairs of legs are much shorter and are used for grabbing prey and manipulating it into the best position for feeding. They have stabbing piercing mouthparts. They use these to inject saliva into their prey before sucking out the contents.

Water boatmen usually hatch in April and May, from eggs laid either on the stems of pondweed or on hard surfaces, depending on the particular species. Water boatmen are about 15 mm long when fully grown, as they are by July. When they first hatch, as miniature adults, waterboatmen are about 3 mm long. They moult to about 6 mm, then 9 mm, then 12 mm, before their final moult.

Their prey depends on their age — a water flea (*Daphnia*) is worth catching if you are only 3 mm long, but larger waterboatmen prey on mosquito larvae and pupae, as well as other freshwater invertebrates.

You can watch waterboatmen in action if you have a pond that is safe enough to lie down by and peer in. But it can be more interesting to take them out of the pond to have a closer look.

Looking after predator and prey

Waterboatmen can be kept in a glass jar with water and a few sprigs of pondweed.

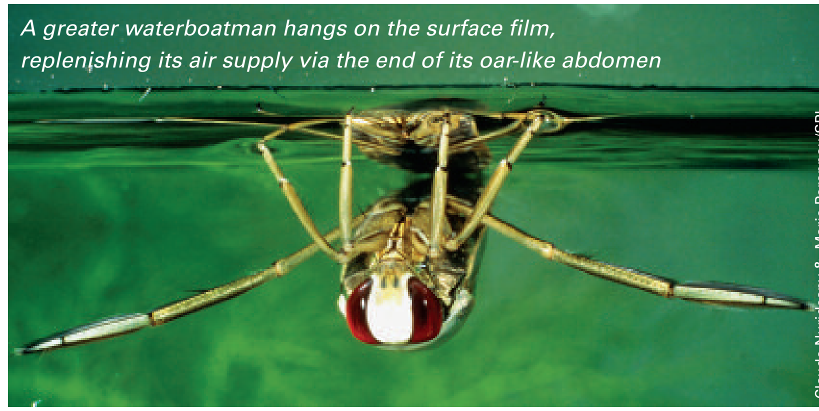
Water fleas are common in ponds in the spring and summer but can also be bought from aquarists. If you catch mosquito or midge larvae or pupae, remember that any adults which eventually hatch can bite!

- Keep all animals in pond or rainwater.
- Return the survivors to the pond from which they came.
- Adult waterboatmen have sharp mouthparts, which can pierce skin if you pick the insects up by hand.

Predation in action

Put a waterboatman in with some prey and watch what happens. What happens if the prey makes contact with the surface? What happens if you touch the surface with a hair?

The waterboatman can also see prey below the water surface. How good is it at locating prey this way?



A greater waterboatman hangs on the surface film, replenishing its air supply via the end of its oar-like abdomen

Claude Nuridsany & Marie Perennou/SPL

What you need

- a means of catching predator and prey — if you don't have a net, a plastic kitchen sieve is fine
- some glass jars, or plastic lemonade bottles cut to make beakers, to keep predator and prey
- a glass dish or a plastic tray in which to see predators in action — it helps to have a large surface area
- a magnifying glass helps, although you can see a lot with the naked eye
- plastic or metal spoons to transfer predator and prey
- watch or timer

Box 1 Warning!

Be careful near open water. Do not go near open water on your own and take care when watching or collecting waterboatmen and their prey from ponds or lakes.

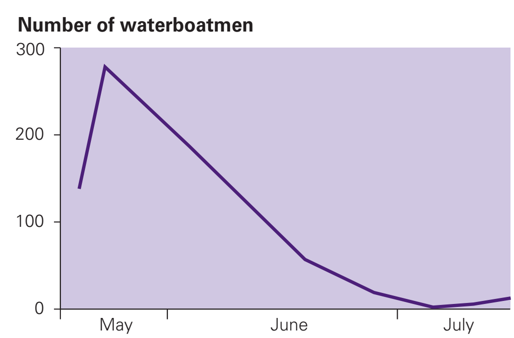


Figure 1 *Changes in waterboatmen population, May to July*

Once it has caught something, how does it hold it? Does it move the prey around at all? Can you see when it sticks its piercing mouthparts into its prey? How long does it feed for before discarding its prey?

- What happens if you catch waterboatmen that have fed well, rather than some that have not eaten in a while? You could keep waterboatmen isolated for a day before offering them prey.
- What happens if you offer waterboatmen different sorts of prey in different proportions?
- Is there any difference in the way a waterboatman behaves when it has only one prey item in the tank with it, compared with when there are lots?

Some overwinter, but many only survive the one season.

Waterboatmen are in a group called the *Hemiptera* — the true bugs.

Nigel Collins *is an editor of* CATALYST. *His excitement at watching waterboatmen in action used to bemuse his students.*

TopFoto

Educational psychology

- **Find out which combinations of A-levels are suitable for entry to a psychology degree by going to the British Psychological Society website (www.bps.org.uk) and investigating the careers section.**

Psychology is an increasingly popular subject at A-level and university, but many students are not sure what psychology is or what they would be doing if they chose to study psychology or to work as a psychologist. Jane Leadbetter tells us about her job as an educational psychologist.

Many television programmes show psychologists helping to solve crimes, commenting on families who are experiencing difficulties or helping parents to control their difficult children. They all show psychologists applying their knowledge of psychology to everyday situations, but what is the subject of psychology about?

According to the British Psychological Society website (**www.bps.org.uk**): 'Psychology is the study of people: how they think, how they act, react and interact. Psychology is concerned with all aspects of behaviour and the thoughts, feelings and motivation underlying such behaviour.'

Working as an educational psychologist

Educational psychology is just one of the careers you can choose if you have a degree in psychology (Box 1). It is a fascinating and worthwhile job as it focuses on tackling the problems encountered by young people in education. These may involve learning difficulties or social or emotional problems.

Educational psychologists normally work in schools, colleges, nurseries and specialist settings. They spend some of their time working with children and young people to assess their difficulties and suggest ways forward. They also spend a lot of time in

Box 1 Other types of psychology

Interested in psychology but not educational psychology? Here are some other types of psychology courses listed by UCAS:

- animal psychology
- applied psychology
- applied social psychology
- behavioural science
- business psychology
- clinical psychology
- cognitive psychology
- cognitive science
- counselling psychology
- developmental psychology
- European social psychology
- experimental psychology
- forensic psychology
- health psychology
- human psychology
- occupational psychology
- psychology of communications
- social psychology
- sport psychology

Find out more about these and other courses on the UCAS website (www.ucas.com).

Box 2 A typical working day

Nursery visit

Today starts with a visit to a nursery. A child is causing concern because he is not talking to other children and does not interact socially with them. Perhaps this child has a speech or language problem?

After observing the child and playing alongside him in the nursery, I meet with the important people in the child's life. These are the child's parents, the staff in the nursery and, in this case, perhaps a speech and language therapist, to discuss the particular worries and to suggest plans that can be put into place.

I will probably make a follow-up visit to see the child at home, to do a detailed assessment with the child to find out the exact nature of the problem. The health services will also be contacted to check on the child's overall development. Psychologists know how children develop and can detect if a child is developing differently from the usual patterns.

School visit

Later in the morning it's a school visit to check how a class teacher is getting on with a plan to improve the classroom environment. The behaviour of some boisterous and unruly pupils is causing problems. After observing how the classroom is arranged, how the lessons are planned and how the teacher manages the children, I made suggestions about how things might be improved. The teacher has tried some of the suggestions and noticed that the lessons have improved. Psychologists know about factors that affect behaviour and aggression and also about 'classroom ecology'.

Teacher session

The first afternoon session is with teachers, not children. Educational psychologists train teachers and other adults in schools. This afternoon is a training session about children's social and emotional needs. Other sessions have been about new initiatives such as peer mentoring and paired reading. After a training session there will be more visits to help the staff to put the new systems in place and ensure that they work properly.

Home visit

Late afternoon is a home visit to a family whose child has been referred for help. This visit is about finding a suitable school. Some children need a fresh start at another school or are in danger of being permanently excluded from their current school. It is the time to find out the parents' views and to compare the child's behaviour across the very different environments of home and school.

Speech and language specialists work with children who have difficulty speaking, hearing or understanding spoken words.

- **Get involved in any peer listening and peer mentoring groups at your school.**
- **Go to www.psychnet-uk.com/games/games.htm to try some psychological games.**
- **Find out about the lives and work of some famous psychologists at www.psychnet-uk.com/training_ethics/psychologists.htm**

schools with teachers and others discussing problems that arise within the whole school, or within particular classes, and, of course, with specific children who may be causing concern.

The work is incredibly varied as it involves children and young people from the age of 2 to 19. Box 2 describes a typical working day. More and more educational psychologists are working closely with other professionals who are concerned about children's wellbeing outside schools.

How to become an educational psychologist

To be an educational psychologist, you must have a degree in psychology. You will need very high grades at A-level to gain a place on a suitable psychology course.

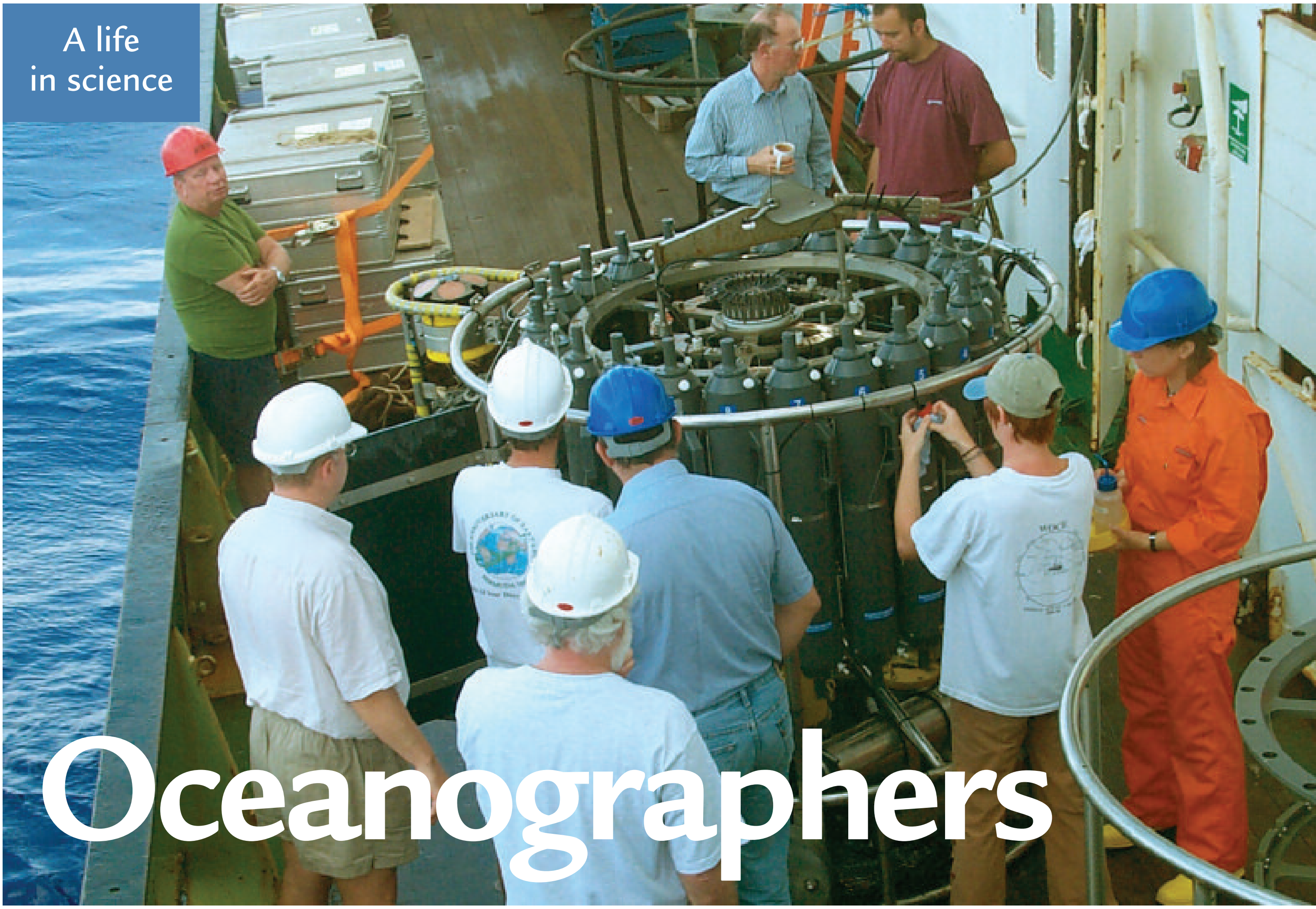
After graduating you must spend at least 2 years working with children in a range of settings; many people train and then work as teachers to gain the experience. Finally, you need to complete a 3-year doctoral course at university to qualify as an educational psychologist. It's a long training, but it's worth it in the end!

Dr Jane Leadbetter *is Tutor in Educational Psychology, University of Birmingham, and Senior Educational Psychologist, Birmingham LEA.*

Educational psychologists often assess the needs of individual children

TopFoto

A life in science



Oceanographers

Above: *Professor Harry Bryden enjoys a mug of tea while an array of water samplers is prepared for lowering into the ocean*

The three oceanographic scientists — Harry Bryden, Stuart Cunningham and Hannah Longworth — who were involved in investigating the Gulf Stream (pages 6–7) relate something of their lives in science.

Scientific research often involves people working together on problems, either directly in teams or by maintaining close contact with each other. Scientists might work with engineers to create new instruments for a space probe or with mathematicians and software engineers as they model the workings of cells or climate change.

The Royal Society is the UK Academy of Sciences. When he was made a Fellow the citation said that 'Professor Harry Bryden is known internationally for the outstanding contributions he has made through careful observation and innovative analysis and interpretation of data to the study of the meridional transport of heat in the ocean.'

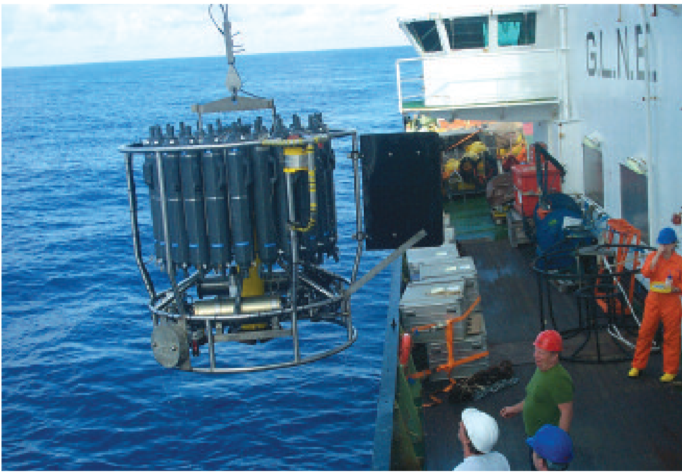
Box 1 Stuart Cunningham

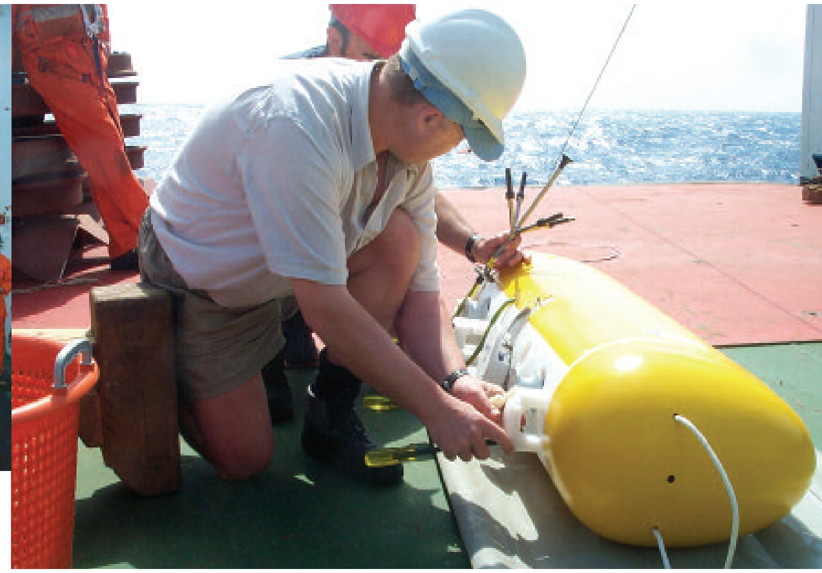
There is great debate about the relative importance of environment and genetics for determining what makes you you — nature versus nurture. My early life supports both sides. My father was an analytical chemist working in the steel industry; perhaps I inherited some 'science' genes from him. But I also grew up discussing science — mainly physics and astronomy — on a daily basis. My mother's side of the family were all boat builders. So there it is. Take one chemist and one boat builder's daughter to make one oceanographer!

After completing a BSc in astrophysics from the University of Edinburgh, I converted to physical oceanography by completing a MSc at Bangor, before joining the Institute of Oceanographic Sciences as a sea-going oceanographer. At first I worked with the UK team in the World Ocean Circulation Experiment. This was a grand project, involving tens of thousands of scientists from around the world, whose goal was to define the mean state of the ocean over a 7-year period.

I have spent about 2.5 years of my life at sea all over the world on this and subsequent projects, making measurements of ocean temperature, salinity and currents.

I completed my PhD at the University of Liverpool in 1997 and am now a principal investigator in an international programme to measure the role of the ocean in rapid climate change (www.noc.soton.ac.uk/rapidmoc).





Above: *The water samplers are lowered into the ocean*
Right: *Stuart Cunningham working on a profiler before it is attached to a mooring cable (see back page)*

All photographs: National Oceanography Centre, Southampton

The project studying the ocean currents in the north Atlantic, described on pages 6–7, involves a large international team of people. The principal investigator for the UK component is **Professor Harry Bryden**. He was born in the USA at Providence, Rhode Island, and went on from high school to do a degree in mathematics at Dartmouth College in 1968.

Following a summer spent at an oceanographic research institute called Woods Hole, Harry applied his mathematics to oceanography, first with the US Navy and then when he became involved in research at Woods Hole. He worked on to complete a PhD in 1975. During this time he was supported by a series of research grants, but by 1983 Harry had earned a permanent position as a Senior Scientist.

In 1993 Harry moved to England and in 1995 joined the Southampton Oceanography Centre. Last year he was elected to become a Fellow of the Royal Society. As Professor of Physical Oceanography at Southampton University, he teaches and conducts research with other scientists, including his fellow author Stuart Cunningham, and supervises the research of PhD students, such as Hannah Longworth. In Boxes 1 and 2 Stuart and Hannah tell their own stories about how they became involved in oceanography.

- **You can read more about life and work on cruises to deploy moorings to monitor ocean currents, temperature and salinity at www.soc.soton.ac.uk/rapidmoc/home.html by clicking on 'News' and choosing a cruise.**

Box 2 Hannah Longworth

I have always enjoyed problem solving — this fuelled my early interest in science. When I was doing my GCSEs I had a work experience placement at Merlewood, a research station on the southern edge of the Lake District. I met scientists studying climate change and had my first experience of fieldwork with a group studying soils.

I went on to study A-levels in mathematics, further mathematics, physics, chemistry and general studies. My degree choice of Oceanography with Mathematics (BSc) at the University of Southampton was determined by the potential to combine mathematical analysis of the dynamic ocean system with fieldwork at sea.

After graduating, I had the chance to stay on in Southampton at the National Oceanography Centre, to work for a PhD. I am analysing oceanographic observations made over the last 25 years at 26°N to try to build up a picture of the Atlantic Meridional Overturning Circulation (MOC) over that time.

Hannah Longworth working on a sampler at 26°N

The current MOC monitoring project, which is funded for 4 years, involves more frequent observations, so this will provide much more detail over the short term to complement the 25-year picture.

Both projects rely on cruises to deploy/recover moorings and measure *in situ* water properties. Going to sea provides invaluable insight into the limitations of the data but is an intense experience. For up to 6 weeks, scientists, technicians and the ship's crew work a shift system, allowing almost continuous data collection and processing of parameters, including water temperature, salinity, velocity, nutrient, carbon and oxygen content.

I am looking forward to seeing the results from the first year of monitoring and how they tie in with the five historical sections.

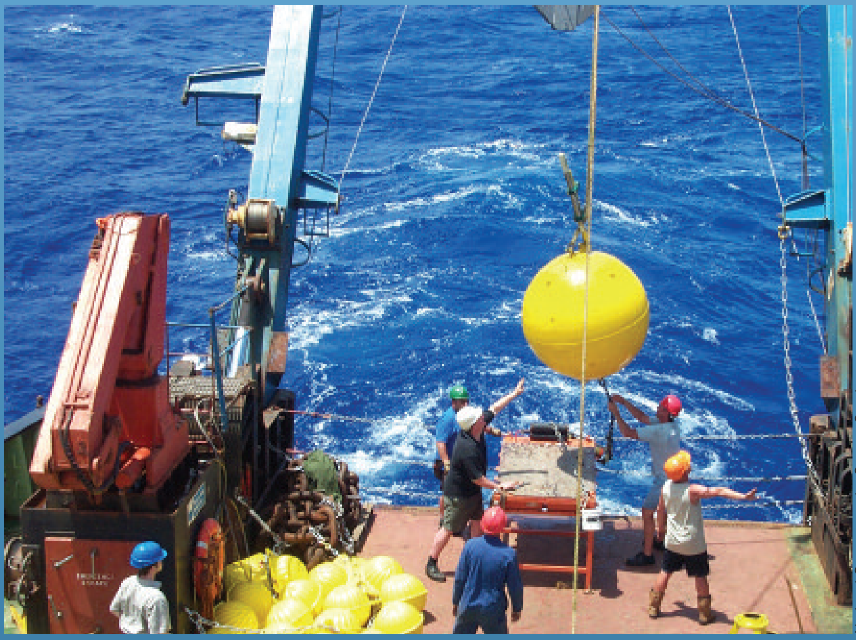
The Centre for Ecology and Hydrology which used to be based at Merlewood, Grange-over-Sands, Cumbria, is now based at Lancaster University.

Logging data from the world's oceans

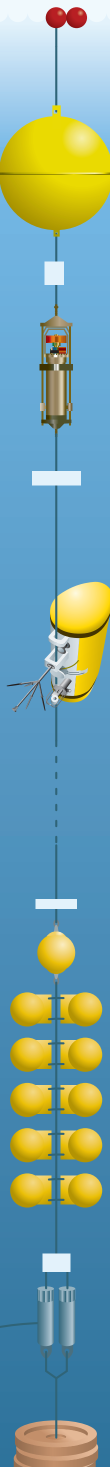
Scientists collect all sorts of information about the world's oceans. Temperature, salinity, currents, depth and other parameters, such as amounts of plankton, are all of interest to oceanographers and other scientists. Sometimes data are collected using devices towed behind ships; sometimes ships heave to and lower instruments on cables. Some data are collected by instruments attached to submerged buoys, floating with the ocean currents. These surface every so often and transmit the data they have logged to laboratories far away, via satellite.

The international project described on pages 6–7 involves instruments attached to wires up to 5000 metres long. The wires are anchored to the seabed and buoys at the top, just under the surface, hold them straight. Some instruments motor up and down the wires every 2 days, taking measurements.

In all there are 22 moorings on the continental slope off Africa, either side of the Mid-Atlantic Ridge, and on the continental slope of the USA.



National Oceanography Centre, Southampton



Activities

- You can watch a short film of the cruise to put out these moorings by clicking on www.noc.soton.ac.uk/rapid/sis/moc_monitor.php
- Plankton monitoring is described in CATALYST Vol. 15, No. 3.
- You can find out more about datalogging carried out by submerged buoys at www.noc.soton.ac.uk/JRD/HYDRO/argo/op_argo.php