Winter 2006 Issue 3

SCIENCE in SCHOOL

In this issue:

Human diversity

Alec Jeffreys' early fascination with chemistry, and current work with Chernobyl survivors

Also:

Highlighting the best in science teaching and research

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www.eiroforum.org

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The great yellow bumblebee, *Bombus distinguendus*
Image courtesy of Dave Goulson, University of Stirling, UK

Energy production in the Sun
Image courtesy of Mark Tiele Westra, European Fusion Development Agreement, Germany

Contents

Welcome to the third issue of *Science in School*

Feedback from our readers has continued to be very positive: you've told us that you like the variety of articles, the informative but readable style, and the unique combination of ideas drawn from teachers and scientists across Europe. This issue, like the first two, offers a wide range of subjects and contributors: teachers, scientists, politicians and others from nine European countries cover topics as varied as bird flu, proteomics, solar fusion and what it feels like to discover your very own comet.

In our feature article, world-renowned geneticist Alec Jeffreys, the inventor of DNA fingerprinting, reminisces about his childhood passion for science and describes his current work on the aftermath of the Chernobyl disaster – how profound are the effects and how long will they be felt? Meanwhile, deep below the ocean surface, scientists are using plankton to predict an even more far-reaching phenomenon: climate change.

If you prefer something more hands-on, Graham Gardner is sure to entertain and inspire with his school detective mystery. Or why not help save European bumblebees, explore the behaviour of maggots, or investigate whether a good night's sleep really does help you to learn?

In the events section, we review some recent and future activities in science education across Europe. Stephen Parker from the European Commission describes the excitement of the European Union Contest for Young Scientists in Stockholm; Sabina Griffith reports on how EIROforum took a group of young people for a virtual trip around the world; and Douglas Pierce-Price invites school students to enter an astronomy competition and win a trip to Chile.

When several readers asked us to include articles on the history of science, we took up the challenge. This issue offers not only a consideration of the Muslim contribution to Western science and a fascinating project combining evolution and anatomy, but also a do-it-yourself (and then eat-it-yourself) geological map.

But *Science in School* is not only **for** you; it also depends on your involvement. You can leave comments online

for all readers to see or email your suggestions directly to us. We are also still looking for teachers to join our reviewer panel, to help us decide which articles to include and how to improve them; see the *Science in School* website for details.

Several of you have already translated *Science in School* articles from English, to make them available to a wider European audience. Thanks to your efforts, we now have articles online in 16 languages (Albanian, Bulgarian, Czech, Dutch, Estonian, French, German, Italian, Latvian, Portuguese, Romanian, Russian, Slovene, Spanish, Swedish and Ukrainian). This is a good start, but we still need more help: we are still far from including all articles in all European languages. If you would like to help, please contact us.

Finally, you are not only our readers, but also potential authors. Have you prepared some original and exciting teaching materials? Are you involved in a project that could serve as a role model for teachers, scientists or museums in other European countries? Would you like to try your hand at writing a short, amusing and informative article for the 'Back in the staffroom' slot? Or do you use a popular film to teach an aspect of science?

We are looking particularly for good ideas for interdisciplinary teaching, as well as articles on chemistry, mathematics and earth sciences. Have you combined science topics in a creative way? Or linked science with subjects such as art, languages, information technology (IT) or ethics? Perhaps you've looked at the connections between mathematics, physics and medieval church architecture? Or used Google Earth in a biology lesson? This is your chance to share those ideas with teachers and others across Europe!

In the meantime, enjoy the articles in this issue.

Eleanor Hayes
Editor, *Science in School*
editor@scienceinschool.org

Forthcoming events

Throughout 2006
Europe-wide
Competition: Marine photography
By sharing the enthusiasm of scientific discovery and the beauty of the sea, Marine Genomics Europe wishes to raise awareness among European citizens of the value of science and the need to protect our marine heritage. In a photography competition, underwater images will be publicly exhibited during 2006 in a travelling exhibition at aquaria, museums and schools. Schools, science museums and others are invited to host the exhibition.
More information: www.marine-genomics-europe.org
Contact: Michele Barbier (barbier@sb-roscoff.fr)

3-6 January 2007
Birmingham, UK
Conference: The Association for Science Education (ASE) annual conference
Science teachers and technicians are invited to explore, debate and discover what is important to them in the world of science education in over 350 lectures and workshops. Highlights include:
- Lectures on teaching and learning
- Cutting-edge science
- Hands-on practicals to use in the classroom
- A commercial exhibition of resources for making science accessible to young people.

More information: www.ase.org.uk

4-6 January 2007
Birmingham University, UK
Workshops: Dynamic Science
Aimed at teachers of 11-16-year-olds, these 90-minute workshops help biology, physics and chemistry teachers to teach science in an earth-science context, making the science relevant to the world around us, our environment and our lives. Workshops are relevant to teachers in all countries. The workshops are led by science educators from the Earth Science Education Unit and will take place within the Association of Science Education (ASE) annual conference.
More information: www.earthscienceeducation.com
Contact: eseu@keele.ac.uk

14 March 2007
Keele, UK
Training course: Motivating the Disaffected in Science
This new course views learning from the pupils' perspective and seeks engaging solutions to motivate and inspire adolescents to succeed in science. Pop culture, movies and games can all be applied in new teaching and learning approaches. This course will share outcomes from classroom-trialled activities and recent research findings to provide participants with immediate ideas for the classroom.
More information: www.slcs.ac.uk/wm
Contact: enquiries@slcwm.keele.ac.uk

19 March 2007
Warwickshire, UK
Training course: Learning Skills in Science
This training course aims to:
- Enhance learning skills for science among secondary school students
- Provide teachers with resources that can be easily integrated into a variety of scientific subjects
- Design flexible teaching and learning tasks suitable for different levels of students and a variety of learning styles.

More information: www.slcs.ac.uk/wm
Contact: enquiries@slcwm.keele.ac.uk

20 March 2007
Worcestershire, UK
Training course: Learning Skills in Science
This training course aims to:
- Enhance learning skills for science among secondary school students
- Provide teachers with resources that can be easily integrated into a variety of scientific subjects
- Design flexible teaching and learning tasks suitable for different levels of students and a variety of learning styles.

More information: www.slcs.ac.uk/wm
Contact: enquiries@slcwm.keele.ac.uk

Until 30 March 2007
Europe-wide
Competition: Marine Biodiversity
To celebrate Biodiversity Day, MarBEF (Marine Biodiversity and

Ecosystem Functioning) are launching a competition for European children and adults to capture marine biodiversity by:

- Drawing a picture
- Designing a mascot
- Taking a photograph.

Winners will receive prizes of value up to €100, and their entries may be published online and in the MarBEF newsletter, which is delivered to almost 1000 scientists across Europe.
More information: www.marbef.org/outreach/kids/competition.php
Contact: Chris Emblow (cemblow@ecoserve.ie)

2-6 April 2007
European Synchrotron Radiation Facility, Grenoble, France
Science teaching festival: Science on Stage 2
The Science on Stage programme offers European science teachers the chance to exchange successful and innovative teaching methods and materials. The goal is to strengthen the awareness and interest of young people in science and technology by increasing the attractiveness of science lessons through the promotion of exciting ideas.
Competitions, workshops and events organised by national steering committees will take place in 30 participating European countries in 2006. These activities will raise awareness of best practices in science teaching and identify exceptional teaching projects and outstanding educators in each country.
At the European science teaching festival at the European Synchrotron Radiation Facility in Grenoble, France, from 2-6 April 2007, 500 teachers from 30 countries are expected to take part. The event will showcase the very best of today's science education and serve as a discussion forum for relevant topics.
European teachers can apply through their national steering committees to take part in their countries' activities. The best proposals will be selected for the international festival. Proposals can be for workshops, displays at the teaching fair or on-stage activities, such as presentations or performances. The national webpages and contact points can be accessed from the European Science on Stage project website.
Science on Stage is organised by EIROforum (a collaboration between seven European inter-governmental scientific research organisations), who also publish *Science in School*. It is part of the NUCLEUS project supported by the European Union. Science on Stage is also supported by the European Physical Society and the European Association for Astronomy Education.
More information: www.scienceonstage.net
Contact: Physics.on.Stage@esa.int

26-31 August 2007
Opatija, Croatia
Conference: GIREP-EPEC: Frontiers of Physics Education
For the first time, the GIREP (International Research Group on Physics Teaching) Seminar is organised as a joint event with European Physics Education Conference (EPEC). While GIREP traditionally gathers experts and practitioners in educational physics, EPEC is a young conference organised by the European Physical Society, which attracts the top physicists in Europe.
The joint conference will bring together physics teachers from schools and universities across the European continent, encouraging dialogue and the exchange of best practice in physics education. Teachers are invited to join this conference. (Theme to be arranged, the working language will be English.)
More information: www.ffri.hr/GE2
Contact: ge2@ffri.hr

Until 30 November 2007
Italy, Austria and Switzerland
Competition: Junge Forscher gesucht! – Giovani ricercatori cercansi! (Wanted: young researchers!)
In this search for talented young researchers, young people are required to develop scientific projects on many topics, including art and music. Regional finalists, selected on the basis of a report they submit, present their project to an international jury and the public. Prizes of €1500-3000 are awarded.
The competition is open people aged 16-20, living in South Tyrol (Italy), Trentino (Italy), Tyrol (Austria) or Grisons (Switzerland), and is held in the regional languages German and Italian.
To enter the next competition, register before 30 November 2007. The final event will take place in March 2008 at the University of Innsbruck, Austria.
More information: www.explora-science.net/wettbewerb

Throughout 2007
Schullabor Novartis, Basel, Switzerland
Workshop: 'Gentechnik Erleben' (Experience Genetic Engineering)
These workshops focus on practical laboratory work, but background information is given for all experiments. Students isolate plasmid DNA from bacterial cultures and digest it with restriction enzymes. The resulting DNA fragments are separated and visualised by gel electrophoresis. Students should already have the necessary theoretical background and be over 17 years of age. The workshops are free, are run in German or English (on request) and have a maximum of 20 participants.
More information: www.schullabor.ch
Contact: gesche.standke@novartis.com

Throughout 2007

10 locations around the UK

Training courses: Science Continuing Professional Development

The national network of Science Learning Centres, set up by the UK Department for Education and Skills and the Wellcome Trust, provides continuing professional education for everyone involved in UK science education, at all levels. With nine regional centres and a national centre in York, access to innovative and inspiring courses is within reach across the UK. The centres not only deliver hundreds of courses, but also act as a focus for all the science learning activities in their region.

More information:
www.sciencelearningcentres.org.uk
Contact: enquiries@national.slcs.ac.uk

Throughout 2007

Pembrokeshire, Wales, UK

Field trip: Rockpools

The Pembrokeshire Darwin Science Festival invites all primary schools in Pembrokeshire to book a rockpool ramble and identification field trip. The course is aimed at Key Stage 2 pupils (ages 8-11), takes half a day and is led by three qualified marine scientists. Cost: £250 with a bus or £170 without a bus. Maximum 30 children.

More information:
Pembrokeshire Darwin Science Festival
Contact: Marten Lewis
(M.B.Lewis@pembrokeshire.ac.uk)

Throughout 2007

Pembrokeshire, Wales, UK

Workshops: Primary school

The Pembrokeshire Darwin Science Festival offers a double workshop visit for a maximum of 30 Key Stage 2 pupils (ages 8-11) and costs £200 for half a day. The group is split into two workshops, which run simultaneously:

- Plankton / microscopy identification workshop
- Energy workshop using dynamos, solar panels and a steam engine as hands-on props.

Also available are three 90-minute workshops, each for a maximum of 20 pupils and costing £120:

- Oil-spill workshop for Key Stage 2 pupils (ages 8-11)
- Climate change workshop for Key Stage 2 pupils (ages 8-11)
- Marine litter workshop for Key Stage 1 pupils (ages 4-7)

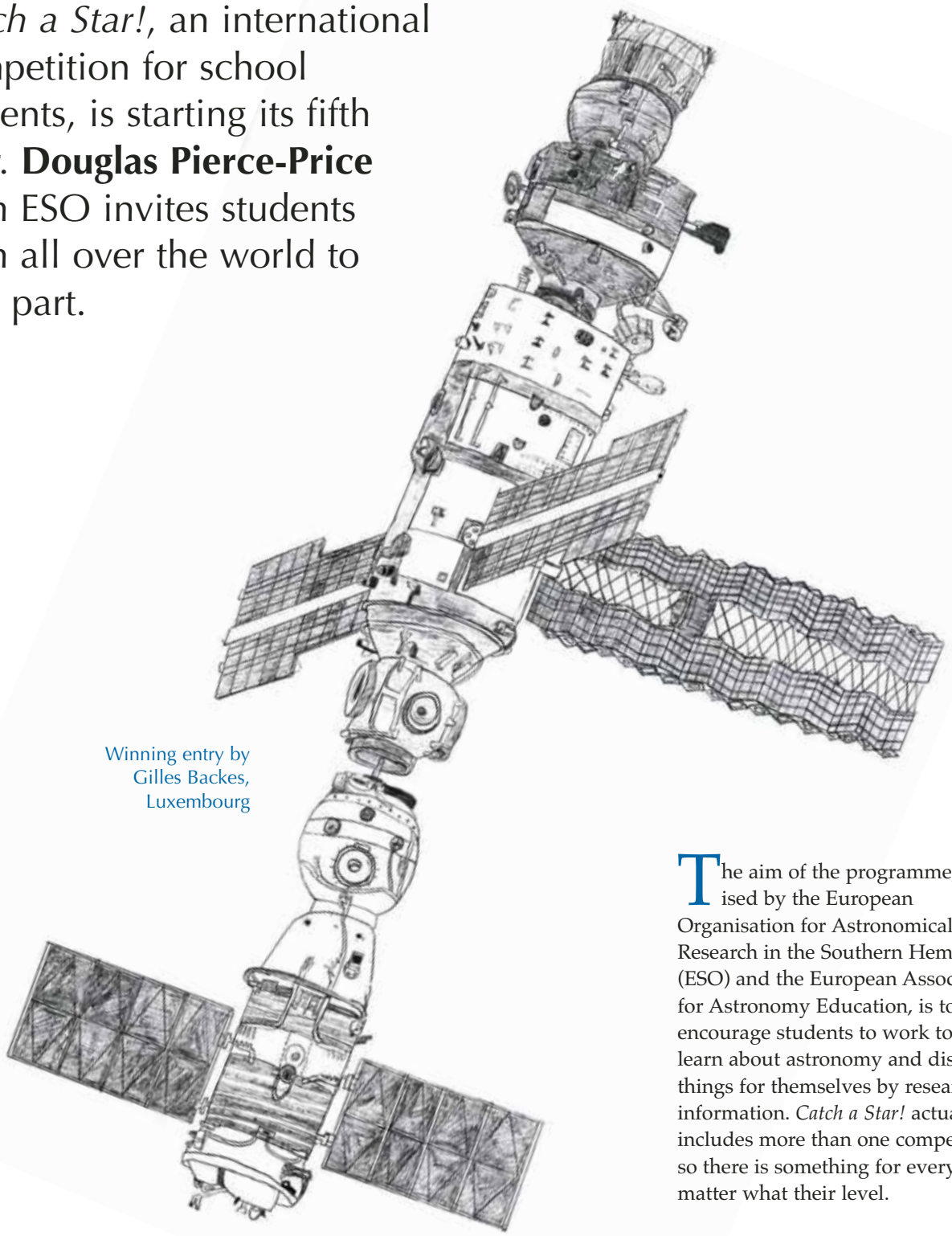
More information:
Pembrokeshire Darwin Science Festival
Contact: Marten Lewis
(M.B.Lewis@pembrokeshire.ac.uk)

If you organise events or competitions that would be of interest to European science teachers and would like to see them mentioned in Science in School, please email details, including date, location, title, abstract, website and contact email address to editor@scienceinschool.org

For a frequently updated list of forthcoming events, see the *Science in School* website: www.scienceinschool.org

Catch a Star! and win an astronomical competition!

Catch a Star!, an international competition for school students, is starting its fifth year. **Douglas Pierce-Price** from ESO invites students from all over the world to take part.



Winning entry by Gilles Backes, Luxembourg

The aim of the programme, organised by the European Organisation for Astronomical Research in the Southern Hemisphere (ESO) and the European Association for Astronomy Education, is to encourage students to work together, learn about astronomy and discover things for themselves by researching information. *Catch a Star!* actually includes more than one competition, so there is something for everyone, no matter what their level.

Winning entry by Karolis Markauskas, Lithuania

Winning entry by Tom Dumont, Luxembourg

Student teams can write a project about a chosen topic in astronomy, selecting an astronomical object such as a nebula, star, planet or moon, or a more general theme such as 'black holes' or 'star formation'. They research this theme, and discuss how large telescopes such as ESO's can play a part in studying it. The most important goal is to develop an interest in science and astronomy through investigation and teamwork. For this reason, to make the programme inclusive and to avoid a sense of elitism, one section of the competition has prizes awarded by lottery.

There is also another section in which an international jury awards prizes including a trip to visit ESO's Very Large Telescope facility on the Paranal mountain-top in Chile.

Younger students are invited to take part in an additional *Catch a Star!* drawing and painting competition, with prizes awarded with the help of a public web-based vote.

How to take part

To take part in this year's *Catch a Star!*, visit the website at www.eso.org/catchastar/ to find full details of the competition and to submit your entries. The contest is now open, and the deadline for entries is 2 March 2007. Winners will be announced at the Science on Stage 2 teaching festival in Grenoble, France, in April 2007.

Results from the previous competition

In the previous competition, which ran in 2005-2006, more than 130 teams

Winning entry by Yuriy Baluk, Belarus

Winning entry by Ruta Eistreike, Latvia

from 24 countries wrote projects about astronomy. Winning projects included topics such as 'Star clusters and the structure of the Milky Way', 'The fireworks galaxy – NGC 6946', 'The annual solar eclipse vs the Venus transit', and 'Sunspots'. In the picture competition, students created a large number of very impressive drawings and paintings, and some of the winners are shown in this article.

Given the importance of gender issues in science, and especially physics, it is encouraging to note that girls did particularly well in the competition. For example, of the 11 students who won travel prizes, ten are girls. There was also, as we have consistently seen in ESO's educational projects, a strong showing from Central and Eastern European nations.

We welcome the wide range of students who took part and learned something new about the wonders of the Universe. With the new and updated competition, we hope that even more students, from even more countries, will *Catch a Star!*

BACKGROUND

ESO's education activities:

In addition to the *Catch a Star!* series of competitions (www.eso.org/catchastar/), ESO has other educational projects, often organised together with the European Association for Astronomy Education (EAAE).

- We are currently working on an interdisciplinary teaching project based on the Atacama Large Millimeter Array (ALMA). ALMA is a new telescope which ESO is in the process of building, as part of a global collaboration, at an altutude of 5000 m in Chile's Atacama desert – the driest place on Earth. ESO and the EAAE are working with teachers to produce exciting interdisciplinary teaching material about ALMA. This material will highlight the links between 21st-century astronomy and the topics in engineering, earth sciences, biology, medicine, history and culture which spring from ALMA's location in the Atacama desert. To find out more and to get involved, visit www.eso.org/outreach/eduoff/edu-prog/almaitp/
- A comprehensive website about the 2004 Venus transit is available at www.vt-2004.org
- A series of information sheets for students and teachers, the ESO/EAAE 'Journey across the Solar System', is available at www.eso.org/outreach/eduoff/edu-materials/info-solsys/
- ESO, in conjunction with the European Space Agency, also offers a series of astronomy exercises at www.astroex.org

For questions about these resources or other material, please contact the ESO Educational Office at eduinfo@eso.org

ESOF 2006: science close up and personal

Image courtesy of Hans Hermann Heyer, ESO ©

At first, only a few of the audience dared to ask. Then one after the other, they realised that this might be a once-in-a-lifetime chance. How often do you get to talk to an astronomer on his way home after a long night shift under the world's largest telescope in the Chilean Atacama Desert?

More than 80 students, pupils and teachers from schools in and around Munich, Germany, took the chance and attended the live video conference that linked to six leading European research institutes: CERN in Geneva, Switzerland, ESO in Chile, JET in Culham, UK, and the joint site of EMBL, ILL and ESRF in Grenoble, France. The videolink was part of this year's European Open Science Forum (ESOF), taking place from 15-19 July 2006 in the Deutsches Museum in Munich. Its intention was to give young people the possibility to interact with representatives of the scientific community and, by doing so, hopefully raise their interest in research and perhaps a scientific career.

Geneva, Switzerland

The round-the-world trip guided by Rolf Landua from CERN started in the Swiss Alps, in Geneva, home of CERN and more than 3000 scientists and engineers from all over the world. One of them is Anne-Sylvie Giolo-Nicollerat, a physicist who is part of a team building the detector for CERN's new flagship, the Large Hadron Collider (LHC). The LHC is a particle accelerator which will probe into matter deeper than ever before. The first collision is due to start in 2007.

Heavy welding and hammering was going on inside the cavern where the detector is currently being built when the young scientist wearing a yellow helmet walked up to the camera and microphone that had been

Students and scientists communicating across the globe

How do I become a star-chaser? How do we recognise particles that we don't know? When will fusion power become available to mankind? **Sabina Griffith** from the European Fusion Development Agreement in Garching, Germany, describes the guided round-the-world trip through the science of the EIROforum organisations.

installed for the live videolink. "As you can see," Anne addressed the audience gathered in the Deutsches Museum, "we have to build very large machines to detect very small particles."

With the LHC, the scientists at CERN hope to gain new information about the origin of the Universe. And the new detector Anne and her team are constructing will help them to do so. "This machine can take more than one billion pictures per second with one million pixels per picture," Anne explained. "But how do you detect particles that you don't know?" a young girl wanted to know. "Thanks

Image courtesy of Hans Hermann Heyer, ESO ©

Inside the Large Hadron Collider

to computer models, we know pretty well what to expect," Anne replied. "Nevertheless the unexpected happens. That's always thrilling and sends the theoreticians back to their desks."

But it wasn't only the scientific aspect of Anne's work in which the young listeners expressed an interest. When it was their turn to ask questions, they wanted to know why she had chosen to be a physicist, a career in what (in their eyes) is still a man's world. "I was always interested in books about the Big Bang," Anne replied. "I guess I just wanted to know how it worked. And yes," she added, "there are still more men around in this field than women. But that has never been a problem for me."

Paranal, Chile

From Geneva, the journey continued across the Atlantic Ocean to the Atacama Desert in Chile, where the German astronomer Daniel Kubas was expecting the virtual travellers from Munich. At six o'clock in the morning local time, Kubas had just returned from his night watch scanning the Universe with ESO's impressive machine, the Very Large Telescope. Though obviously tired, he still had enough energy to explain all the questions about Einstein Rings, gravitational lenses and the capacity of the ESO telescope. Its resolution is comparable with the Hubble Space Telescope, Kubas said – and gave the young listeners a stunning example of what that means. "If there was a car driving on the Moon, we would be able to distinguish the two front lights." But if they could do so, had they found any evidence that Americans had ever set foot on the Moon, a young listener wanted to know? Not yet, it seems.

Culham, UK

At 12.25 GMT the satellite link switched back to Europe to connect the audience with Marco de Baar and Sandra Grünhagen at the Joint European Torus (JET) in Culham, UK. Sitting in the heart of 'Ground Control', the two physicists explained the principles and aims of fusion in general and in detail.

"When will the technique that will be tested in the ITER project, the next step in the development of fusion energy, be ready for commercial use?" the audience wanted to know. The answer? If ITER is a success, the first commercial fusion power plants are expected in some 40 years.

"What is work like at an international place like JET?" The response: "Thrilling". This big project involves not only many different nationalities, but also different cultures.

Finally, "Is there a chance for engineers to participate?" ITER is a large, complex device, which will be used by physicists, but is largely being developed and built by engineers. So there are lots of possibilities!

Grenoble, France

The final stop on the round-the-world trip was Grenoble, home to the European Synchrotron Radiation Facility (ESRF), the European Molecular Biology Laboratory (EMBL) and the Institut Laue-Langevin (ILL). Although the laboratories use different methods, neutron-beam or X-ray, some of their work overlaps: investigating the structures of molecules and proteins. The results of their research deliver important information for the development of drug treatments as well as new materials. "Sometimes we test very old ones too," Christoph Müller explained, live from his lab at EMBL. "For example, we are currently investigating what gives wood its excellent mechanical properties."

One and a half hours after takeoff in Geneva, the trip to the frontiers of science returned to the cinema theatre in Munich. A trip that might be just the beginning of a promising journey of investigation for some of the audience.

Resources

EIROforum is a partnership of Europe's seven largest intergovernmental research organisations. In EIROforum, these organisations pursue joint initiatives, combine resources, and share best practices. Not only does EIROforum publish *Science in School*, it also organises Science on Stage, an international science teaching festival that brings together around 500 science educators from 29 European countries to show how fascinating and entertaining science can be. For more information about EIROforum and its initiatives, see www.eiroforum.org

The European Science Open Forum (ESOF) aims to bring together all groups involved in the scientific endeavour, including researchers, policy-makers, representatives of industrial research and development, science journalists and the general public. It is organised by Euroscience, an organisation of research professionals, science administrators, policy-makers, teachers, PhD students, post-doctoral researchers, engineers, industrialists, and any citizen interested in science and technology and its links with society. For more information about ESOF 2006 and Euroscience, see www.esof2006.org and www.euroscience.org

Master of ceremonies

Image courtesy of Hans Hermann Heyer, ESO ©

Something special in the air

Stephen Parker from the European Commission describes a contest that demonstrates the truly astonishing achievements of some aspiring young scientists.

Michael Kaiser and Johannes Kienl from Austria, Alexander Joos and Johannes Burkart from Germany, and Thomas Wdowik from Poland receive their prizes

They came from all over Europe and beyond; some had already spent hours on aeroplanes before arriving in Stockholm. They came carrying boxes and cases; some brought intricate electronic gadgetry, others just paper rolled up in tubes that they guarded as they would priceless manuscripts. Just what were these young people doing in Stockholm on that sunny Saturday in September? Clandestine participants in some secret ritual, perhaps? The astute observer, however, would not have been so misled. After all, the signs were there: it was the 18th European Union Contest for Young Scientists[w1].

Buses and coaches took the 120 contestants – all winners of national pre-university science competitions from the 33 participating countries – to their hotel; and, on Sunday, from there to the Swedish National Museum of Science and Technology[w2] where the contest was about to begin. The air was pulsating with expectation and unspoken questions: Will my project win? Can I fix this in time? Why won't my PC boot up? Where is that adhesive tape?

Elsewhere in the museum, 15 professional scientists were finalising their preparations, but here the atmosphere was much calmer: they would be the jury, not the judged. They had already read and discussed the descriptions of the 78 projects in the contest, and were almost ready to interview the young scientists who did the work.

Soon it was the opening ceremony. Speeches from the organisers, the Swedish Federation of Young Scientists, the Swedish Research Council[w3] and the Royal Swedish Academy of Science[w4], and music from some very talented young musicians.

Then the judging began: What made you choose this project? Did you consider any other explanation

for what you saw? How did you record those data? Were these measurements repeatable? Had you expected that when you started? Have you thought about protecting your work through patents? How did you split the work up between the members of your team?

Two intense hours later and the first round of interviews was over. The jury retired to exchange first impressions: When I spoke to her I realised that she really did understand the science! That project is outstanding, but who did the work? He was shy at first, but when he started to explain how he got around that technical difficulty, his enthusiasm was unstoppable! And so on.

Monday came and the judging continued. Gradually the jury began to discuss possible winners: it was difficult of course, but it always is. How can you compare a project in computational science with one in the social sciences? Professor Jane Grimson, the president of the jury, reminded her colleagues that up to three joint first, second and third prizes could be awarded. Furthermore, there were those special prizes donated by EIROforum, the European Patent Office and the Swedish Plant Science Centre. The final decisions would be taken on Tuesday after the last judging sessions.

It's now Wednesday and the Awards Ceremony is about to begin. Everyone is seated in the Vinterträdgården of the Grand Hotel. This is where the Nobel laureates stay during the Nobel week, whispers a young contestant to her neighbour. Neither can speak each other's first language and so they share one that they are learning at school. There is something special in the air: an excitement that is almost tangible. More speeches, an outstanding *a cappella* performance by a group of young singers, and then the winners are finally announced.

Later at the press conference, Michael Kaiser from Austria, joint winner of one of the first prizes, explains: "We did not expect it! We are so satisfied and surprised that we won!" Johannes Kienl, his partner on the project, which developed an innovative electrothermal mechanical deicing system for aircraft (see box), adds: "It was brilliant to come here and meet people from all over the world – we have made a really good network!"

Aisling Judge, age 15, receives third prize for her project to develop and evaluate a biological food spoilage indicator

For most, of course, the climax of the four-day event was the farewell party: a chance to say goodbye to new friends, or rather "au revoir"!

Web references

w1 - The 18th European Union Contest for Young Scientists took place in Stockholm, from 23-27 September 2006. A complete list of the winning projects can be found on the official website. In 2007, the contest will take place in Valencia.

The European Union Contest for Young Scientists is an initiative of the European Commission to promote co-operation and interchange between young scientists, and demonstrate the best in European student scientific achievement. By giving young scientists the chance to meet others with similar abilities and interests and to be guided by some of the most prominent scientists in Europe, the European

Commission seeks to strengthen the efforts made in each participating country to attract young people to careers in science and technology.

For more details, see http://ec.europa.eu/research/youngscientists

w2 - For more information about Tekniska Museet, the Swedish National Museum of Science and Technology, see www.tekniska-museet.se

w3 - For more information on the Swedish Research Council, see www.vr.se

w4 - For more information about the Royal Swedish Academy of Science, see www.kva.se

BACKGROUND

Some of the winning projects

Aspiring Austrian pilots Michael Kaiser and Johannes Kienl (both 19) developed a new de-icing system for aircraft. This advanced system, planned in co-operation with two offices of technical engineers, can be used to de-ice all important aerofoils of aircraft and wind-power stations. Attached to an aircraft's wings or vertical and horizontal stabilizers, or to the rotors of wind-power stations, the device pushes ice off the surface when a heated metal layer expands. This has a significant advantage over conventional de-icing systems: Michael's and Johannes's invention only requires heat and power when ice is actually present, in contrast to the traditional 'bleed air system', which has to use power to heat the aerofoils whenever the aircraft is at risk of icing. The advanced Austrian de-icing system also has the advantage in terms of weight, size, energy efficiency and power.

Table tennis probably is one of the fastest sports in the world for both players and spectators. Johannes Burkart (20) and Alexander Joos (19), both of whom aim to be physicists, were fascinated by how professional table-tennis players manage to place balls exactly on the edge of the table and serve difficult top-spins, so they wanted to understand and simulate the curve of the flying ball. Using a computer, the young scientists analysed the paths of balls served by a training machine, then compared flight curve experiments with simulated trajectories and were able to imitate several real table-tennis situations.

Heart diseases are among the most common causes of death in humans. One group of drugs often used to treat these diseases is beta-blockers, such as propranolol and metoprolol. Tomek Wdowik (19) from Poland carried out a complex organic chemical synthesis to produce a new compound that may add a new and efficient drug to the family of beta-blockers. Tomek, who would like to become a chemist, explained the action of the known beta-blockers and described how he designed and performed his synthesis.

Alec Jeffreys interview: a pioneer on the frontier of human diversity

Professor Sir Alec Jeffreys, the inventor of DNA fingerprinting, remembers his childhood passion for science, explains what we have learned from direct DNA analysis, and describes his work with Chernobyl survivors. Interviewed by **Russ Hodge** and **Anna-Lynn Wegener** from the European Molecular Biology Laboratory in Heidelberg, Germany.

What attracted you to science in the first place?

I was born a curious child; I was the sort of child who would go around slicing up earthworms to see what was inside – a fairly ghastly child. But at the age of eight, I got two great things from my dad: a microscope and a chemistry set. And not any ordinary set; this was a real, fully lethal chemistry set.

Basically, I was a self-taught organic chemist. By the age of 11 or 12, through sheer enthusiasm, I'd taken myself up to first-year university level. There were bangs, there were stinks, I was making the most extraordinary compounds and you learn very rapidly if you're doing that sort of practical science. It's a way of getting immersed in science which today is absolutely impossible because of health and safety concerns.

And nothing happened at school to distract you or put you off science?

I had the most fantastic teachers, particularly my biology teacher, Mr Barton. I'd say, "I want to know what a starfish looks like inside," and he'd get me a dead starfish so I could dissect it. So the school was enormously important, but they were working on a child who had already been converted – at that point, I was completely addicted to science anyway.

The author aged eight with his new microscope

You've been studying genetics and human variation for nearly three decades now. What do we know now about human variation that we didn't know thirty years ago?

We first had the tools for beginning to look at human variation in late 1977. Before that, what we knew was based on indirect inference. We could look at proteins in the blood or in saliva, and by studying variations in the products of genes, we could make inferences about variation in the genes themselves. Thirty years ago, though, we had no inkling of the true level of variation at that most fundamental level of all: the DNA level. Within about two years, though, it became clear that there were going to be many, many millions of sites of differences between two people.

Hand in hand with the Human Genome Project[w1], there's been the parallel Human Genome Diversity Project[w2]. We've learned not only the true extent of variation, but also a great deal about how that variation is distributed between different populations, and that most genetic variation is shared by everybody on the planet. That simply reflects the fact that we're a young species which has not had enough time to split into different, genetically distinct, subspecies. The project has also told us that Africa is the richest source of genetic diversity, which is consistent with mankind having evolved in Africa. Again, these are insights that simply couldn't have been achieved without looking at the DNA.

But the other thing that direct analysis of DNA has taught us is that the old model for how DNA varies from one person to another was radically wrong. DNA was seen as just a string of letters, with individuals differing in terms of single letter changes, the so-called single nucleotide polymorphisms, or SNPs. We now know not only that there are many sites of these single nucleotide polymorphisms, but also that the human genome is full of little deletions, duplications, inversions, all sorts of rearrangements. There are even little segments of DNA that can copy themselves to a new location – the so-called transposable elements. These little molecular fleas, hopping around on the human genome host, make up about 25-30% of the entire human genome.

There are also regions of repeat segments of DNA, known as minisatellites. These are my favourites and they're the ones that underpin DNA fingerprinting[w3]. They really interest me because some of them are fantastically variable, hence their use in DNA fingerprinting. Not only that, but some of them can be major causes of inherited disease, such as Huntington's Disease, which is caused by repeat segments of DNA replicating and making toxic gene products, killing cells in the brain. We can also look at the origin of inherited disease itself: we can take the most common cystic fibrosis mutation and begin to estimate when it arose in human history and how it spread.

So direct analysis of DNA has told us about normal variation, pathological variation and the origins of pathological changes; it's created entirely new types of genetic marker, such as those used in forensic DNA fingerprinting, and it's told us quite a lot about the overall evolution of the species.

This whole field is now moving really fast. What do you expect will be the kinds of new issues that we'll be able to deal with in the next decade?

Many of the issues that we're going to be talking about ten years from now haven't even been thought about now. Having said that, it's obvious that some things are going to be important, such as the genetic basis of common diseases like diabetes. Diabetes has a genetic component but it's very difficult to know which of all the millions of sites of genetic variation directly affect your risk of developing the disease. The environmental pathways are absolutely obvious – lack of exercise and lousy diet – and that can be changed right now: people can dramatically modify their risk of diabetes without even thinking about genetics. But genetics would give insights into the mechanisms, and could lead to new drugs to minimise an obese person's risk of developing diabetes.

Could you explain the distinction between DNA fingerprinting and the types of profiling that are used to try to anticipate future disease?

With old-fashioned DNA fingerprinting, you couldn't distinguish between ethnic groups, or even predict things like hair colour and eye colour, or disease liability. With modern forensic DNA typing systems, that's not quite true: there are some weak hints about ethnicity and some very, very weak hints about specific disease liabilities, particularly about diabetes.

People have said, "Why don't you create very high-throughput DNA-typing systems to help the police in their enquiries and simultaneously identify people at risk of disease and help them make the right lifestyle decisions?" My view is that the police use of DNA and the medical use of DNA should be totally, completely and utterly separate. I would be content for the police to have a sample of my DNA if it were to help in a specific investigation. I would not be happy for the police to look at characters in my DNA that are important to me as an individual – that's an invasion of my genetic privacy. As soon as you cross the boundary between the forensic and medical uses of DNA, I think you are creating a seriously difficult situation.

That would undermine the great success story of the forensic use of DNA. The public by and large are content for the police to retain samples of DNA from convicted people, analyse them and create databases. That sympathy would start evaporating if the police had all sorts of information on disease liabilities, ethnic origins of people, and family relationships.

You've been involved with some work involving Chernobyl. Could you explain what you've been doing and what's come out of that work?

This came straight out of DNA fingerprinting. The repeat segments of DNA we use for DNA fingerprinting are highly variable because they are unstable, so as they are transmitted from parent to child, they quite often spontaneously change – which is very different from an average human gene. If you were to use a typical gene, you might have to look at 10 000 children before you found a new mutation. With these bits of DNA, in the most extreme example, about one child in four carries a new version. So they're very easy to pick up.

Given that instability, a colleague of mine, Yuri Dubrova from Moscow, came up with the idea of using these DNA segments for mutation monitoring. For example, in Chernobyl, where there was a mass release of radioactivity into the environment, can you detect radiation-induced mutations in children? We did some of the experiments in an animal model system, and showed that if you irradiate mice, more mutations accumulate in the repeat segments of DNA in their offspring. So these bits of DNA are not only spontaneously highly unstable, they are also exceedingly sensitive to radiation, and give us a very simple way to pick up radiation-induced mutations.

Having shown that, Yuri then went on to parallel studies in Chernobyl, which blew up in April 1986. He recruited mother-father-child trios in Belarus, where the child had been born some time after the disaster, where both parents had been permanently living in the area, and where there was information available on the level of radiation in the environment. Again, he found that the children had an elevated number of these mutations and that the elevation seemed to be roughly in proportion to the amount of radioactivity in the environment.

Now if that is true, that is the first direct evidence in humans for radiation-induced heritable mutations. Big genetic studies of the survivors of Hiroshima and Nagasaki lacked the power to be able to ask those sorts of

questions. We also saw these mutations in both mice and humans at levels of radiation exposure that were traditionally thought to be without significant genetic risk. That may well question the basis for setting radiation thresholds and for risk estimation.

In mice, we also saw a trans-generational phenomenon, whereby if you expose a mouse to radiation, you see new radiation-induced mutations appearing not only in its offspring, but also in its offspring's offspring and in their offspring, even though they've never been exposed to radiation. We don't know if that happens in humans, but if it does, then it raises issues about the effects of radiation – not just for individuals, but for their unexposed children, grandchildren, and more distant descendents. *If* that phenomenon works in a trans-generational way, as it does in mice.

Is there still debate about what the results of this study mean?

Yes, I have to stress that there is no consensus yet on the human response. I mean, there is a response, but this is epidemiology and one thing you cannot do with population studies is define cause and effect. So you can always argue that maybe it's got nothing to do with radiation, that maybe the people living in the most seriously contaminated areas were so nervous that they smoked a lot and that it was the smoking that induced the mutations. You can see correlations, but to really pin down cause and effect, to really see if radiation is the cause, is very difficult.

The most direct experiment that we subsequently did – which shows just how confusing this particular field can be – was to collect semen from men and count the number of sperm that had the mutations. We then irradiated these men's testes, waited a while and then collected and analysed further semen samples. After radiation, we found no effect on mutation rate whatsoever!

You might wonder how we got anyone to volunteer. We worked with testicular cancer patients, so we needed to find a patient who's not only going to undergo radiotherapy – hence the testis irradiation – but is also prepared to give semen samples. Worldwide we found three people who were prepared to do that. However, despite the small size of the study, there was clearly no effect.

So to summarise, we found radiation-induced heritable mutations in Belarus, and when the study was repeated in the northern Ukraine, we saw the same effect. At a nuclear weapons test site in Kazakhstan, with contaminated villages, the same effect was seen. Studies on survivors of the Japanese atom bombs showed no effect. Direct exposure of the testes also showed no effect. And studies of the Chernobyl clean-up workers and their families likewise showed no effect. So there's no consensus yet – and that's the way science works.

Web references

w1 - Wikipedia entry on the Human Genome Project: http://en.wikipedia.org/wiki/Human_Genome_Project

w2 - Wikipedia entry on the Human Genome Diversity Project: http://en.wikipedia.org/wiki/Human_Genome_Diversity_Project

w3 - Wikipedia entry on DNA fingerprinting: http://en.wikipedia.org/wiki/Dna_fingerprinting

REVIEW

As a teacher, I was particularly impressed by the first part of the article, in which Professor Jeffreys remembers his fantastic science teacher. This is a real reward for good science teachers.

Immacolata Ercolino, Italy

Resources

Alec Jeffreys' website: www.le.ac.uk/genetics/pages/staff/staff_pages/jeffreys.html

Wikipedia entry on Alec Jeffreys: http://en.wikipedia.org/wiki/Alec_Jeffreys

The International HapMap Project is an effort to develop a haplotype map of the human genome, to identify and catalogue genetic similarities and differences in human beings: www.hapmap.org

Image courtesy of Peter Stättmayer ©

The joy of discovery: a personal experience

Comet West

Richard West
describes the excitement and joy of discovering a new comet.

Yesterday, in front of the computer at home, I had a funny feeling of déjà vu. The photo on the website of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO)[w1] somehow looked familiar. The comet seemed a bit unsharp, and there were several diffuse blobs. Clearly, Comet Schwassmann-Wachmann 3[w2] was in the process of breaking up (see image). After the comet's numerous approaches to the Sun in its elongated orbit, the intense solar radiation was finally taking its toll. This cosmic iceberg full of dust – the comet's 'nucleus', as we astronomers call it – was falling apart, producing a swarm of baby comets.

Almost exactly 30 years ago, in March 1976, I had seen this happen to another comet. Looking through one of the largest telescopes at ESO's La Silla observatory on a remote mountain in the Chilean Atacama desert, I had witnessed the awesome demise of one of the brightest comets of the 20th century, marvelling at the forces of nature in action. Once more, my thoughts went back further to an exhilarating afternoon in November 1975. I remember it as if it were yesterday. What a lucky day in my life!

But wait, I must tell the story from the beginning. It started much earlier, in the early 1960s, when astronomers from several countries decided to unite their efforts and set up what

Image courtesy of ESO

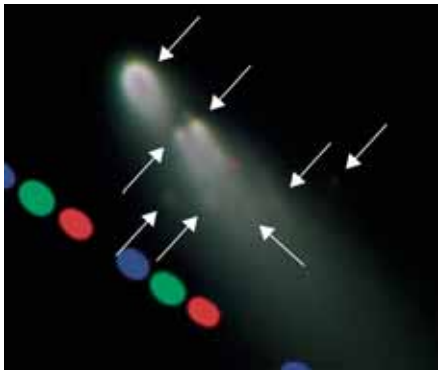


Image of Fragment B of disintegrating Comet Schwassmann-Wachmann 3 and associated mini-comets (arrows)

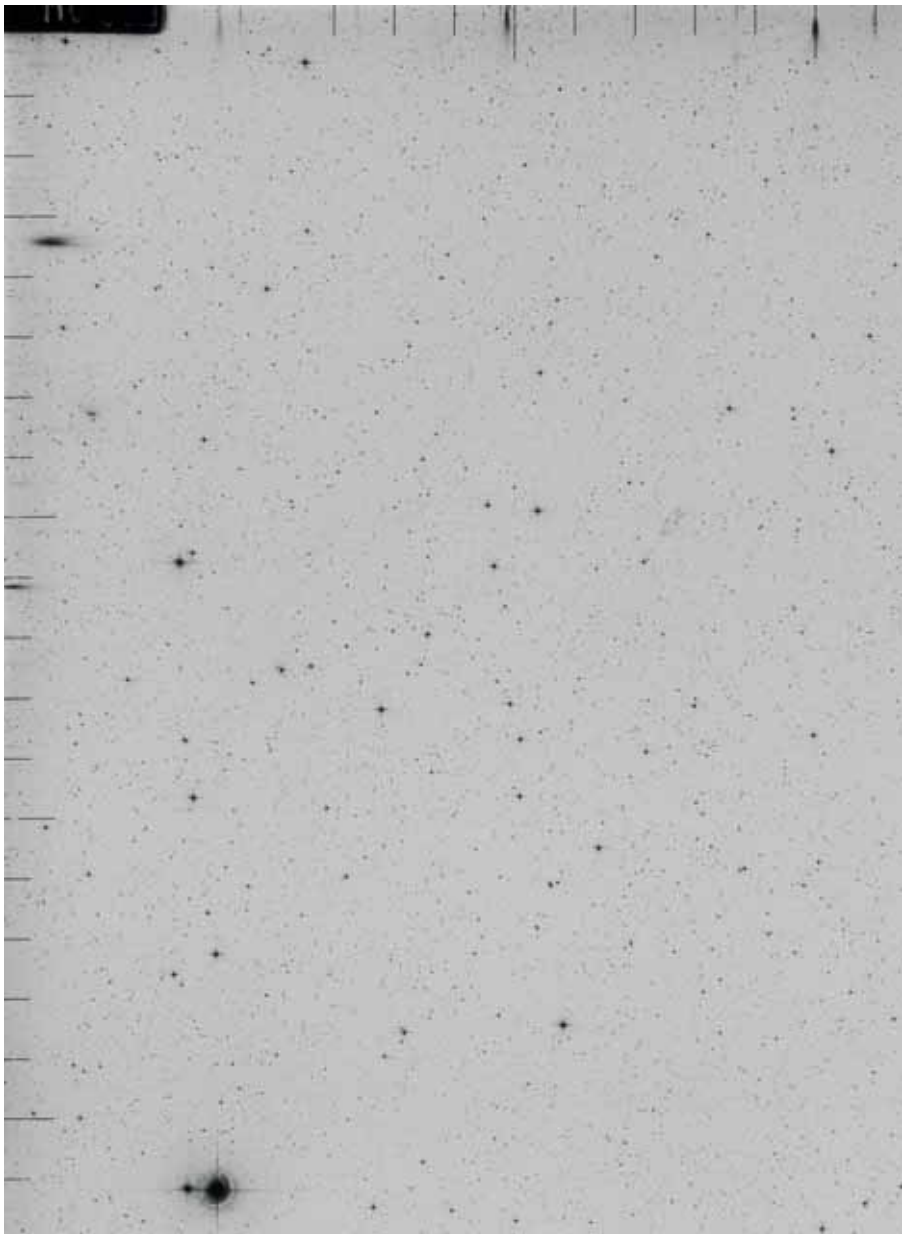
was to become Europe's astronomy organisation, ESO. One of its most important tasks was to survey the relatively little-known southern sky, mapping hundreds of millions of heavenly objects south of the celestial equator. Such a programme would find many hitherto unknown stars, planets, nebulae and galaxies, opening wonderful opportunities for subsequent detailed studies and leading to an astrophysical bonanza.

My own country, Denmark, joined ESO in 1967. At that time, I worked at the Copenhagen University Astronomical Observatory. Two years later, I was fortunate to obtain a position at ESO, as Assistant Astronomer to the Director General, Professor Adriaan Blaauw. In 1972, I was charged with setting up the new ESO Sky Atlas Laboratory on the premises of CERN[w3] in Geneva, Switzerland, as part of a collaboration between the sister organisations. The laboratory's main task was the production of ESO's *Atlas of the Southern Sky*, consisting of faithful reproductions of 30 x 30 cm photographic glass plates exposed with a giant camera (a 1 m Schmidt telescope), optimised to survey large sky areas. For this, I worked closely with the German astronomer Hans-Emil Schuster and his night assistants, the brothers Guido and Oscar Pizarro from Chile, who did the original exposures at La Silla, as well as with the laboratory staff, including Bernard Dumoulin, Françoise Patard, Bernard Pillet and Jean Quebatte.

The real work started in 1974, when a steady stream of exposed glass plates arrived in Geneva, carefully packed in big containers to survive the hardships of the long journey from Chile. It was one of my jobs to check all these plates, judging their quality, e.g. in terms of image sharpness and limiting magnitude (a measure of the faintest stars visible on the plate). Only the very best plates, with the sharpest images and the faintest objects, were then included in the *Atlas* and several hundred photographic copies were made and delivered to other observatories all over the world.

On these negative plates, images of stars and galaxies appeared as small

Image courtesy of ESO



Part of the photographic plate on which the trail of Comet West was first seen. Can you find the fuzzy comet trail? Stars and galaxies appear as black dots; the brighter ones have different forms that are artefacts of light reflection in the telescope. See page 74

clusters of silver grains in the photographic emulsion. I normally started out with a quick 'eye scan' – being rather short-sighted, I could see even quite small details on the plates. Then followed a careful evaluation under a microscope, examining even the faintest smudges. The scrutiny of each plate normally took between five and 15 minutes.

Each plate contained images of several million stars in the Milky Way and thousands of galaxies. Depending on the position in the sky, there were also nebulae of gas and dust, or short trails of asteroids in the Solar System which had moved in their orbits during the exposure. It was a strenuous but fascinating job. The photos showed innumerable celestial objects that had never before been seen by human eye – what a privilege! Many of them were later catalogued systematically from the *Atlas* copies by diligent colleagues in various countries.

Little did I know, on the morning of 5 November 1975, what would happen later that day. It must have been about two o'clock in the afternoon when I cautiously removed a newly arrived plate from its white cover, took off my heavy glasses and made a first quick scan, supporting the plate edges with my hands a few centimetres in front of my eyes. At one edge, I came upon a little black smudge that looked somehow strange. Yes, it was like the trail of a minor planet, but it was fuzzy, as the trails of planets are not. And it looked fuzzier on one side than the other! Could it possible be...? A quick glance through the microscope confirmed my suspicion – it was indeed the image of a moving object. Oh yes, it was undoubtedly that of a comet with a short tail, and thus most likely located in the inner Solar System.

In the 1970s, only two dozen comets were being discovered each year. This was becoming exciting! Questions arose: where was this comet in space? Was it perhaps already known? A quick check in the tables did not obviously identify it as any known comet. Which way was this comet moving – east or west? You cannot tell this from one trail alone, but suppose I could find another trail on another plate taken before or after this one! Then the direction would become known. And if I found three trails, it would become possible to calculate the orbit and predict the comet's future motion....!

This plate was taken by Guido Pizarro on 24 September 1975, so I searched some other plates obtained a month earlier. One hour passed: nothing found. But then, incredibly, there it was: another, much fainter, trail right in the corner of a plate taken by Oscar Pizarro on 10 August. And another one on a plate from 13 August! I could hardly believe my luck. Lost to the world, I went to the large measuring machine to determine the exact sky positions of the three trails; this took me another hour.

The rest is recorded history. We telexed (no emails in those days!) the data to Brian Marsden at the Central Bureau of the International Astronomical Union (IAU) in Baltimore (Maryland, USA). I went home that evening and tried to relax with my family, but those trails were in my head all the time. Brian's telex answer came the next day. The three trails were of the same comet, it was hitherto unknown, and Brian was able to calculate the orbit! He issued IAU Circular 2860 the same day, and under the heading "COMET WEST (1975n)", he stated that "the orbit indicates that the comet should be conveniently placed for observation in the northern hemisphere in the morning sky at m1 ~ 5 in mid-March 1976". Magnitude five! That meant that this comet might become visible to the naked eye! I had in fact discovered a relatively rare object.

As the comet moved nearer to the Sun, it continued to brighten, as predicted. However, in mid-February 1976, it quite unexpectedly brightened more than 15 times within a few days. It then disappeared behind the Sun as seen from the Earth and when it reappeared in late February, it had become very bright. Indeed, several observers were able to see the comet's 'head' (the gas and dust cloud surrounding the nucleus) in broad daylight. One wrote: "brilliant like the planet Venus".

Early in the morning of 1 March, I woke my 7-year-old son. Leaving sleeping Geneva behind us, we ascended nearby Mount Salève and found a site with a view towards the eastern horizon. Dawn was approaching and the colour of the clear sky above the grandiose alpine mountains slowly changed from black to dark blue to red. Anxiously waiting, we strained our eyes and soon noticed a bright spot rising behind the mountains, almost like a distant lighthouse. It was deeply touching to show my son the comet I had seen on that plate four months earlier. During the next few days, it moved further away from the Sun and rose earlier, now with a long and majestic tail in a darker sky. I got a call from my parents. Living north of Copenhagen, they went to the Øresund beach in the early morning and saw the comet rising just south of the island of Hven (Ven), the site of the observatory of Tycho Brahe (1546-1601), one of the most famous astronomers before the invention of the telescope changed astronomy forever.

The comet was observed intensively over this period. Thanks to its unusual brightness, detailed investigations could be made of its composition and the impressive structures in its coloured tails. It broke up, right in front of the astronomers, with an intense release of fresh cometary material. Enormous amounts of glowing gas and reflected sunlight produced a spectacular sight for professionals and amateurs alike, as well as for many stalwart, early risers among the public. Marvellous photos were

Image courtesy of Peter Stättmayer ©

An impressive photo of Comet West in the morning sky, obtained in early March 1976

taken, some by teachers and their school classes.

Comets are named by the International Astronomical Union[w4] after the discoverer(s). For me, to have a celestial body – 'Comet West' – named after me was a very great honour and a wonderful feeling!

This is a personal story which illustrates an important phenomenon in real science: the joy of making a discovery. I have been fortunate to experience this fantastic feeling in my career as an astronomer, certainly that afternoon in Geneva, and sometimes at night in front of the computer screen on mountain observatories. Such moments are priceless. Of course, scientists study science to gain new insights and make them known to the world, contributing to our common knowledge. However, I think that many will agree that it is not only the final results, but also many facets of the process itself – and especially some rare and intense moments on the road towards understanding – which constitute the true highlights of the scientific profession.

Web references

w1 - For more information about the European Organisation for Astronomical Research in the Southern Hemisphere (ESO) see: www.eso.org

w2 - The ESO press release about Comet Schwassmann-Wachmann 3 is available here: www.eso.org/outreach/press-rel/pr-2006/pr-15-06.html

w3 - CERN is the world's largest particle physics laboratory: www.cern.ch

w4 - The International Astronomical Union aims to promote and safeguard the science of astronomy in all its aspects through international co-operation: www.iau.org

Resources

Further reading about Comet West is available on Gary Kronk's Cometography: www.cometography.com/lcomets/1975v1.html

More details of Comet West are also available from Wikipedia: http://en.wikipedia.org/wiki/Comet_West

IAU Circular 2860 announcing the discovery is available here: http://cfa-www.harvard.edu/iauc/02800/02860.html (more information about the comet can be seen on Circulars 2910, 2919, 2924, 2927, and 2928).

Comet West became a 'great comet' and was technically the brightest – if only for a very short time – in the 20th century. Background information on great comets is available from:

Wikipedia: http://en.wikipedia.org/wiki/Great_comet

NASA: http://ssd.jpl.nasa.gov/?great_comets

The ecologist's view of bird flu

The white-fronted goose is an excellent example of a migrating bird. It breeds in north-west Russia and Siberia in summer-time and hibernates in west, central and south-east Europe

Image courtesy of Jan Visser, NIOO-KNAW

Are migratory birds responsible for the spread of bird flu? Should we kill them all? **Lucienne Niekoop** and **Froukje Rienks** from the Netherlands Institute of Ecology argue for a more scientific approach.

"Kill all migratory birds." With this controversial statement, Russian politician Vladimir Zjirinovski caused widespread consternation in January 2006, when the bird flu virus was spreading rapidly. The big question, however, is which birds are to blame. By addressing this question, ecological research can play a key role in the understanding of avian flu.

An overview

In mid-2003, the H5N1 bird flu outbreak began in south-east Asia. We do not yet fully understand how this

Image courtesy of Jan Visser, NIOO-KNAW

Millions of birds migrate each year, but are they spreading bird flu? Millions of lorries carrying poultry travel roads around the world...

virus spreads, but to prevent a pandemic, it is important to take a multidisciplinary approach. Ecologists from the Netherlands Institute of Ecology[w1] are co-operating closely with virologists at the Erasmus Medical Centre in Rotterdam[w2], the Netherlands, to understand the role of migratory birds in the transmission of bird flu.

Lethal subtypes

First, let us go back to bird flu basics. Viruses, small pieces of RNA or DNA covered in a protein coat, occur in many forms. Flu is caused by the influenza virus, which has three types: A, B, and C, all of which can infect humans. Bird flu (avian influenza) is caused by influenza A viruses, for which birds form the reservoir.

There are several subtypes of influenza A. The severe virus that is currently spreading has the codename H5N1, derived from the membrane proteins on the virus particle. H5 stands for the haemagglutinin type 5 membrane protein (there are 16 types in total). Neuraminidase is the full name of the membrane protein N, of which there are nine variants. Different combinations of the H and N membrane protein types result in many virus subtypes. Subtypes may be harmless, in which case they are known as low pathogenic avian influenza (LPAI) viruses. Harmful or lethal subtypes are classed as highly pathogenic avian influenza (HPAI) viruses.

Global outbreak

Usually, influenza viruses do not cross the species barrier, which means that different species of organisms cannot pass the infection from one to another. However, the highly pathogenic bird flu H5N1 has been shown to jump from birds to humans, although not easily. In the recent outbreak, there have been at least 256

Table 1: Only those influenza A virus subtypes shown in blue are found in wild birds. The list of subtypes in poultry is not complete, but it most likely resembles that of wild birds.

Source: Dr. Vincent Munster, Erasmus Medical Centre, Rotterdam, the Netherlands

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
N1																
N2																
N3																
N4																
N5																
N6																
N7																
N8																
N9																

Table 2: Human cases of influenza A (blue) involve far fewer virus subtypes than are found in birds.
H1N1 = 1918 'Spanish flu' (>40 million deaths) H2N2 = 1957 'Asian Flu' (1-4 million deaths) H3N2 = 1968 'Hong Kong Flu' (1-4 million deaths)
Source: Dr. Vincent Munster, Erasmus Medical Centre, Rotterdam, the Netherlands

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
N1																
N2																
N3																
N4																
N5																
N6																
N7																
N8																
N9																

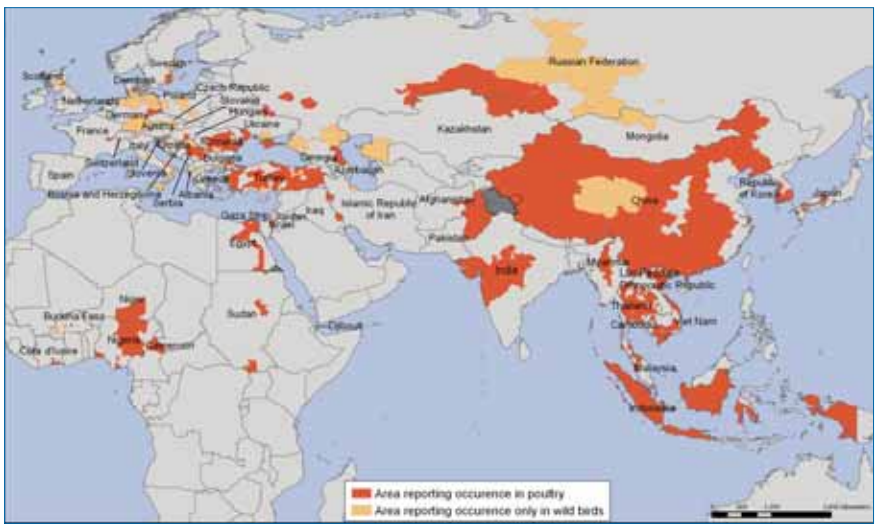


Image courtesy of the World Health Organization

Since 2003, H5N1 has been reported in poultry or wild birds in many areas (situation on 12 September 2006)

human cases, of whom more than half died (as of 16 October 2006), according to the World Health Organization (WHO)[w3]. Nonetheless, the WHO states that this is a small number compared with the huge number of birds affected.

The H5N1 virus has been shown to spread from human to human only sporadically, as a result of intensive contact. However, because the virus mutates rapidly, researchers all over the world predict that the H5N1 virus will eventually merge with a human-specific influenza virus. The resulting highly pathogenic germ could then disperse freely from person to person and result in a global outbreak or pandemic.

Faeces

It is likely that all species of birds can become infected with avian influenza. Affected birds secrete the virus in high concentrations in their faeces, and the main known infection route is oral intake of these contagious faeces. Waterfowl like ducks, geese and swans seem to be among the most infected species of birds and form a natural reservoir of all influenza viruses, usually the low pathogenic forms. Jan van Gils, an ecologist at the Netherlands Institute of Ecology, explains: "Notably water-foraging birds appear to be sensitive. This is probably because they forage in contaminated water." Colleague Marcel Klaassen continues: "There are four potential reasons for the higher sensitivity of waterfowl. First, many of them travel over long distances as migratory birds, so their chances of visiting an infection hotspot are higher. Second, they prefer to live in wet areas. Outside the host, the virus is capable of surviving for long periods, especially in fresh water at low temperatures: after one month in ice, the virus is still virulent. Furthermore, waterfowl are highly social birds, which can increase the possibility of exchanging the virus." Klaassen finishes by pointing out the role of their food source: "They produce large

Images courtesy of Jan Visser, NIOO-KNAW

Outside the breeding season, migrating birds form mixed groups with other migratory bird species, making them vulnerable to viruses

amounts of faeces due to their vegetarian diet. As such a diet has low nutritional value, herbivores eat large amounts of food per day and produce a lot of dung. For example, geese defecate every five minutes."

Migratory birds are being regarded with great suspicion as H5N1 spreads rapidly. Their food availability fluctuates seasonally; for this and other reasons, migratory birds travel enormous distances – up to 30 000 km annually – and can disperse pathogenic micro-organisms such as viruses. Many migratory birds cross each other's paths, forming a network of migratory routes and resulting in contact between many species and populations. Depending on the extent of contact between migratory birds and the way in which birds infect each other, viruses may ultimately spread across the world. Thus the infection route is determined to a large extent by the specific ecology of the pathogen and the host.

Sick birds

Ecological research is necessary for us to understand how the bird flu virus is distributed in a bird population, the location of infection, the transmission and the effects influenza viruses have on their migratory host. To this end, ecologists at the Netherlands Institute of Ecology study migratory water birds, such as the Bewick's swan. The scientists collect faeces and take swabs or cloacal samples, observe the birds' behaviour and study the food intake and diet of this small swan. The faeces and swabs are then sent to virologists at the Erasmus Medical Centre, who analyse them for pathogens like influenza viruses. By doing this, the researchers aim to make an inventory of which hosts carry which influenza subtype.

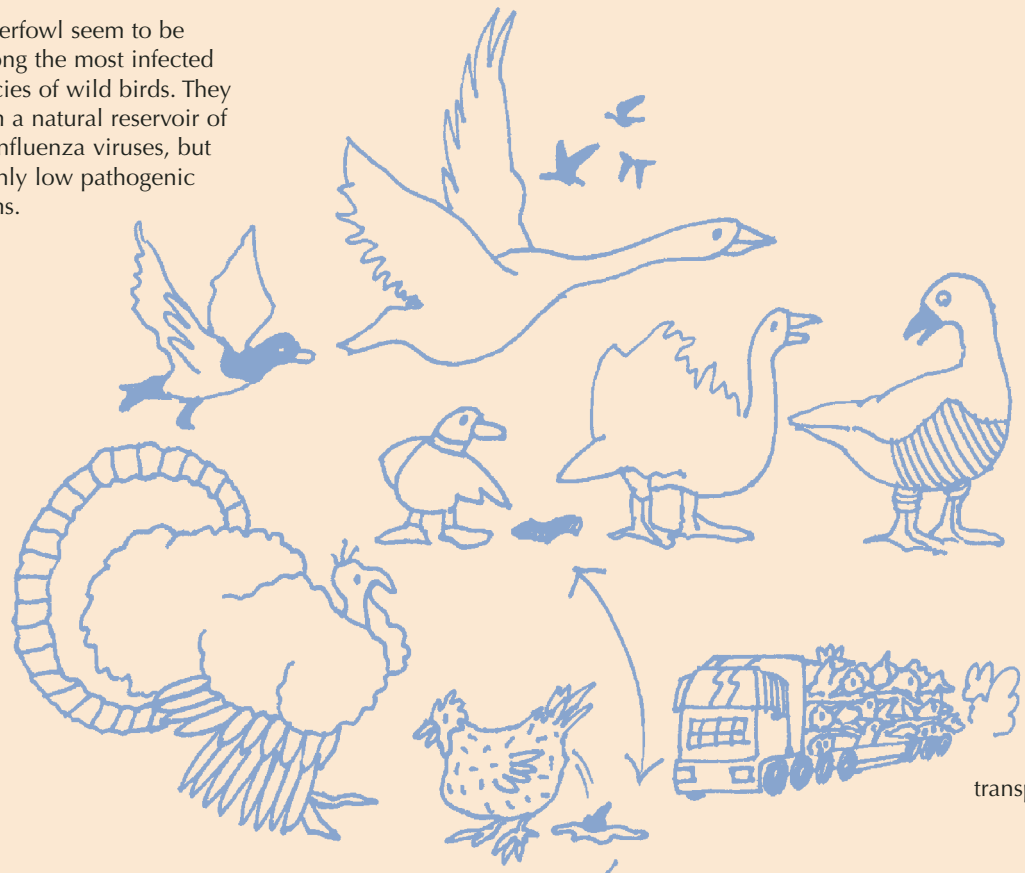
So far, only LPAI viruses have been found. Until recently, scientists did not know that birds could become ill from an LPAI infection: only HPAI viruses were thought to cause symptoms such as sudden death, oedema in head and neck, diarrhoea, subcutaneous haemorrhages, loss of appetite, lethargy, and respiratory problems. However, this year the ecologists found two LPAI-infected swans (infected with H6N2 and H6N8) that began their spring migration more than a month behind schedule. Jan van Gils explains: "When we found the infected birds, they were in poor condition. They ate less and had poor digestion, resulting in less stored fat. We are curious about the condition in which these two infected swans will return in winter and whether they will produce offspring." Hopefully, the knowledge acquired on the LPAI will contribute to the HPAI research.

High-tech collar

To predict the continuing spread of bird flu, it is crucial to study migratory routes. At the Netherlands Institute of Ecology, data is collected by the Dutch Ringing Centre[w4] to study the routes of migratory birds in co-operation with other European countries.

How do bird flu viruses spread?

Waterfowl seem to be among the most infected species of wild birds. They form a natural reservoir of all influenza viruses, but mainly low pathogenic forms.

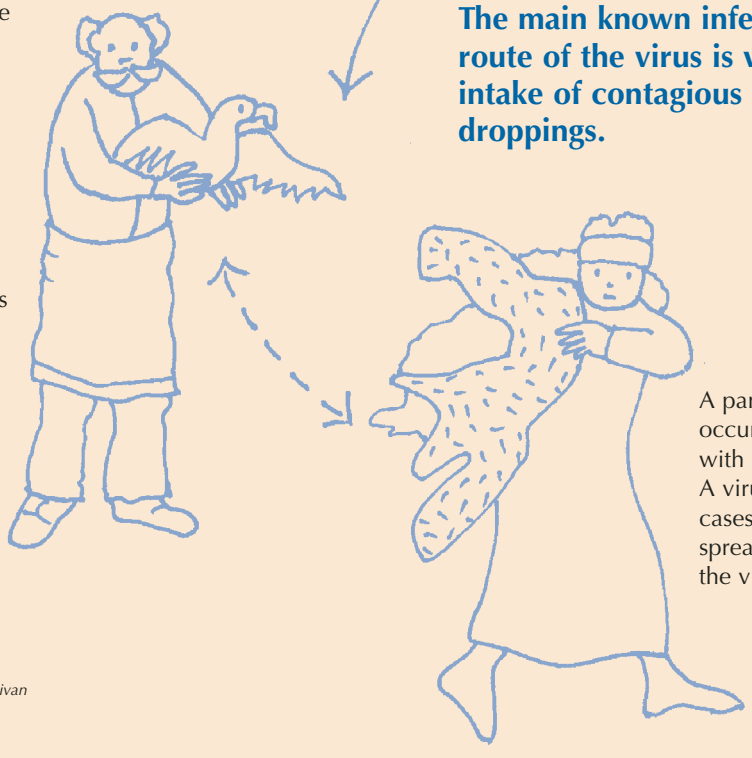


Low pathogenic avian influenza mutates rapidly in poultry. Moreover, the flu virus can spread easily due to very densely accommodated poultry, the poultry trade and frequent transport of these domestic birds.

You can prevent an H5N1 infection by taking some precautions:

1. Avoid any direct contact with infected birds.
2. Cook your eggs and poultry well before you eat them.
3. Stay away from droppings of infected birds or contaminated surfaces.

The main known infection route of the virus is via oral intake of contagious bird droppings.



A pandemic outbreak could occur if the H5N1 virus merged with a human specific influenza A virus. So far, only sporadic cases of human-to-human spread have been confirmed, but the virus mutates rapidly.

Image courtesy of Elaine Sullivan

Image courtesy of Jan Visser, NIOO-KNAW

The migratory pintail duck, Anas acuta, is widespread in the north of Europe, Asia, and North America. In winter, it flies south as far as the equator. Outside the breeding season, this social duck forms mixed groups with other species of duck

Numerous bird species are captured and ringed by volunteers. The light metal ring is a bird's passport: if someone finds a ringed bird, they inform the Ringing Centre. In this way, individual birds can be tracked and the flight routes of different species obtained. The route of the Bewick's swan is also studied by fitting some of these swans with a global positioning system (GPS) collar, which allows the birds to be traced more accurately. Some other species of water birds are followed in a similar way by other ecologists (see image), and the information on these flight routes is compared with the hotbeds of H5N1 outbreaks.

The core of the problem

So far, migratory water birds have received the most attention as health hazards. They are considered by many to be the main or even the only virus

BACKGROUND

Eco-factsheets

The Netherlands Institute of Ecology offers up-to-date ecological information in eco-factsheets. The first factsheet deals with the ecology of bird flu and is tailored to secondary school students, for use in school assignments such as reports, experiments, presentations and preparations for debate. Biology teachers can find supplementary ecological information on topical subjects from the associated website.

The eco-factsheets contain:

- Background on current ecological themes
- Supporting graphics and pictures
- Online quizzes or other challenges
- Information on, or interviews with, researchers
- Future research questions
- Links, e.g. to short movies.

The eco-factsheet *The Ecology of Bird Flu* is available in English and Dutch from www.nioo.knaw.nl/NEWS/ecofactsheets/

Birds equipped with GPS collars can be traced at all times. The pink dots represent the path of the white-fronted goose Harry; the yellow dots show that of Adri. Examples of live tracking satellite pictures are available online (e.g. www.blessgans.de)

vectors infecting people and poultry, but solid scientific evidence is lacking. Ecologist Marcel Klaassen says, "There is a lot of hysteria about the role migratory birds play. Perhaps because this distracts the attention from the real core of the problem: the very densely kept poultry, constituting a virus's paradise. And due to trade, poultry is transported very frequently and extensively. In these ways, the flu virus can spread easily." Furthermore, virologists from the Erasmus Medical Centre found that LPAI infections naturally present in wild migratory birds are stable, unlike the rapidly mutating LPAI viruses found in poultry. In summary, migratory birds are involved in the spread of bird flu, as victims but not necessarily as offenders.

Research need to continue into the role that migratory birds and poultry play in the spread of influenza virus before people like Zhirinovski advocate harming migratory birds. In particular, the exact link between host and infecting influenza virus should be investigated.

Web references

w1 - The Netherlands Institute of Ecology focuses on basic and strategic research into individual organisms, populations, ecological communities and ecosystems: www.nioo.knaw.nl

w2 - The Erasmus Medical Centre in Rotterdam is the largest university medical centre in the Netherlands: www.erasmusmc.nl

w3 - The World Health Organization (WHO) is the United Nations specialised agency for health: www.who.int

w4 - The Dutch Ringing Centre administers almost everything concerning rings on wild birds in the Netherlands: www.vogeltrekstation.nl

REVIEW

In the last three years, bird flu has captured people's attention more than any other disease. Frequent updates on its spread and victims have been routinely included in the news, alarming scientists, governments and the lay public. As expected, student curiosity regarding bird flu is also on the rise.

This article provides the reader with a brief but useful account of the scientific specifics of bird flu with a focus on the role played by migratory birds in the spread of the disease.

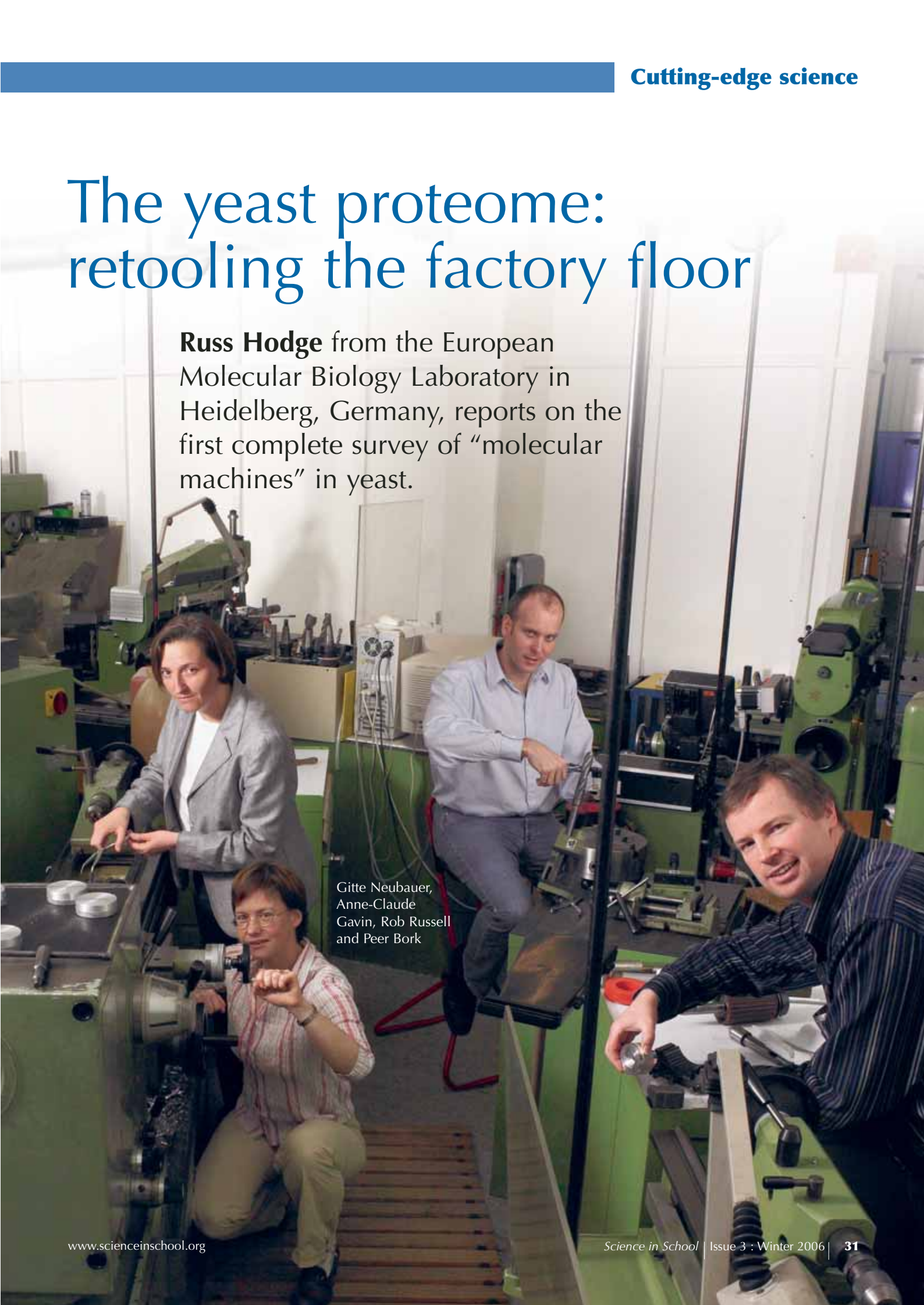
The information in the article could serve directly as a means of satisfying students' curiosity. Additionally, it could inspire teachers and students to design small investigations to collect additional information concerning the role of migratory birds as vectors of the deadly bird flu virus. Group projects could be aimed at gathering data to determine whether migratory birds are, as accused, good candidates for spreading bird flu and eventually causing a global outbreak. Other investigations could focus on what measures could be taken to prevent the disease from spreading to even more parts of the world.

The nature and subject of these investigations make them ideal for interdisciplinary studies. For example, biology and geography could be combined to shed more light onto the facts and myths surrounding the correlation between migratory birds and bird flu outbreaks.

Michalis Hadjimarcou, Cyprus

The yeast proteome: retooling the factory floor

Russ Hodge from the European Molecular Biology Laboratory in Heidelberg, Germany, reports on the first complete survey of "molecular machines" in yeast.



Gitte Neubauer, Anne-Claude Gavin, Rob Russell and Peer Bork

In 1901, Franz Hofmeister compared the cell to a factory, able to take in raw elements and convert them into the necessities of life; he even suggested that the sub-compartments of cells that had been identified under the microscope might be responsible for specific types of conversions.

The factory analogy has persisted through a century of discoveries about the functions of molecules. Proteins were described as 'worker molecules' and chemical processes as 'assembly lines'. Unlike a car factory, however, where machines usually remain bolted to the floor and are only changed as new models come into fashion, the cell continually retools itself. Proteins are simultaneously workers and components of intricate robots that are continually assembled and taken apart; often, the same molecule can be found in several machines.

The full extent of this flexible organisation has only become clear through a recent study published in the journal *Nature* (Gavin et al., 2006). Previously, scientists had a very limited view of the machines and their components. "The situation was like coming into a factory and finding parts of single machines scattered across the floor," says lead researcher Anne-Claude Gavin, a scientist at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany. "We have known what some machines do, and a bit about how they operate, but there was really no view of the whole context."

Scientists had already started to puzzle together the construction of

Patrick Aloy and Rob Russell

yeast machines based on single pieces, using a method called a two-hybrid screen. This matches every yeast protein to every other, like completely disassembling everything in a car factory and trying to fit pieces together one-by-one. The method has generated a wealth of useful information but also many false leads.

It might be physically possible to insert a gear stick into an exhaust pipe, but that doesn't mean it ever happens in a functioning automobile. With 6500 parts to deal with – approximately the number of proteins encoded in the yeast genome – the one-by-one method provides a very limited view of complete machines, let alone the complete factory.

An alternative would be to start with complete machines and then analyse the molecules that compose them. But methods of extracting proteins from cells usually break complexes apart. Then, several years ago, Bertrand Séraphin's lab at EMBL invented a process called tandem affinity purification (TAP), a method which fishes single molecules from cells along with any machines attached to them, intact. The components of complexes could then be analysed using mass spectrometry – a method that fragments proteins and 'weighs' the pieces. Since each protein has a unique composition, mass spectrometry gives scientists measurements that can be matched by computer to the profile of a specific molecule. Working with scientists at EMBL, the company Cellzome decided to tackle the entire yeast genome using these methods. Thousands of experiments later, this has produced the first full scan of the genes of a eukaryotic cell, searching for molecular machines.

★ ★ ★

The study revealed 491 complexes, 257 of them wholly new. The rest were familiar from other research, but now virtually all of them were found to have new components.

Is the list exhaustive? "We estimate there may about 300 more," Anne-Claude says. "Some complexes may appear only when particular conditions are used to grow the yeast, and others may not be discoverable with this method of extracting them." For example, it has been notoriously difficult to purify complexes attached to the cell membrane. The researchers adapted the method for doing so, and found 74 new complexes involving membrane proteins, but Anne-Claude is sure that many more exist.

A parts list is only the beginning: the scientists also want to know where the complexes are stationed in the cell, what they do, and how they

function. Sometimes these questions can be answered from the components alone. A complex with three proteins that respond to heat undoubtedly plays a role in helping the organism adapt to changes in temperature. Other complexes could be linked to processes such as binding to DNA, or assisting in the refinement of other molecules.

The information has also provided new insights into how the cell manages the incredibly complicated task of putting complexes together, and this says something important about the biology of yeast and other organisms. "Does a cell pre-assemble machines and have them on hand, or are they built from scratch when something happens?" Anne-Claude says. "In other words, how are the machines – and the factory as a whole – really managed? We didn't know, but now we can say a lot about this. To do that, we had to find new ways of understanding the data."

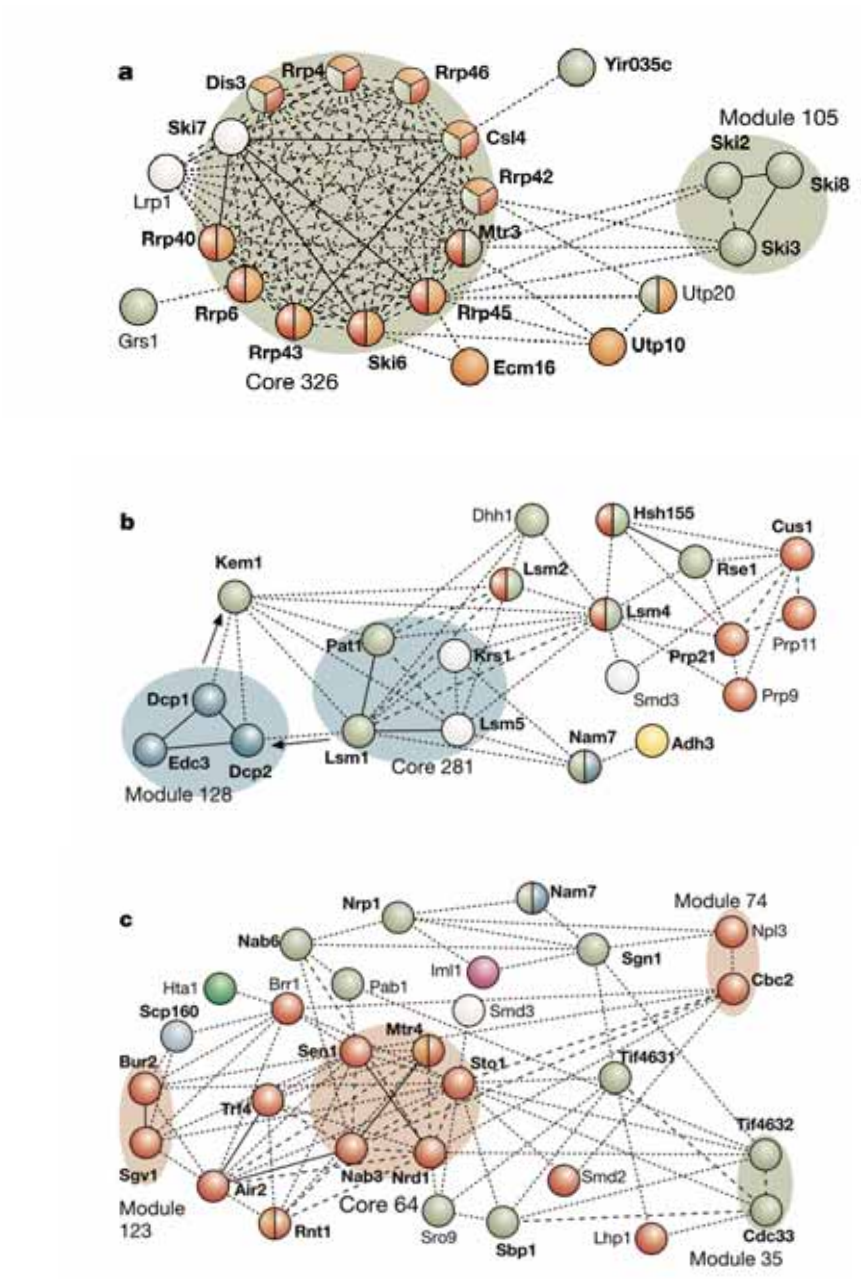
★★★

Road atlases often contain a chart showing the driving distances between cities. For example, 1150 kilometres separate Rome and Heidelberg; Heidelberg to Cambridge is 2045 kilometres (counting a transit by ferry). From such a chart and a bit more information, you could sort cities into regions, states, and countries. To understand the inner workings of protein complexes, says Patrick Aloy, scientists would like to have such a map of molecules.

Patrick was a member of Rob Russell's group at EMBL, where computational techniques are used to understand the inner workings of protein complexes. Combining information on protein shapes and functions with data on how they bind to other molecules has permitted the scientists to start drawing 'technical diagrams' of machines. But sketchy knowledge has restricted the scope of these efforts.

"Imagine replacing a chart of distances with a table that tells you only yes or no – can you get there from here?" Patrick says. "From that information you wouldn't be able to draw a very meaningful map, but that type of study is what we've had so far. Well, now we've produced something more like the distance chart – each pair of proteins has a value which gives the likelihood that they are found together in purifications."

That information has now been converted into a map of the factory floor, complete with finished and partial machines, prefabricated parts, and snap-on modules. "What you discover is that most complexes have a core set of components that are almost always found together and others that



Some of the complexes and dynamic modules discovered in the yeast proteomics project

REVIEW

In the field of life sciences, the word proteome has become very popular, like other words ending with "-ome", but it is rare to find it explained as clearly as it is in this article.

Beginning with the metaphor of the cell as a factory, Russ Hodge leads the reader into its complex protein machinery using a plain and captivating style, with vivid examples from everyday life.

Another engaging feature of the article is the description of methods and strategies used by researchers to investigate the structure, function and evolution of those incredibly tiny objects that are cell protein complexes.

I recommend this article to teachers and students of upper secondary school within the curriculum of biochemistry and/or cell biology. In fact, it can be used for classroom teaching or for autonomous investigation of the subject by students.

Finally I would stress that this article, in spite of the simple and friendly style, offers an illuminating and synthetic view of a very complex issue: with the exciting taste of the adventure of discovery, it gives an excellent example of high-level science popularisation, which is especially needed at present to encourage scientific vocations.

Giulia Realdon, Italy

come and go," Rob says. "You can think of the cores as crucial, prefabricated parts of machines that are kept on hand, with temporary modules added on as the need arises."

The function of such modules, Anne-Claude says, may be to alter the job of the core machine, to link it to other things going on in the factory, to switch it on or shut it down. "This has several very important effects. First, it gives the cell a way to carry out a large number of tasks with a limited number of basic machines. That gives it quite a bit of flexibility. Secondly, it means that in an emergency, the cell doesn't have to build all the machines it needs from scratch. It only has to produce a few really essential parts. The other side of that is that it may be relatively simple for the cell to control a quite sophisticated machine, just by supplying or blocking the delivery of a critical piece."

There is an important connection to evolution because generally, certain types of machines and their basic components have been conserved over hundreds of millions of years as new species arose. Peer Bork's group at EMBL has helped in investigating this question.

"If you compare what goes on in yeast and our own cells, you find many of the same machines, using the same basic components to do the same things," Peer says. "The complexes reflect how evolution works – as variations on a theme. You don't find every species inventing a new way of doing things; instead, they're refining what they're up to by adding on specialised modules, or slightly changing the way the whole thing is regulated."

The study reveals a great deal about individual machines and how they work together. Yet much remains to be learned about their work in living cells – where many of them are located, and how many copies of each machine are at work at any given time. Structural information about the complexes is helping to answer some of these questions, because it gives scientists an idea about the overall shape of a complex. This means it can be looked for under the microscope.

"Even with electron microscopy, protein complexes are fuzzy spots that are difficult or impossible to identify," Anne-Claude says. "But with good shape information, we might be able to put names to some of the shapes."

Health reflects the operation of the entire cell in the context of the organism. The level of molecular machines is crucial in influencing that and keeping things in balance. What the scientists have accomplished is changing what we think about not only how individual machines work and are regulated, but how they function together. That will obviously be crucial as scientists try to guide organisms from a diseased state to a healthy one.

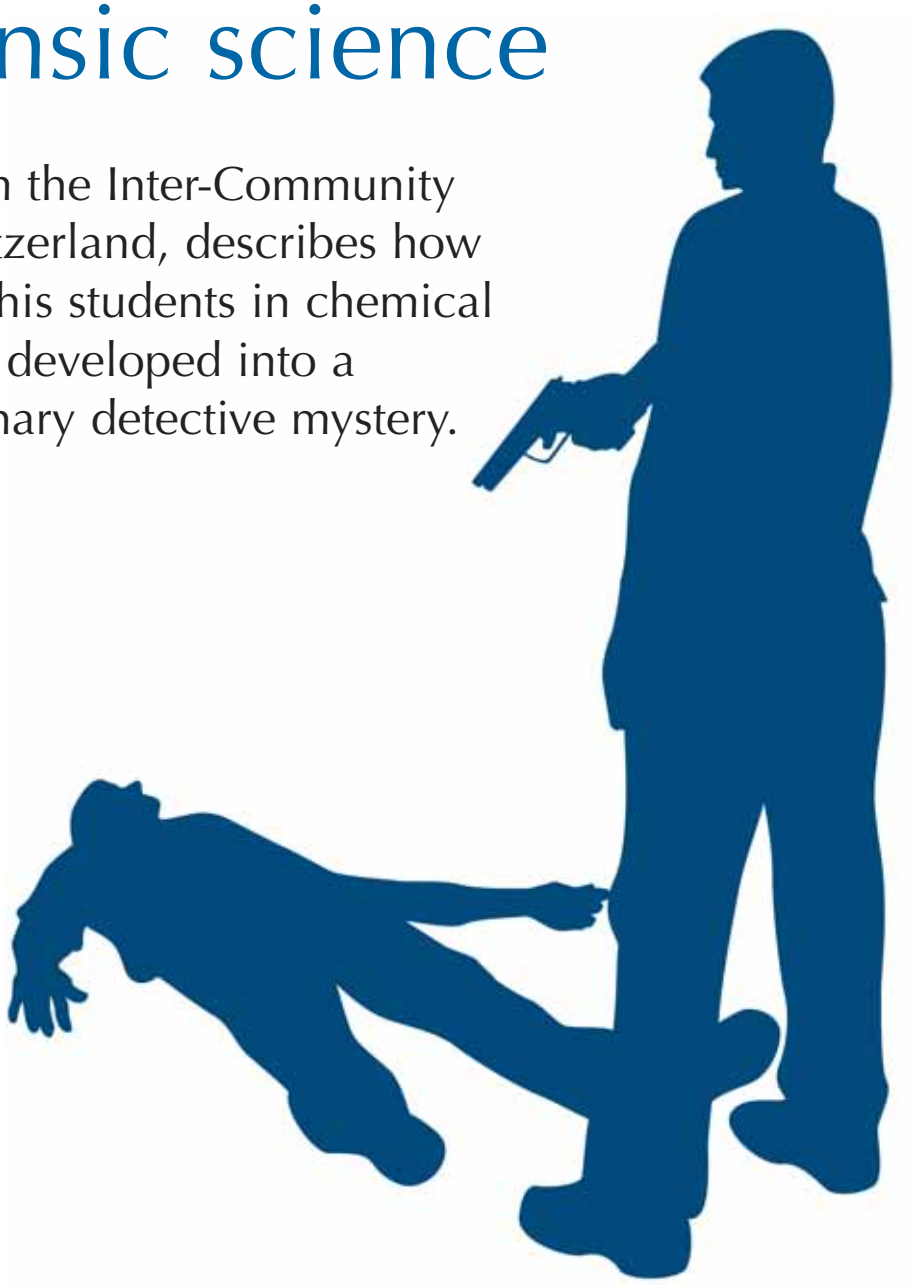
References

Gavin, AC et al. (2006) Proteome survey reveals modularity of the yeast cell machinery. *Nature* **440**: 631-636. doi:10.1038/nature04532

This article appears in the annual report of the European Molecular Biology Laboratory, a collection of articles on topics from the most current science. The rest of the report is available here: www.embl.org/aboutus/news/publications/report/report06.html

The detective mystery: an interdisciplinary foray into basic forensic science

Graham Gardner from the Inter-Community School in Zürich, Switzerland, describes how an attempt to interest his students in chemical separation techniques developed into a full-scale interdisciplinary detective mystery.



I had been teaching a unit on chemical separation techniques to my 8th grade class (14-year-olds) for several years and noticed that it was one of the most tedious parts of the science course for these students. The unit introduced them to a range of techniques from the obvious and simple method of filtration to the more abstract and complicated technique of chromatography. The most common question the unit raised from students was "what's the point?"

So with one particularly difficult group of students, I introduced a practical test situation where four suspects of a crime had various samples taken from them. The students were given pre-analysed samples from the crime scene that they then had to match to their own analysis from each suspect. The two lessons I set aside for this activity quickly became four. The students all arrived at class well before each lesson started with lab coats and safety glasses on (normally I have to repeat this instruction several times). At the end of each class I even had to throw them out to let my next class in. They wanted more time – even asking to work during breaks and lunchtimes! They had been one of my least motivated classes and now my colleagues were asking what I had done to make them work so diligently – had I punished them or threatened them? One of the most motivating aspects for the students was the final explanation of their analysis, normally a boring written activity. It became a courtroom drama, and the students became expert witnesses and lawyers

who had to cross-examine (exploiting their natural tendency to be argumentative).

The following year, the activity was expanded to a full-day activity. It was still a science activity at this point, but as the timetable had been abandoned for the day, non-science teachers were also involved. They quickly picked up on the potential for the activity to involve many other subjects. From this point on, it became an established interdisciplinary activity in the school year.

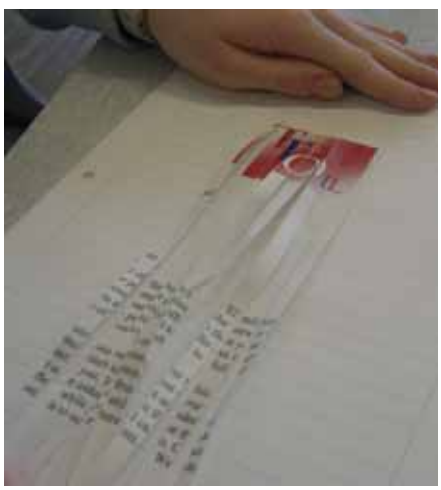
The students do not know in advance when the mystery will take place but they all anticipate it as they have heard about it from previous years' groups.

Over the eight years that the detective mystery has been running, we have had input from the English department through the study of the detective novel as a genre of literature; one year, the students went to the Giessbach Falls to see where Sherlock Holmes met his end. I've even managed to get Shakespeare's *Macbeth* in somehow.

Usually four teachers play the role of the suspects (with suspect photographs) whom the students have to interview. All the students study German as we are located in Zürich, so we have one suspect who will only answer questions posed in German. Sometimes we include a suspect who only speaks French, as that is also a language offered in our curriculum.

One year, we had a crime that revolved around the theft of a $2 million crystal that was on display in the school library. The technology teacher made a glass display case full of anti-theft devices. The school's website advertised the crystal as being an archaeological find on the site of the school when its foundations were being built. It claimed that the local museum had loaned it to us for an exhibition. Most people fell for it and the library was constantly visited by students and teachers amazed by the crystal. Comments overheard by the librarian included "huh, I don't think much of their security system, we could easily steal this" and from a teacher "I can't believe the headmaster didn't tell us about this before." I'd made a fake picture of the headmaster digging the crystal out of the ground. On the day of the activity, in a very hushed assembly, the students were told that the stone had been stolen. As we then explained that they would have to solve the crime, it started to dawn on them that it was part of the mystery. As well as the usual analysis, the students had to work out how the thief had bypassed the security system – by trying to break the system themselves.

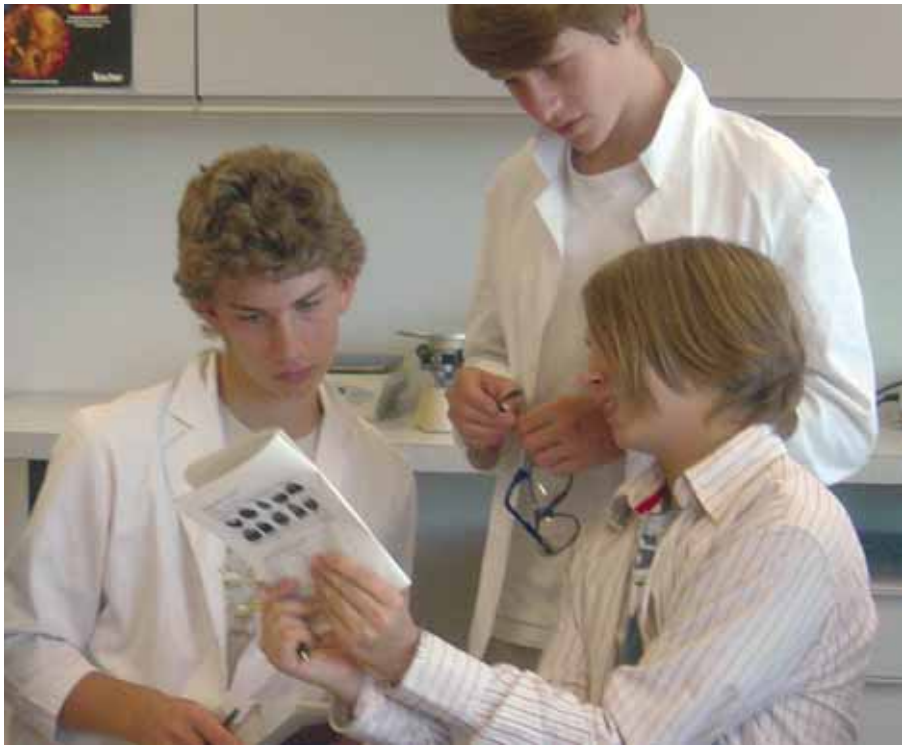
For the last two years, we have had a humanities/science energy conference at the school. Each group of students represents an energy source and they make a presentation stand on the exhibition floor. Teachers in character attend, along with students from other grades and parents. The crime from the mystery is connected to some of the characters that the teacher delegates play, as well as being related to an energy issue. This year, for example, the mystery revolved around a new species of oil seed that would revolutionise the energy industry. A delegate at the conference had recently discovered the seed in the



Amazon rainforest but had not made the seed available or his findings public. Rumours about oil companies and governments trying to get hold of the seed set the scenario for the delegate's mysterious death. We then introduce energy from a science perspective, and the humanities teachers investigate the social issues.

The basic elements of the detective day are:

1. Introduction to the scenario – usually this is a short movie or PowerPoint presentation that explains the characters and the basic evidence found at the crime scene. Each year, I make a new scenario otherwise the students will find out from the previous year what happened.
2. Students are put into working groups; the groups are of mixed ability and will include speakers of the languages of the suspects.
3. There are three pieces of evidence found at the crime scene that I always use but others are added depending on the scenario. Each group is given a pack of their own evidence. The standard evidence is:
   - Fingerprints found on a bottle. The students do not actually take the fingerprints; they are given electronic versions of the fingerprints. A sheet with the suspects' fingerprints on it accompanies a set of fingerprints found at the scene. I only use one fingerprint per suspect otherwise it is too time-consuming for the students to analyse. Some students print out the documents and identify loops and arches in the fingerprints; others use computer graphics to illustrate the features they have identified.
   - A toxic chemical from a bottle, and also found in the victim's body. Students are given substances that have been obtained from each suspect, as well as a sample found at the crime scene that the police have already matched with the toxic substance found in the victim's body. The students characterise the substances in terms of solubility, crystallisation and melting points, to identify which of the suspects' substances match the poison in the victim's body. The actual substances used are harmless: salt, alum, sugar and chalk.
   - Ink on a note to be matched to ink from pens found on each suspect. The suspects each had a black ink pen that the police have collected as evidence. There is also a sample of ink that has already been analysed – it is usually from an apparent suicide note or a threatening note found on the victim. The students carry out chromatographies on the other pens and try to find a match. They need to analyse the chromatogram, describing colours and the extent to which each colour has travelled to obtain data that can be compared, not just a visual impression.
4. Supporting evidence is given in the school's online curriculum centre. Access to this information is by passwords that can be obtained by solving simple problems and puzzles, for example Sudoku or optical illusions. This supporting evidence is background information about the suspects, such as bank statements, police records, marriage certificates, passports and newspaper articles.
5. There is usually surveillance of a suspect. This is one of the most popular activities. Each group is given a time to observe the suspect. The suspect repeats the same routine for each group, usually in the library. The surveillance team tries to blend in with the environment (I'm sure they read more in this time than on their regular visits to the library). They make notes of the suspect's movements and conversations as well as sneakily taking photographs.
6. The day ends with the courtroom trial. At short notice, each group is given a specific piece of evidence to present. This prevents presenta-



Macbeth, which the 8th grade is also studying, is not short on bloody murders and it is not likely to be removed from the curriculum. It may be an interesting aspect for the school counsellor to explore, and certainly in terms of the students' imagination, the more gory aspects come out in full when we get them to dramatise how they thought the crime had been committed.

Resources

The student workbook for this year's detective mystery can be downloaded here:
www.scienceinschool.org/2006/issue3/detective/workbook

REVIEW

This article represents a great idea, which needs much time for planning and co-ordination. I am fully convinced that the students will find these activities more exciting than traditional educational methods. I think guiding the students through detective mysteries like those mentioned in the article is very motivating, and another valuable source for teachers searching for different educational methods.

Sølve Tegner Stenmark, Norway

tions being repetitive. They can be asked to give evidence for either the prosecution or the defence.

Such an activity requires a lot of preparation so it is important that the school administration fully supports the activity by allowing planning time, especially if it involves teachers from different disciplines. Originally, when I just had the activity in the science class, it only took a few hours to prepare. Involving the suspects, interviews, surveillance, setting up lots of clues such as a database of records, as well as the little movie I always make to introduce it, takes many, many hours. The more complex the mystery, the more time it takes to prepare. This year's activity probably took 15-20 hours.

The main issue that I've had with the mystery has been the insensitive nature of dealing with death as a fun activity. The crystal theft successfully got around this but in trying to have a different scenario each year, I have gone back to a murder investigation. A former colleague once pointed out that detective novels and TV programmes such as CSI treat death as entertainment and children are not only exposed to this but thrive on it.

Introducing radio transmission with a simple experiment

Do you ever get frustrated with that mess of cables connecting your DVD player to your satellite dish, TV and video recorder? Did you know that you can cut those cables – and still get a signal to pass between the machines? **Alessandro Iscra**, **Maria Teresa Quaglini** and **Giuseppina Rossi** from Italy describe an experiment that will astound your students.

Stimulated by the widespread use of modern wireless devices, such as mobile phones, satellite TV receivers and wireless computer networks, many students are interested in the topic of radio transmission. Recognising this interest, we have developed both educational documents and experiments[w1], some of which use common modern wireless equipment. The project has involved many teachers working collaboratively to produce papers, multimedia activities and practical protocols.

Below, we describe a simple experiment that introduces radio transmissions to young students using a video cassette recorder (VCR) and a television (TV).

The radio transmission experiment

A VCR can transmit sound and images to a TV via either the SCART cable or the classic coaxial antenna cable. When transmitting via the coaxial cable, the VCR emulates a TV transmitter: in other words, the receiver doesn't know whether it is receiving a programme transmitted by a distant, normal transmitter or by the nearer VCR. The VCR generates a radio signal that reaches the TV via the coaxial cable. If we cut the cable, and connect the pieces of cable to two antennae, the TV will receive the audio and video signals transmitted by the VCR without any physical connection: we have achieved radio transmission. The signal transmitted is very weak, so the two antennae can be separated by only a few metres.

The following instructions should be suitable for all teachers, including those who are unfamiliar with electrical equipment. A Microsoft PowerPoint presentation[w2] and a short video clip[w3] are available online.

Image courtesy of PixelQuelle.de

Materials

- A TV
- A VCR
- Two coaxial antenna cables used to connect a VCR to a TV (with one male and one female coaxial connector). One cable will be provided with the VCR; the second, identical to the first, can be bought in a TV shop, or constructed from materials (the coaxial cable and the connectors) bought in an electrical goods shop.
- A metal grid (optional)

A spectrum analyser, a classical directional antenna and a coaxial cable: three very important devices used in radio transmission experiments

A homemade condenser, built by students from Liceo Scientifico Nicoloso da Recco (Recco, Genoa, Italy), is used to show that a variable electric field generates a magnetic field

Methods

Step 1. Connect the VCR to the TV using only the original coaxial antenna cable. A VCR is normally connected to a TV set by a thick cable joining two rectangular connectors (the SCART connectors) and/or by a thin cable joining two cylindrical connectors (the coaxial antenna cable). This latter connection is necessary to receive normal television channels, so it should be present if the TV is not just used to watch videotapes. The first thing to do is remove any other connections from the back of the VCR; the only connection should be to the TV via the coaxial cable (see right).

Step 2. Try to play a videotape using the configuration described in Step 1. This may simply require you to insert and play the videotape, then search the previously set programmes using the remote controller of the TV. Since the VCR is disconnected from the normal antenna, the TV can only receive signals transmitted by the VCR.

If no TV programme has yet been assigned to the VCR, this must be done. You may need to consult the TV instruction manual or ask a technician for help.

Step 3. Replace the original coaxial cable with the second coaxial cable, and check that the system still works. Then cut the new coaxial cable. The TV will not receive any signal.

Step 4. Remove the two pieces of the new coaxial cable from the TV and VCR and remove the external and internal insulating material along a length of about 20-30 cm (this length is not critical).

Step 5. From the un-insulated parts of the two lengths of cable, create two small antennae. Do this by exposing the inner conductor and by manipulating the outer conductor to form a single length, making the configuration shown right. See these websites[w2,w3] for further help.

Step 6. Cover the two antennae with insulating tape.

Step 7. Reconnect the lengths of cable to the TV and VCR. Maintain a distance of about 1 m between the two antennae. The TV should receive a signal from the VCR, which acts as a weak radio transmitter (see right).

Interference

If the experiment is performed outdoors or if the classroom is close to a TV transmitter, the TV may receive signals other than those from the VCR. In this case, re-tune both the TV and the VCR. First, search for a channel on which the TV receives no signal. Then tune the output channel of the VCR to the same channel. If necessary, consult the instruction manuals. Alternatively, try the experiment in another room where the interference may be less.

Cautions

Unauthorised radio transmission is strictly prohibited. Do not interpose devices such as amplifiers between the VCR and the transmitting antenna.

The propagation of electromagnetic waves

The simple experiment described here demonstrates the propagation of electromagnetic waves in air and, by placing the two antennae on either side of an obstruction (e.g. a book, a piece of aluminium foil or a wall), can be used to show how the waves penetrate objects.

The teacher can also demonstrate the polarisation of the waves by plac-

ing a metal grid between the two antennae. The waves cannot pass through the grid if the rods of the grid are parallel to the electric field vector (E in the figure right). However, the grid is penetrable if the rods are at right angles to the electric field vector.

An explanation of the observed phenomena

Radio transmission occurs when energy is carried by electromagnetic waves. This transmission may be achieved simply by applying a high-frequency voltage to a dipole antenna with a total length similar to the wavelength of the electromagnetic waves.

VCRs generate ultra-high frequency (UHF) signals in the 470-862 MHz range; the exact frequency range depends on the European channel selected[w4]. Since the wavelength (λ) is related to the frequency (f) by the simple formula $\lambda = c/f$ (where c is the speed of light), the wavelength is in the range of 0.35-0.63 m, requiring a small antenna.

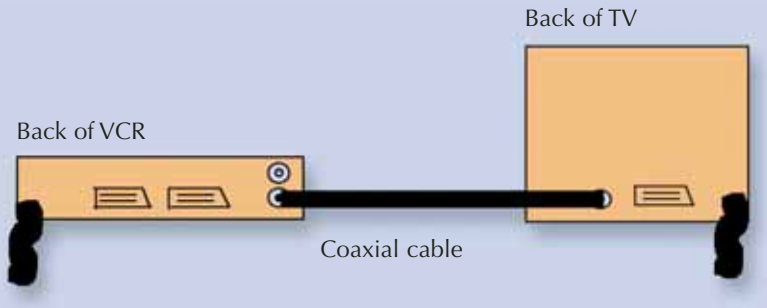
Electromagnetic waves generated by the dipole antenna are linearly polarised. The direction of the electric field (E in the figure right) is parallel to the antenna.

Web references

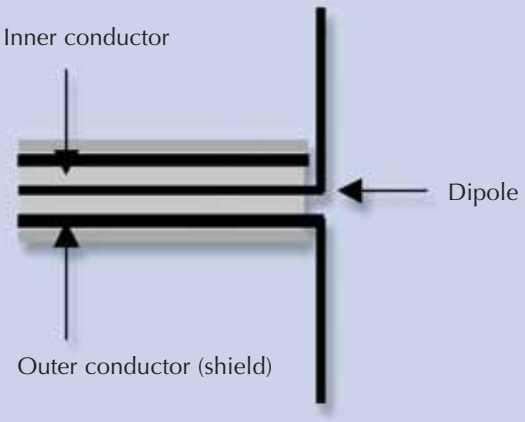
w1 - *Radio Transmissions Experiments for Educational Purposes* from a network of Italian schools: www.iscra.net/radio_educational

w2 - *How to Make a Simple Radiotransmission by Using a Videorecorder and a TV-receiver*, a PowerPoint presentation from Luisa Bove, Alessandro Iscra and Giuseppina Rossi: www.iscra.net/radio_educational/english/englishvcr.ppt

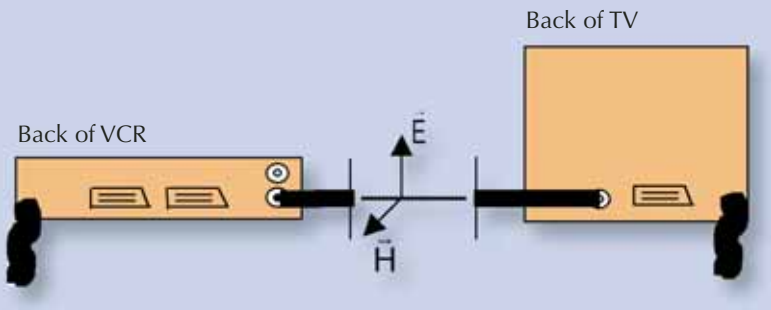
w3 - *Transmitting from a Videorecorder*, from some students of IIS "Caramuel" in Vigevano (Italy): www.iscra.net/radio_educational/english/englishvcrclip.mpg



The VCR connected to the TV using only the coaxial cable



A dipole antenna formed from a length of coaxial cable



Radio transmission and polarisation of the electromagnetic waves: *E* represents the electric field vector and *H*, the magnetic field vector. The dotted line represents the direction of propagation

BACKGROUND

A related event

The schools involved in this project recently organised a public event about the scientific, technical and social aspects of electromagnetic fields. During this event, seven projects were presented to visitors by the school students.

The event was supported by Consorzio Elettra 2000[w5], which organised a national contest – Campi Elettromagnetici e Società (Electromagnetic Fields and Society) – to stimulate secondary schools to develop projects to communicate the social aspects of electromagnetism. Consorzio Elettra 2000 provided the instruments necessary to measure the electric and magnetic fields. More details about this event are available online[w6].

The seven school projects also took part in the national contest, with one of them winning a trip to Rome.

w4 - TV Channel, CATV and FM Broadcast Frequencies from ARRL, the national association for amateur radio in the USA: www.arrl.org/tis/info/catv-ch.html

w5 - The Consorzio Elettra 2000 website: www.elettra2000.it (the Italian website links to an English version)

w6 - The website of the public event organised by the schools involved in this project: www.iscra.net/eta (only in Italian)

Resources

A more analytical approach to these experiments can be found on the following websites:

A Simple Approach to Radio Transmissions by Alessandro Iscra and Maria Teresa Quaglini: www.iscra.net/radio_educational/english/englishradiocom.ppt

Radio Transmissions by Catia Fina, Alessandro Iscra and Maria Teresa Quaglini: www.iscra.net/radio_educational/english/radiotransmissions.doc

REVIEW

This article describes an easy to prepare and interesting physics experiment to show wireless electromagnetism. Both the simple theoretical and practical aspects are covered.

Myrto Pouangare, Cyprus

Students at the IIS "Deambrosis-Natta" testing electromagnetic hazards associated with hand-held radio devices

Alessandro Iscra teaches at the IIS "Deambrosis-Natta" in Sestri Levante, Italy.

Maria Teresa Quaglini teaches at the IIS "Maserati" in Voghera, Italy.

Giuseppina Rossi teaches at the Liceo "Cairoli" in Pavia, Italy.

Putting the buzz back into school grounds

Dave Goulson and **Ben Darvill** from the Bumblebee Conservation Trust at the University of Stirling, UK, explain why these furry insects are under threat – and what schools can do to help.

A honeybee, *Apis mellifera*, (right) and a typical bumblebee, the buff-tailed bumblebee, *Bombus terrestris*

Bumblebees are among the most familiar and endearing of garden insects. Chubby insects with yellow and black stripes that are recognisable, bumblebees are widely featured in children's story books, cartoons, greetings cards and advertising logos. Yet most people are unaware that there is a distinction between bumblebees (genus *Bombus*) and the honeybees from which we get honey (genus *Apis*), although they are quite different in appearance.

It is also not widely recognised that there are lots of different species of bumblebee, with very different colour patterns, many of which can be seen in almost any garden or park in Europe. In fact there are about 250 known species of bumblebee (~65 in Europe), found throughout the cooler parts of the northern hemisphere. Unfortunately for bumblebees, this region also contains much of the world's human population and the most intensive agricultural regions. Probably as a result of this, many bumblebees appear to be undergoing dramatic declines in range.

This decline has drawn considerable media attention, which is generally positive, but it has led to some confusion. Articles in various national newspapers have claimed that bumblebees are "threatened with extinction", yet, paradoxically, they remain a common sight in gardens. In fact most bumblebee species have declined greatly, and have disappeared from intensively farmed areas.

In the UK, three of 26 native species have become locally extinct, and around ten more have suffered range losses of greater than 70% in the last 60 years. However, a small number of species appear to be able to cope with intensive farming and remain widespread and reasonably abundant throughout Europe. These species appear to do particularly well in gardens, exploiting the range of flowers to be found there. In almost any location in Europe, planting a few square metres of bee-friendly flowers will attract at least five bumblebee species, often more. So why have some species undergone drastic declines while others remain abundant? Recent studies suggest a possible answer. It seems that rare species tend to be more specific in their feeding requirements.

All bumblebees feed exclusively on nectar, which provides sugar (carbohydrates) for energy, and pollen, which is their sole source of protein for growth. Many of the rarer species such as *Bombus ruderatus*, the ruderal

Drifts of red clover on South Uist, Hebrides, Scotland, an area that has largely escaped agricultural intensification and which is home to rare bumblebees such as the great yellow bumblebee, *Bombus distinguendus* (inset)

bumblebee, and the short-haired bumblebee, *Bombus subterraneus*, are heavily dependent on legumes (Fabaceae) as their major source of pollen. In particular red clover, *Trifolium pratense*, seems to be a favourite with bumblebees.

Red clover was once a very common plant in Europe as it was widely grown as a fodder crop (it is also a favourite with horses) and as a ley crop to boost soil fertility (it is able to fix atmospheric nitrogen via mutualistic bacteria in its root nodules). It was also a common plant on the unimproved, nutrient-poor pastures and hay meadows which covered much of lowland Europe. In the mountains of southern Poland, which have largely escaped agricultural intensification and where horses are still widely used for farm transport, red clover leys are still common and rare bumblebees thrive.

In contrast, in western Europe the advent of artificial fertilisers and mechanisation in the middle of the 20th century led to the abandonment of clover leys, and most pastures and hay meadows have either been 'improved' through ploughing and reseeding, or turned over to arable production.

The net result of these changes is that wildflowers in general, and red clover in particular, are now much less abundant, which is almost certainly behind the decline in bumblebees. In Europe, the best places for rare bumblebees are isolated pockets of habitat that have escaped agricultural intensification, such as Salisbury Plain in the UK and the Causses du Larzac in France (both owned by the military) and remote areas where farming has changed little such as the Outer Hebrides, Scotland and the mountains of Central Europe.

So what can we do to halt or reverse the decline of the bumblebee? Overleaf are some ideas of how schools can help.

References

Prys-Jones E, Corbet SA (1991) *Bumblebees*. Richmond, London, UK: Richmond Publishing Co. Ltd. ISBN: 0855462574

Web references

w1 - The Bumblebee Conservation Trust website contains more information about bumblebees, identifying and encouraging them, and much more: www.bumblebeeconservationtrust.co.uk

Resources

Goulson D (2003) *Bumblebees: Their Behaviour and Ecology*. Oxford, UK: Oxford University Press

Some UK specialist seed suppliers are:

Herbiseed: www.herbiseed.com

Naturescape: www.naturescape.co.uk

Emorsgate Wild Seeds: www.wildseed.co.uk

Scotia Seeds: www.scotiaseeds.co.uk

REVIEW

Bumblebees are extremely important native pollinators and are disappearing dramatically across Europe – an environmental disaster that seems to be caused by changes in land use.

This article is of great interest to teachers of the life sciences, for both environmental education and ethology. The hands-on activities can be applied in different ways in both primary and secondary schools, although they might be difficult for inner-city schools because of space requirements. The activities may encourage students to improve their knowledge of science through nature observation – and could help to prevent the insects' extinction.

Immacolata Ercolino, Italy

CLASSROOM ACTIVITY

Projects with bumblebees

I. Create a wildflower garden

Bumblebees are very easy to attract to a wildlife garden. Wildflower seeds are now widely available from specialist suppliers. A selection of excellent bumblebee flowers are given below, all of which have a broad geographic range in Europe:

- Viper's bugloss, *Echium vulgare*
- Foxglove, *Digitalis purpurea*
- Tufted vetch, *Vicia cracca*
- Comfrey, *Symphytum officinale*
- Red clover, *Trifolium pratense*
- Borage, *Borago officinalis* (native to continental Europe)
- Knapweed, *Centaurea* spp.
- Poppy, *Papaver rhoeas*
- Sainfoin, *Onobrychis viciifolia*

Sow any combination of these directly into a well-tilled soil in September or March, either in separate patches or mixed together. Weed occasionally to remove grasses and other invasive weeds. By summer of the first year, some of the plants will have come into flower. Try to identify the bumblebee species that are attracted, using the excellent colour key on the website of the Natural History Museum, London, UK (www.nhm.ac.uk/research-curation/projects/bombus/bumblebeeid.html). In the UK, several good identification guides are available, among the best of which is Prys-Jones & Corbet (1987). This also covers most of the more common species in much of mainland Europe.

Record which species of bumblebee visit which flowers. The feeding preferences of the different species are strikingly different. Bumblebee species vary greatly in the length of their tongue, and tend to visit flowers of an appropriate depth. Thus foxgloves and red clover are mostly visited by the very long-tongued garden bumblebee, *Bombus hortorum*, whereas viper's bugloss and poppies, which have shallower flowers, are visited by a broad range of species with shorter tongues, such as *B. terrestris*. This behaviour reduces competition between the different species.

II. Providing nest sites for bumblebees

Few people have seen a bumblebee nest as they are usually well hidden, but it is relatively easy to provide artificial nest sites for bumblebees. All they need is a dark, draught-free and fairly dry cavity with a small access hole, preferably placed in a shady, quiet corner, such as the bottom of a hedge, or under a shrub. A paving slab placed over a football-sized cavity in the soil is pretty effective. Just make sure there are one or two gaps for the bees to get in. Similarly, a piece of thick plywood placed on the ground amongst long grass seems to be quite attractive as a nest place for carder bees (e.g. *Bombus pascuorum*), although it works best if left in place for a year or two. Alternatively, a few old bricks and/or planks of wood can be used to construct a chamber roughly 15 cm x 15 cm by 10 cm high, again leaving a small gap (about 2 cm wide) at ground level for the bees to get in. A few dried leaves, dried moss, kapok, or bits of an old bird's nest should be added, which the bees will use to insulate their nest. The more

Easily grown wildflowers that will provide food for bumblebees include (from left to right) viper's bugloss (*Echium vulgare*), comfrey (*Symphytum officinale*) and sainfoin (*Onobrychis viciifolia*)

nest sites that are provided, the more likely it is that one will be found and used.

It is noticeable that once a nest site has been used once, it is very often reoccupied the following year. It seems likely that queens searching for nest sites use the faint smell of an old nest as a good indication that the site is suitable for nesting. Thus it is best to leave nest sites in place for many years; the longer the better, for once they are eventually discovered by a queen and used for nesting, they are then likely to be used over and over again.

Once a nest is established, there are many observations that can be made. How often do bees leave/ return to the nest? What proportion of bees are carrying pollen on their legs? How is nest activity affected by temperature and rainfall?

Counting red-tailed bumblebee nest traffic. This nest is in an old bird box that had been left on the ground

III. Bumblebee recording

At present we do not have detailed information on the distributions of bumblebee species across Europe. Schools can play a valuable role by sending in records of the bumblebee species present in their area. Such data are absolutely vital if we are to develop sensible conservation strategies for bumblebees, yet even in the UK (which is relatively well studied) there are many areas where there are currently no bumblebee recorders. Recording sheets can be downloaded from the Bumblebee Conservation Trust website[w1], and should be returned to the Trust. Keen students can, for a small fee, join the Trust and receive a regular newsletter which details various events and activities.

Perfume chemistry, sexual attraction and exploding balloons: university activities for school

Investigating the properties of slime

Tim Harrison and **Dudley Shallcross** from the University of Bristol, UK, describe some of the University's activities to share a delight in chemistry with school students.

Bristol ChemLabS at the University of Bristol's School of Chemistry provides activities to enthuse, excite, inspire and entertain large numbers of school students of all ages. These range from half-day conferences, workshops for school students and master classes for teachers, to two-week summer schools.

Why should a university provide activities for schools?

The two main reasons for putting so much energy and resources into these activities are to assist local, regional and national science teachers and to enthuse and inspire students. Both are hoped to promote the chemical sciences nationally rather than locally, as many local school students who choose to go to university will move away from home to study.

Science and Engineering Ambassadors training

An important aspect of the schools activities is the involvement of enthusiastic postgraduate students, who not only provide technical expertise but also act as role models for school students. The postgraduates receive voluntary training in working with children under the Science and Engineering Ambassadors Scheme[w1] (SEAS) at the University. All the activities are managed by an experienced teacher, giving the young chemists a chance to contribute to the public

Chemistry is cool – not to say, cold!

A Grätzel chemistry workshop with Dr Dimple Patel (left)

Students composing their own perfumes (right)

communication of science while providing them with advice and support. Around 80 of the University's postgraduate chemists have undergone SEAS training in the last year.

Workshops for secondary school students

Several one-day and half-day workshops allow school students to visit the School of Chemistry to hear lectures and do practical work in the University teaching laboratories. Workshop topics include perfume chemistry, polymer chemistry, structure and bonding, and Grätzel cells.

Using perfumes to introduce students to some of the more everyday applications of chemistry is proving very popular. We work with professional perfumer, John Stephen, to give students an understanding of the industry, historical developments, economics and science behind the sense of smell and the formulation of fragrances. The students then spend two hours perfecting their own perfume from a range of 24 components, which they then bottle and package. This workshop has been run at the University, in a school laboratory and in the perfume factory itself.

An extension of the perfume workshop involving a group of 30 students from four state schools is being developed. In this project, the students take perfume chemistry several stages further. They spend a day working with research chemists, using analytical equipment and techniques from thin layer chromatography to gas chromatography/mass spectrometry. Another day is spent at the University synthesising fragrance components, and on the final half-day, the students give a short talk as part of a conference on perfume chemistry, alongside academic speakers.

To allow school students to immerse themselves in chemistry for more than a day, Bristol ChemLabS runs one- and two-week summer schools at the University of Bristol, and provides activities for summer schools run by the science faculty. In July 2006, for example, a joint chemical sciences summer school for 17-

16-year-old school students making aspirin at a summer school

year-olds will be held in conjunction with Trinity College Dublin, Ireland. The potential chemists will take part in biochemistry and pharmaceutical laboratory exercises, attend lectures with practicing research scientists, discuss the ethics of drug testing and visit pharmaceutical and other biochemistry companies. This is a pilot of what is hoped to be an annual two- or three-way student exchange between young chemists from European Union countries.

School chemistry conferences

So that students can visit a university and find out about aspects of chemistry that are not necessarily on a school curriculum, we organise afternoon chemistry conferences. Dramatic demonstrations with liquid nitrogen, colour changes and explosions are included and are always appreciated by students of all ages, as well as their teachers.

In January 2006, 240 17- and 18-year-old students attended an afternoon conference on Alzheimer's disease, the action of aspirin and the chemistry of sexual attraction. In March, another 200 school students attended a food chemistry conference at which three-star Michelin chef Heston Blumenthal talked about the psychology of food and provided beetroot-flavoured sweets for the audience. Postgraduate students or young post-doctoral researchers often give a short scientific lecture, with help from the school teacher fellow to ensure that it is pitched at the correct level for the audience. One recent lecture was on advances in synthetic bone chemistry, with a discussion of tissue engineering and artificial hip and elbow joints for the audience to handle. The young research chemists benefit from the communication experience and the school students see that not all academic chemists fit the stereotype of eccentric, out of touch men.

Master classes for secondary school teachers

To support regional teachers, we provide courses for teachers, student teachers and science technicians, working closely with the Science Learning Centre South West[w2] on some courses.

In the UK, chemistry is taught increasingly by biology graduates. One very successful course is therefore aimed at secondary school science teachers who are new to teaching chemistry, are not chemistry graduates and wish to explore the more dramatic demonstrations and practical lessons to enthuse their students. In the full-day course held in the undergraduate teaching laboratories, teachers have the opportunity to first see and then perform numerous experiments and discuss their use within the curriculum. The course also covers the risk assessment of the experiments.

The expected outcomes for the participants are an increase in the teachers':

- Confidence in performing demonstrations or supervising practical lessons
- Range of practical lessons for enthusing students
- Understanding of health and safety issues relating to the practical lessons
- Use of such experiments with their students.

The practical sessions range from simple experiments such as the removal of the oxide layer from aluminium foil to demonstrate the reactivity of aluminium, the reactions of alkali metals with water and passing steam over magnesium, to the more involved organic experiments such as cracking paraffin oil, esterification and oscillating reactions. Other session include the correct handling of gas cylinders, how to set fire to balloons filled with hydrogen gas, how to make oxygen foam, slime-making investigations, exploding methanol vapour, burning acetylene (ethyne) foam, making nylon threads and the catalytic oxidation of ammonia.

Other activities

In addition to the regular activities described above, Bristol ChemLabS collaborate on many smaller *ad hoc* projects with schools. Examples include providing activities for science clubs or analysing infrared spectra of organic products made in schools.

Bristol ChemLabS not only works with secondary schools, but also visits primary schools to promote practical work in chemistry.

All school students visiting the School of Chemistry may collect careers information from professional bodies such as the Royal Society of Chemistry[w3] and the Association of British Pharmaceutical Industries[w4].

Practicalities

The School of Chemistry at the University of Bristol is one of the biggest chemistry departments in the UK, one of only six in the country with the highest rating for research. It is also the only department to gain funding from the Higher Education Funding Council for England to create a centre for excellence in teaching and learning in practical chemistry – Bristol ChemLabS. Some of this money was used to appoint a qualified and experienced secondary school teacher as a school teacher fellow, to find ways in which the many resources of the University can be used to stimulate an active interest in chemistry by school students and pupils of all ages.

Most university science departments, of course, do not have these financial and staff resources, but this need not stop them from providing effective and inspiring activities for schools. We hope that this article and our website[w5] provide some useful ideas – and Bristol ChemLabS would be happy to offer advice.

Web references

w1 - More information on the Science and Engineering Ambassadors Scheme is available at: www.setnet.org.uk/cgibin/wms.pl/32

w2 - The Science Learning Centres form a national network, set up by the UK Department for Education and Skills and the Wellcome Trust, to provide continuing professional development for everyone involved in science education at all levels: www.sciencelearningcentres.org.uk

w3 - The Royal Society of Chemistry is the largest organisation in Europe for advancing the chemical sciences: www.rsc.org

w4 - The Association of British Pharmaceutical Industries is the trade association of companies in the UK producing prescription medicines: www.abpi.org.uk

w5 - Information on forthcoming and recent events organised by Bristol ChemLabS can be found at: www.chm.bristol.ac.uk/schools/

Tim Harrison is the first Bristol ChemLabS school teacher fellow in the University of Bristol's School of Chemistry and was awarded a Royal Society of Chemistry Schools Education Award in 2005. Email: T.G.Harrison@bristol.ac.uk.

Dudley E. Shallcross, Outreach Director and Reader in Atmospheric Chemistry at the University of Bristol, was awarded a National Teaching Fellowship by the Higher Education Academy, for his excellence and innovation in teaching in 2004. He was awarded a Royal Society of Chemistry Higher Education Award in 2005. Email: D.E.Shallcross@bristol.ac.uk.

REVIEW

This article describes a number of activities developed by a university department to engage with students and teachers at secondary school. It gives several useful ideas for the promotion of chemical sciences through workshops, conferences, master classes for teachers and other activities including the Science and Engineering Ambassadors Scheme.

The most important aspect of the activities described may be to attract students to the chemical sciences at university. However, another important aspect is that it may inspire teachers to make contact with their local chemistry (or other science/engineering) department to see what they can offer, to help them 'sell' and teach science to their students. The inclusion of web references adds to the general usefulness of the article.

This short article gives a concise description of activities, with just enough information to whet the appetite for any teacher interested in finding out more.

Marie Walsh, Republic of Ireland

The Bone Trail: generating enthusiasm for earth sciences in the classroom

Emm Barnes from the British Society for the History of Science describes an initiative to develop exciting interdisciplinary activities. And gives the recipe for a delicious edible geology project!

Build your own dinosaur

'The Bone Trail' is an exciting schools project funded jointly by the British Society for the History of Science, Bolton Local Authority Secondary Strategy, and the Manchester Museum, UK. A team of three educators – one academic historian of science (the author), and two science teachers (Peter Fowler and Alison Henning) – designed two full days of activities for Year 9 students (ages 13-14) on the history of comparative anatomy, geology and palaeontology. The emphasis was on teaching thinking skills, inspiring enthusiasm in earth sciences in particular and in learning in general. Students from Westhoughton High School and the Frances Bardsley School for Girls tested the activities in May 2006, and we are most grateful to the teachers in these schools for their ongoing commitment to the project.

The model iguanadon leg and its creators

Most primary schools in England teach and integrate history and geography, science and art, literacy and numeracy, using themes such as "where we live" or "life in the 1930s". In contrast, children in secondary schools are taught these subjects separately, and many children appear to decide at this stage that they do not like or are not good at science or the humanities, or indeed that they do not belong in school at all. We wanted to combat this tendency by reuniting science with history, mathematics, literature, art and food technology. Interdisciplinary activities encourage children to reflect on their process skills, and offer scope for teachers to cater to the full range of learning preferences. We have tried to produce materials that are as enriching and fun as those that are sometimes made available to children identified as gifted and talented. We intended our materials, however, to be used with *all* children, as we believe that every child can benefit, intellectually and socially, from the extra attention and from making connections between different subject areas.

During the pilot of 'The Bone Trail', it was obvious that those activities which avoided worksheets were the most popular, stimulating discussion over lunch breaks and on follow-up weblog sites set up to evaluate the activities. One of the simplest activities was to present children with two different solid geology maps of England, one a replica of William Smith's 1815 map – the first to represent the whole country – and the other a modern survey. We set the children three tasks to work on in small groups: to list the similarities and differences between the two maps, to suggest when each had been drawn, and to come up with their own questions about the maps. This last task was crucial, as it encouraged the students to decide what the most interesting questions about the maps were, and allowed their teachers to assess more accurately the level at which individual children were working. We found that children were

BACKGROUND

Want to get involved?

For further information on the project, or to register an interest in taking part in the second year of the pilot (2006-2007), please email outreach@bshs.org.uk.

stunned to discover that the older map had been produced almost two centuries ago, from the work of one surveyor, especially given how similar the two maps were.

To explore how we know how extinct animals looked and moved, we set each child the task of compiling a one-page poster about the history of theories about dinosaurs, using Internet searches. We recommended several sites with reproductions of artists' reconstructions from the 19th and 20th centuries, and showed the children how to use image search engines, so that they could discover for themselves how theories about the animals' anatomy and physiology had evolved over time. The children showed great sophistication in presenting their findings to their peers.

The final activity was for teams to design and build a life-size model of an iguanadon leg from galvanised wire, newspaper, and gauze impregnated with plaster of Paris. Children started by dissecting cooked chicken legs to determine how the muscles on a present-day descendent of the dinosaurs attach to the bones. We then set them a simple mathematics problem: to scale up from a chicken to an iguanadon, remembering that volume increases on the cube rule. In one session, we were fortunate enough to have a fossilised iguanadon femur to help the children to calculate the size of the model leg required. The resulting models were, frankly, stunning. Some of those children who were often disruptive in the classroom proved themselves to be great engineers and team leaders in this exercise, and we could see their self-esteem grow as the models took shape.

The full range of resources are available to download from the outreach page of the British Society for the History of Science[w1] . We welcome suggestions on how to improve the resources, as well as stories of how you have used them in classrooms and museums. To give you a taster, here is part of the 'edible geology' activity. Making edible models helps children learn how sedimentary rocks are made, and the theory of superposition. Sculpting with food also increases interest and engagement in class discussion of the different purposes of and relations between various ways of representing strata – 2D representations such cross-sections and surface views of solid geology, and 3D models such a relief maps. In the full set of resources, children are given two ways to make 3D models of the solid geology in their local area: firstly with bread and butter, and secondly with three colours of chocolate. Overleaf is the recipe for the second and sweeter option.

References

Anon (1859) Geological Twelfth-Cakes. *Punch* **36**, p31

Web references

w1 - The full range of 'Bone Trail' resources can be downloaded from the outreach page of the British Society for the History of Science: www.bshs.org.uk/bshs/outreach/

REVIEW

This article is very interesting and enjoyable, and the project addressed is even more engaging. The particularly strong points of The Bone Trail are the link between academic research and school teaching; the interdisciplinary approach, stressing the unity of culture and the multiple connections between science and humanities; the integration of traditional teaching with hands-on and e-learning activities; the use of models built with common household or kitchen materials; and the transferability to other teaching contexts.

I recommend this article to secondary school teachers (for students aged 10-15) willing to develop a multi-disciplinary curriculum and to foster students' interest in the history of science. The practical activities like building the anatomical model of a dinosaur's leg and preparing the 'geological cake' (with geological faults!) are simply fantastic to arouse enthusiasm and motivation among the pupils.

Creative teachers may also be inspired to extend and adapt the proposed materials with the help of the quoted website.

Giulia Realdon, Italy

CLASSROOM ACTIVITY

Stratified chocolate refrigerator cake

In 1859, *Punch* jokingly suggested that a good way to teach the public about geology would be through the sale of layered cakes: "Let cakes be made to illustrate the science of geology – composed of strata resembling those of the earth except in their relation to the sense of taste. Children might thus be crammed at once with cake and geological science, and acquire a knowledge of the crust of the earth in eating the model of it" (Anon, 1859).

In this recipe, children sandwich a cherry-studded layer in between two other strata of chocolate "rock". After it has set, they create a fault line to reveal the cherry seam.

Ingredients

100 g white chocolate

100 g milk chocolate

100 g dark chocolate

3 pieces of butter, each weighing 20 g

25 g rice crispies

120 g glacé cherries, cut into halves (if not available, use sultanas or raisins)

75 g digestive biscuits, broken into crumbs

You also need a round cake tin 15-17 cm in diameter. (Small disposable foil baking trays also work and can simply be ripped open when it is time to cut, mine and eat the cake, which removes the need to line the cake tins.)

Method

1. If using a cake tin, prepare it by lining with baking parchment.
2. Melt the white chocolate with one of the 20 g pieces of butter, in a microwave on medium power (set it for 30 s and then stir, and repeat until it is melted; it will take about 2 min in total), or in a heatproof bowl placed over a saucepan of simmering water.

   Add the rice crispies.

   Pour the mixture into the cake tin, level it off and press down. (Here you are compressing 'sediments' to help them become densely packed rock.)

   Place somewhere cold to help it set a little while you prepare the next layer.
3. Melt the milk chocolate with 20 g of the butter, as above.

   Add the cherries.

   Pour on top of the white chocolate layer, level it, then press down.
4. Melt the dark chocolate with the remaining 20 g of butter.

   Add the biscuit crumbs.

   Pour onto the top of the other two layers, level it and then press firmly.
4. Place the cake tin in a refrigerator and leave to set for about 8 h.

   Once the cake has set, remove it from the tin by lifting it out onto the baking parchment. Carefully remove the paper. Leave to warm for 15 min or so before attempting to 'fault' the 'rock'.
5. Take a sharp knife and make a cut through the middle of the cake, preferably at a slight angle rather than straight down. This is your fault line.
6. Now move one of the pieces so that the top of the dark chocolate layer on one half is level with the middle of top of the milk chocolate layer on the other, exposing the cherry seam. If you like, you could use toothpicks to carefully mine out the cherries. Try not to disturb the other layers of rock – you don't want to cause a rock fall!

Bringing global climate change to the classroom

Ivo Grigorov from the EurOCEANS project describes how the deep seas can help us to understand and predict climate change.

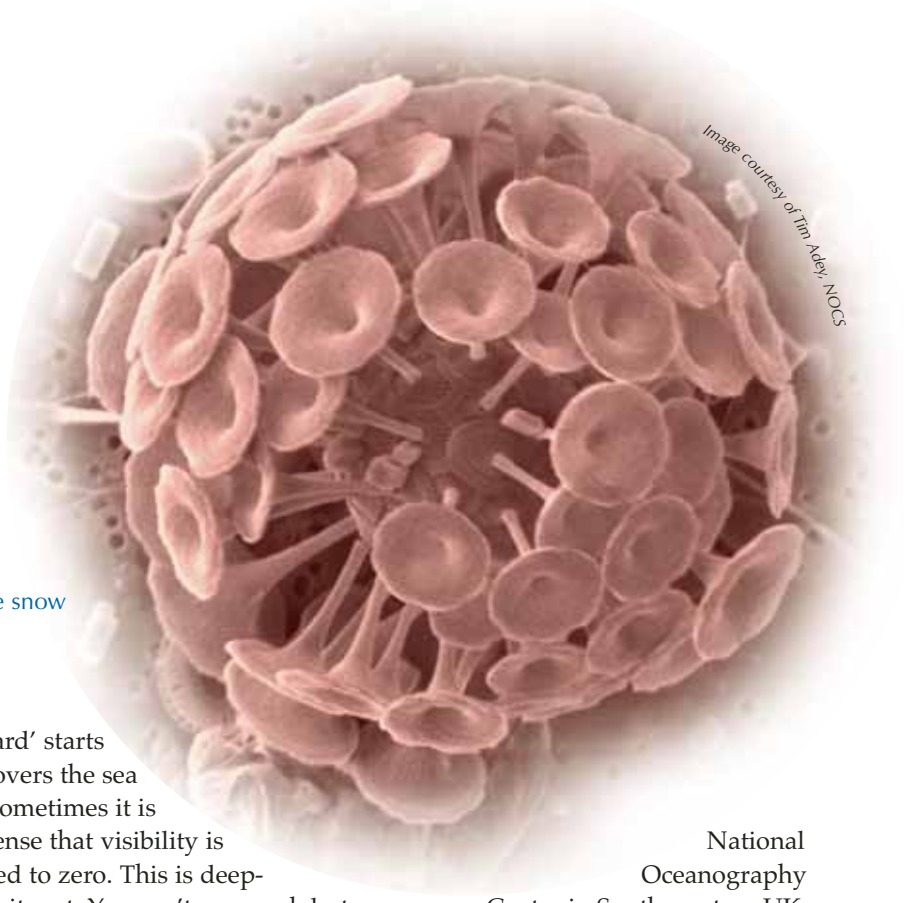


Image courtesy of Tim Adey, NOCS

Marine snow

It's spring. It's dark, but then it always is. The drift is gentle, it's the calm before the storm. You would have to be on the *Nautilus* sitting next to Captain Nemo to experience it. At first sight not much lives here, and what life there is, is more suitable for a 1960s horror sci-fi film than for factual science. The pressure is enormous and seawater corrosion is vicious. Even treated steel is reduced to crumbs after a year, yet delicate life forms thrive here. Gelatinous sea stars of all varieties and deep-sea cucumbers are all waiting for the 'snow'. Pretty soon they are rewarded. The 'blizzard' starts and covers the sea bed. Sometimes it is so intense that visibility is reduced to zero. This is deep-sea whiteout. You can't see much but it's an awesome sight.

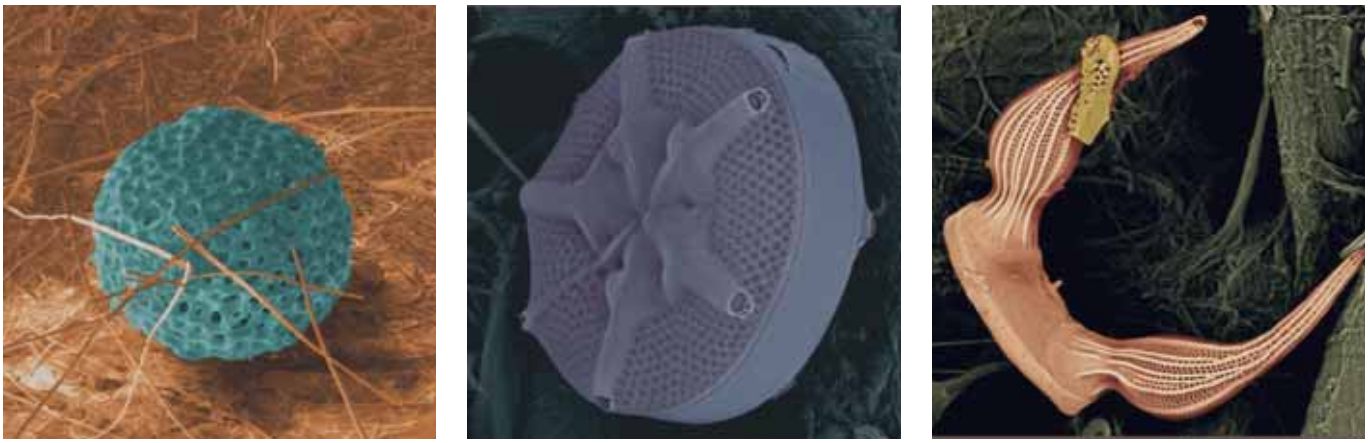
The depths of the oceans hide many secrets which at first glance have little to do with our daily lives. If deep-sea 'blizzards' tickle your imagination, and Captain Nemo's *Nautilus* is not at hand, no problem! Just climb aboard the online weblog of the UK's oceanographic research ship *Discovery*. Every year oceanographers from the National Oceanography Centre in Southampton, UK, organise an oceanographic cruise to the North Atlantic and invite students and teachers to join them at the frontier of multidisciplinary research in almost real time. Day by day, students and teachers can follow life and research at sea, send questions to the scientists and learn about climate change and how it is measured and studied. The aim of the cruise is to continuously measure the fall of these deep-sea 'blizzards' to the depths of the ocean and find out how they are linked to the climate we experience every day.

So what are deep-sea 'blizzards'? The 'snowflakes' are not of the familiar type. Most of them are the settling remains of a battle taking place at the surface of the oceans. Except for a

Images courtesy of Richard Lampitt, NOCS

Snow falls 4800 m below sea level! Fluff and mucus cover the seabed in a brief moment

Images courtesy of www.sinia-planeta.com



Deep-sea snowflakes: the elegant remnants of the blooming phytoplankton. The sinking shells of the single-celled algae bring with them organic matter, thus sequestering atmospheric CO_2 to the bowels of the oceans

Image courtesy of Richard Lampitt, NOCS

Measuring marine snow: RRS *Discovery* deploying a sediment trap west of the English Channel to capture sinking marine snow and analyse its composition

very thin sun-lit layer, the ocean is a dark and cold place. At its surface, however, the Sun supports a diverse variety of single-celled phytoplankton. These are the green meadows of the oceans on which the majority of the ecosystem relies for food.

The single-celled phytoplankton are grazed by agile zooplankton armed with fierce mandibles ready to crush anything in their path. But for the zooplankton, it is not a simple triumph. Although single-celled phytoplankton cannot outswim the fast zooplankton, their strength is in numbers. Despite their microscopic size, the phytoplankton can bloom in such high densities that long wisps gently swayed by the ocean currents can be seen even from space.

Phytoplankton armour also includes spines, hooks and all-encompassing calcite, glass or organic shells. These are the architects-supreme of the nano-world. Their shell designs not only serve a protective purpose, but are also intricate and elegant, providing maximum functionality with minimum material – every architect's dream.

But even when the body armour serves its purpose, the phytoplankton blooms have a limited lifespan. Nutrients in the surface waters are eventually exhausted and the blooms settle out of sight, into the depths. Moults of marine crustaceans, faecal pellets of animals of all sizes, and dust swept off the continents by the wind also accompany the dead plankton to the bowels of the ocean. Together, these remnants are termed 'marine snow'. And at depths of 4500 m, the 'snowflakes' seem to go in all directions, depending on the prevailing currents – rather like snow blizzards, kilometres above.

BACKGROUND

How to get involved

Students can put their questions to the scientists involved in the 2006 oceanographic cruise by contacting Ivo Grigorov (ivo.grigorov@eur-oceans.org). Please include the name and location of your school.

Teachers keen to involve their science class, in real-time during future oceanography expeditions or in future web conferences with European oceanographers and climate change scientists, can express their interest to Ivo Grigorov or Sylvain Ghiron (sylvain.ghiron@oceanopolis.com).

Trapping and analysing the fragile 'snowflakes' requires the services of engineers and materials scientists who design instruments that will sur-

BACKGROUND

Other projects and materials from the partners

EurOCEANS

The European Network of Excellence for OCean Ecosystem ANalysiS focuses on the future impact of climate change on the ocean ecosystem. The research of its members is disseminated through:

Short films – regularly released short films on topical issues such as climate change and ocean acidification (Languages: English, French)

Web conferences – live online conferences and Q&A sessions with European oceanographers and climate change researchers. To express your interest, contact Sylvain Ghiron (sylvain.ghiron@oceanopolis.com) or visit www.eur-oceans.info/conferences/ for announcement of the next conference. (Languages: English, French)

Educational cards – currently in French but other European languages can be supplied depending on demand: www.eur-oceans.info/education/

To date, schools from France, UK and Italy have taken part in the EurOCEANS educational projects. To express and register your interest, contact edu-contact @eur-oceans.info or visit www.eur-oceans.info /education/.

National Oceanography Centre (NOC), Southampton, UK

NOC is a leading research institution and produces the Oceans4Schools online educational aids as well as a very popular series of posters on earth science topics. The institute also has a project that lets teachers participate in oceanographic cruises. Visit www.noc.soton.ac.uk. (Language: English)

www.sinia-planeta.com

www.sinia-planeta.com is a popular science web portal aimed at schools in Bulgaria. Products include in-depth articles on topical scientific discoveries as well as educational aids on earth science topics. (Language: Bulgarian)

vive very hostile conditions for months and years at a time. Once the marine snow has been gathered, identifying its composition takes many chemists and biologists. Even computer scientists and mathematicians help, creating sophisticated computer models and trying to simulate the processes that form the deep sea 'blizzards'.

This phenomenon, however, is more than just a 'strange but true' fact. This is deep-sea climate, and it is directly linked to climate changes around the world, both past and future. After the burst of spring productivity at the ocean's surface, the sea bed is covered with the nutritious snow of organic material. Some of it feeds deep-sea animals, but some of it is buried in subsequent years, forming layer upon layer of deep-sea sediments. Just as tree rings can tell us about annual rainfall and forest fires, and the trapped bubbles in the layers of ice in ancient glaciers help us to recreate the composition of the atmosphere, deep-sea sediments contain a wealth of information on how the oceans function and interact with the rest of the planet. The watery two-thirds of our planet act as a radiator, with the top few metres of its surface containing more heat than the entire atmosphere. A well-known example today is the Gulf Stream, which brings warm tropical waters to European shores. But how did it behave in the past? How much heat did ocean currents carry, and where did they take it? And as for the future, how will these same currents behave under the pressure of human activity?

The answer lies in the chemical composition of deep-sea 'blizzards'. Understanding their biology and chemistry is the key to unlocking the secrets of the deep-sea layers they form. The shells of the long dead and buried phytoplankton within these layers hold clues to the climate conditions under which they were formed. Their isotopic composition can tell us about sea surface temperature, nutrients and productivity in the oceans, and the amount of wind-borne dust gives clues to the planet's aridity and wind regimes millions of years ago. And knowing the past is key to predicting climate change in the future.

Today, scientists can recreate sea surface temperature, ocean currents and wind patterns, as well as how much polar ice caps changed and how this caused sea level to oscillate by more that 100 m. Reading the sedimentary encyclopaedia formed by annual deep sea 'blizzards' is not just an exercise in curiosity. All these parameters shape the weather we experience every day.

Image courtesy of Tim Adey, NOCS

Learn more

To find out more about how oceanographers measure the deep-sea 'blizzards' and what it takes to be an oceanographer, visit the online weblog of *Discovery* Oceanography Expedition 2006 at www.eur-oceans.info/diary/index.php. The annual weblog is a joint project between www.sinia-planeta.com (Bulgaria) together with National Oceanography Center, Southampton (UK) and EurOCEANS – the European Network of Excellence for OCean Ecosystem ANalysiS. The 2006 weblog was run in English, French, Portuguese, Bulgarian and Turkish.

The climate puzzle is a complex one. It transcends the boundaries of the scientific disciplines that we are so used to at school, and requires co-operation between geologists and chemists, biologists and mathematicians. It also fosters a new breed of scientist – the type that seeks answers in areas where they have little knowledge. It creates a new science too – the multidisciplinary type, where the boundaries between biology, chemistry and mathematics melt away.

Ivo Grigorov is a project officer for EurOCEANS (European Network of Excellence for OCean Ecosystem ANalysiS) and editor of a popular science website in Bulgarian.

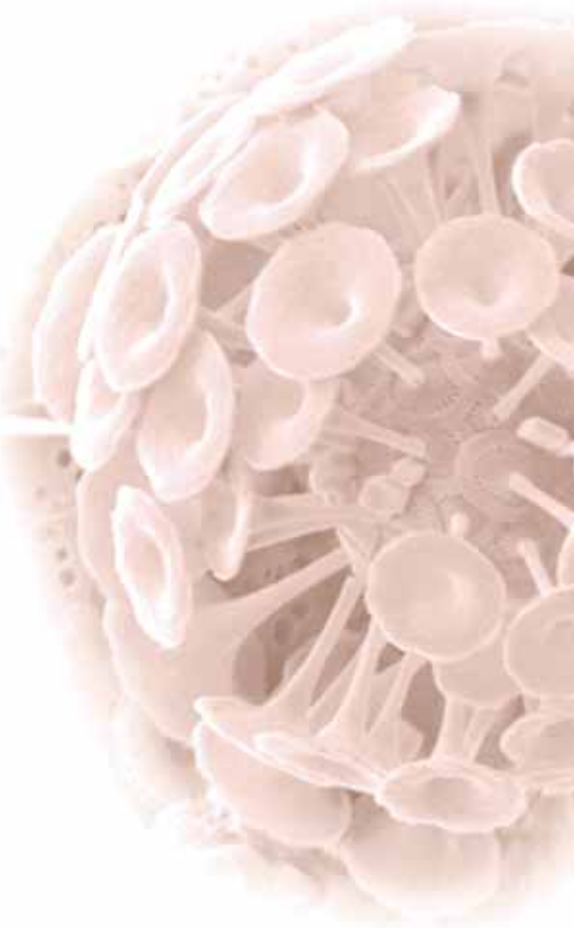
REVIEW

Ivo Grigorov draws a colourful picture of the ocean world and introduces a non-traditional, highly interesting way of predicting global climate change, based on studying deep-sea 'blizzards'. In doing so, he draws attention to two important issues in modern science research: how various science disciplines are often brought together to study a single phenomenon, and how research can be made available to those interested, including high-school students.

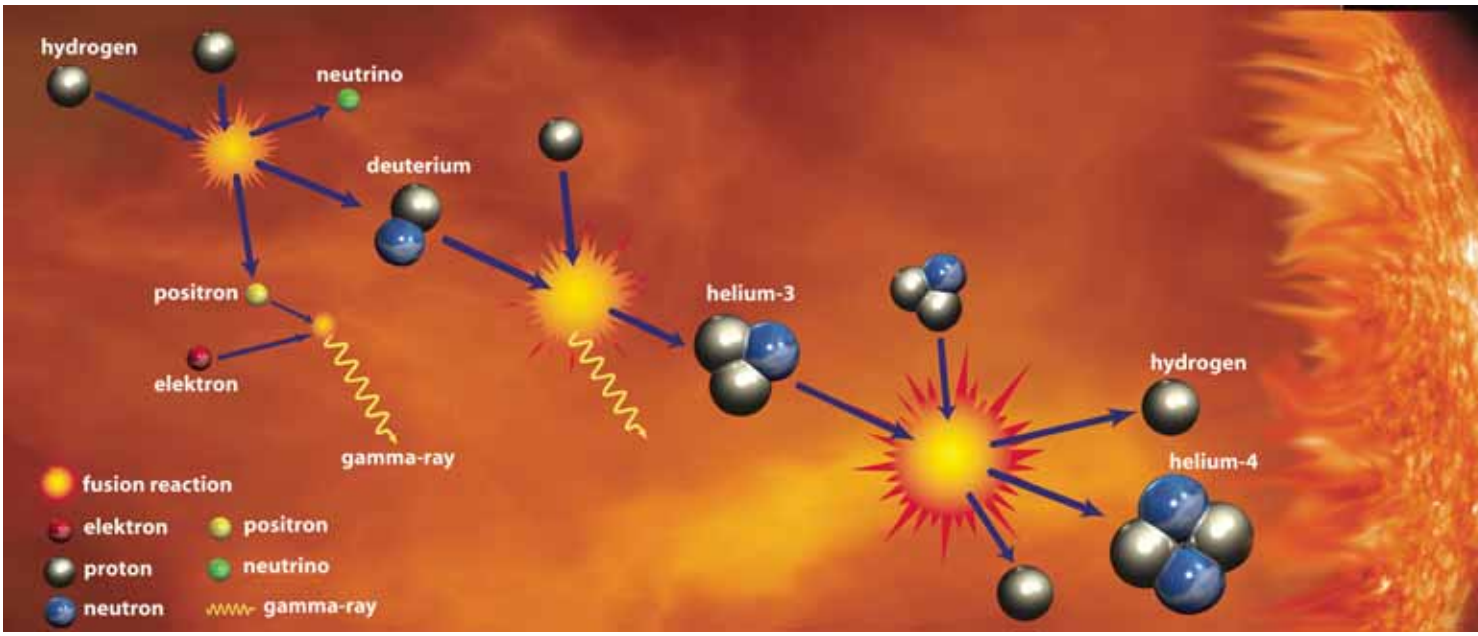
This is crucial in developing students' attitudes towards science as it makes it more attractive to them. Furthermore, as this method of studying global climate change deals with a mostly unknown world, the mysteriousness of which fascinates people, it is likely to capture students' imagination and motivate them to learn more.

In the classroom, projects can be designed to investigate how the findings from the study of the deep-sea 'blizzards', made readily available by the actual research scientists, can correlate with the surface climate and other global phenomena. Such studies might require co-operation between students studying a variety of science disciplines, including biology, chemistry, geography and geology. This can emphasise the interdisciplinary nature of modern science.

Michalis Hadjimarcou, Cyprus



Fusion in the Universe: the power of the Sun



Mark Tiele Westra from the European Fusion Development Agreement (EFDA) in Garching, Germany, elucidates the source of power on Earth: the Sun.

Just over one hundred years ago, nobody had a clue how the Sun manages to produce the enormous amount of energy it radiates into space. Sure, there were thoughts and ideas, many of them very clever. Some scholars thought the Sun was a huge cloud of gas, collapsing under its own gravity, with the resulting friction and collisions causing it to heat up. Others thought that the Sun just hadn't had a chance to cool down since its creation. These ideas led to a similar conclusion: that the Sun couldn't be much older than a couple of tens of millions of years. Any older and it would have already cooled down.

But along came Darwin and his colleagues, studying the formation and erosion of rocks, and the slow, slow evolution of life. For their theories to make sense, they needed the Sun to be much older, at least hundreds of

Energy production in the Sun: two hydrogen nuclei fuse to form a deuterium nucleus, a positron and a neutrino. The positron quickly encounters an electron, they annihilate each other, and only energy remains. The deuterium nucleus goes on to fuse with another hydrogen nucleus to form helium-3. In the final step, two helium-3 nuclei fuse to form helium-4 and two hydrogen nuclei

millions of years, perhaps even a billion years, old. Controversy reigned.

It was not until the discovery of radioactivity, and the acceptance of the surprising notion that mass and energy are somehow interchangeable according to Einstein's $E=mc^2$, that a solution was in sight. Sir Arthur Eddington, a British astronomer, was the first to weigh up all the evidence, and boldly conjecture that it might be nuclear fusion, the process that creates heavier elements by fusing lighter ones, that was responsible for the Sun's copious energy production. In the meantime, we know that the Sun indeed burns hydrogen, the lightest gas in the universe, and turns it into helium. We even know how – see the figure above.

The details of this process are intriguing. First, a hydrogen nucleus (proton) in the Sun has to wait on average of five billion years before it

BACKGROUND

The discovery of helium

In the 17th century, scientists studied the composition of light (the spectrum) by splitting it into its composite colours using a thin slit and a prism. From experiments with glowing gases, it was well known that elements, when heated, selectively emit certain precise colours of light, showing up as bright lines in the spectrum (think of a neon tube).

Looking at the spectrum of the Sun, people found dark lines that corresponded exactly to the place in the spectrum where bright lines appeared in glowing gases. People were quick to realise that the dark bands must be caused by the same element, which, instead of emitting light, *absorbs* it. In this way, the composition of the Sun could be analysed by carefully studying the spectrum of sunlight.

Most bands in the solar spectrum were known to belong to elements occurring on Earth, but there was a set in the solar spectrum that eluded scientists. In 1868, the British astronomer Norman Lockyer hypothesised that these dark bands were caused by a hitherto unknown element present in the Sun, which he dubbed "helium", after the Greek Sun god Helios. It was not until 25 years later that helium was first isolated on Earth.

takes the plunge, fusing with another hydrogen nucleus to form deuterium. This is actually good news for us: if it happened any faster, the Sun would have run out of fuel long ago, and we wouldn't be here. The second step, in which helium-3 is produced from deuterium and hydrogen, happens on average after 1.4 seconds, and the final step, the production of helium, takes 240 000 years. The energy released during the fusion process is turned into photons: light.

When the first excitement is over, and photons of light have been produced that could one day reach Earth, they still need some patience. A photon sets off on its journey to Earth at the speed of light, but almost immediately bumps into an electron, which scatters the incoming photon in a random direction, like the ball in a pinball machine. This happens again, and again and again. It takes the average photon over 20 000 years to make the 695 000 kilometre trip from the centre of the Sun to the Sun's surface, which translates into a rather pathetic four metres per hour.

After this long and erratic journey, the photon covers the remaining 149 *million* kilometres to Earth with the usual speed of light, and 8 minutes later finally arrives at its destination. And those are the lucky ones: there are also photons in the Sun that were formed five billion years ago, but have still not made it out. Imagine that for a maze...

In the fusion process, another odd particle is formed: the neutrino (see figure). A neutrino hardly interacts with matter, and can therefore escape from the Sun in an instant. Huge numbers of neutrinos are formed by the Sun: every second, 100 *billion* solar neutrinos fly through the tip of each of your fingers! Most neutrinos fly straight through the entire Earth, without being affected by it at all. In fact, a neutrino would fly through a light-year of lead, without being stopped!

When we think about the centre of the Sun, we image some fierce, fiery furnace, blasting out heat. With a density 150 times that of water (half a litre of Sun weighs as much as an average person), and a temperature of 15 000 000 degrees Celsius, it is a pretty daunting environment by any standards. But if you were to take a cubic metre from the centre of the Sun, you would find that it only produces about 30 Watt, hardly enough to power a light bulb. It is the sheer size of the Sun that ensures that we actually feel warm on Earth.

At the moment, the Sun burns 600 million tonnes of hydrogen each second, turning it into 596 million tonnes of helium. Where did the missing four million tonnes go? It has been completely transformed into energy. Applying $E=mc^2$ (with E the energy, m the mass, and c the speed of light), we find that 4 million tonnes of matter equate to 100 000 000 000 000 000 000 Kilowatt hours of energy, or roughly *one million* times the amount of energy that the entire world uses in a year. And that energy is released by the Sun every second. Now that's solar power!

So far, the Sun has burned up half of its hydrogen fuel supply. It has been burning for five billion years, and will burn for another five billion. What then? Then the party is over. The Sun will swell up to become a 'red giant', boiling away the atmosphere and all water and life on our home planet. We'd better get out before that time, but let's enjoy it while it lasts.

Resources

For a discussion of fusion as a future energy source, see:

Warrick C (2006) Fusion – ace in the energy pack? *Science in School* **1**: 52-55. www.scienceinschool.org/2006/issue1/fusion

REVIEW

In an age where non-renewable sources of energy are fast disappearing and efficient renewable sources of energy are frantically sought, fusion is often the subject of discussion in many scientific journals and newspapers. From a young age, students may be faced with such a term without understanding quite what it means.

Mark Tiele Westra from the European Fusion Development Agreement in Garching, Germany, gives us a very interesting and concise account of the fusion process occurring within the Sun. Although the article provides a theoretical treatment of the topic and is of interest to the science teacher just as it is, it comes with a very informative illustration, both of which can be easily adapted and used according to the students' abilities to explain fusion in the science classroom. For more advanced students, there is also some detailed information on the discovery of helium.

Elton Micallef, Malta

Sleep and learning

When we sleep, are we just passively recovering from a hard day, or is there something more going on? **Angelika Börsch-Haubold** considers the implications of some intriguing research – was her grandmother right all along? Test the scientists' conclusions for yourself!

My grandmother used to say that a good night's sleep is essential for learning. She even insisted that the sleep before midnight was best. Children are usually happy to go to bed when tired but most teenagers see it as part of their emancipation from parental interference to stay up late. And our society seems to approve: today, we sleep 20% less than our ancestors did because we push ourselves to work longer hours and to have evenings full of social activities (Hargreaves, 2000).

Everybody knows that our own cognitive performance is impaired after a late night or even after regularly losing small amounts of sleep. Fatigue is estimated to be an important factor in one-third of traffic accidents and to be the number one cause of fatal crashes in 18-to 25-year-olds. But sleeping too little puts not only your own life at risk. In an anonymous survey in San Francisco, over 40% of hospital staff admitted causing the death of at least one patient by making a fatigue-related mistake.

A simple indicator of sleep deprivation is the urge to fall asleep during the day. This happens to pupils during lessons, to students over their textbooks, to travelling business people, or to elderly people in front of the TV. So, sleep deprivation is a widespread phenomenon and apart from its potentially fatal consequences, this impinges strongly on our ability to remember and hence to learn.

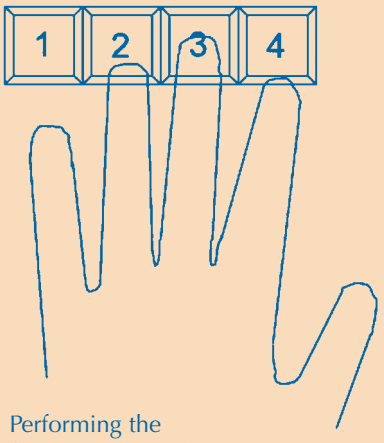
Image courtesy of PixelQuelle.de

Memory consolidation and sudden insight

In the past few years, scientists have discovered that there is more to sleep than a simple refreshing of our nerves. The process of learning is actively taken up by our brain during sleep (Huber et al., 2004), which is essential for the formation of long-term memory. The first memory that is built when we learn a new task is susceptible to interference. After a certain time, an automatic process called memory consolidation sets in, which stabilises that memory. Memory consolidation continues during sleep, but then leads to the additional effect of memory enhancement. Thus, our brain performs better after an afternoon nap and much better after a full night of sleep (Stickgold, 2005). Also, when we are searching for the solution for a tricky problem, our brain continues to work on it while we are sleeping. As a result, we may experience a sudden understand-

CLASSROOM ACTIVITY

Experimental protocol for the finger-tapping task



Performing the finger-tapping task

For the finger tapping task, please download the pre-programmed Excel worksheet FingerTap.xls[w1]. Before the spreadsheet is used, copy it and save the copy under the name of the student learning the task. Two students work together. One of them, who needs to be right-handed, puts four fingers of his/her left hand onto the keys 1 to 4 of the computer keyboard, see figure. Starting in the column 'run 1', the subject must repeatedly tap the five-figure target sequence shown at the top of the sheet as quickly and as accurately as possible. The typed sequence is not displayed in the cells. After each sequence, the student presses the enter key with his/her right hand to move the cursor one cell down. The partner measures the time. Each run is performed for 30 seconds, followed by a 30 second rest; the training phase consists of 12 runs (one in each of the 'train' columns labelled 'run 1' to 'run 12'). The retest with 6 runs ('retest' columns 'run 1' to run 6') under the same conditions is performed either 6-8 hours later on the same day (no sleep group) or the next day after a full night's sleep (sleep group).

The first sheet of the Excel spreadsheet is programmed to count all correct sequence entries and to give the result in the row entitled 'score' (row 56). The second sheet automatically analyses the data, plotting the run number against the score result and comparing the training results with the retest results. To quantify the difference between the sleep and the no-sleep group, the mean number of correct sequences of the training phase is compared with the mean of the retest; the mean values for each student are automatically calculated in the spreadsheet.

Examples of completed spreadsheets can be downloaded from the *Science in School* website[w1]

ing of a rule, an insight, that is sometimes even triggered by a dream. Two experiments that measure the effect of sleep on memory consolidation and on sudden insight are described below.

What happens to our brain while we sleep?

The hypothalamus, as the central regulatory organ of the autonomic nervous system, controls the circadian rhythms (body clock) of our body temperature, hormone release, appetite and sleep. It contains a neuronal switch that regulates 'wake nerves' and 'sleep nerves'. A sudden transition to the sleeping mode ('falling' asleep) means that sleep nerves fire to inhibit wake nerves. The switch is stabilised by a third group of neurons, otherwise we would frequently wake up at night (Saper et al., 2005). To picture the neuronal mechanism underlying sleep, imagine three children on a see-saw. One sits on either side of the beam bouncing up and down – the switch. The third child sits on top of the axis. When it shifts its weight to one side of the beam, it effectively stops the motion – the stabiliser.

This dynamic system generates the different stages of sleep that have been known for some time: rapid eye-movement sleep (REM) in which dreaming occurs, and non-REM sleep with the light sleep stages I and II and the deep sleep stages III and IV. The pattern of a night of sleep is characterised by 90-minute cycles composed of deep sleep and light sleep phases. An initial long period of stage III and IV sleep is followed by a short period of REM and stage I and II sleep. As the night progresses, the deep sleep phases become shorter and the dreaming phases longer.

The physiological function of sleep seems to be two-fold. First, non-REM sleep is a period of low metabolic demand in which the adenosine triphosphate (ATP) energy stores, used up while we are awake, are replenished. The degradation product of ATP, adenosine, acts as a physiological sleeping agent by directly activating the sleep-promoting neurons. Second, sleep plays a key role in neural plasticity. During sleep, significant connections between neurons are reinforced while accidental connections are eliminated. All the different stages of sleep have been implicated in sleep-dependent learning.

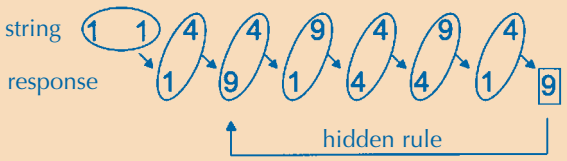
CLASSROOM ACTIVITY

Experimental protocol for the number-reduction task

Students are taught a standard algorithm for reducing a given eight-digit sequence (composed of the digits 1, 4, and 9) to a final solution (see figure). They must apply two simple rules: 1) the 'same rule' states that the result of two identical digits is just this digit (e.g. 1 and 1 results in 1); 2) the 'different rule' states that the result of two non-identical digits is the remaining third digit (e.g. 1 and 4 results in 9). After the first response, comparisons are made between the preceding result and the next digit (i.e. between the circled digits; the arrow points to the correct result). The seventh response indicates the final solution; the time needed to solving the sequence should be recorded.

What the students do not know is that there is a 'hidden rule': the strings are generated in such a way that the second response of each trial coincides with the final response. Insight into this hidden rule sharply reduces the time needed to reach the final response for a string.

Before the experiment starts, students perform without mistakes on ten practice sequences (that do not obey the hidden rule) to ensure their understanding of the 'same' and 'different' rule. A Word document with practice and experiment sequences (NumberRed.doc) can be downloaded[w1].



The number-reduction task

The experiment consists of an initial training phase (three task blocks each of 30 sequences), a period of 8 hours of sleep or wakefulness and retesting (ten task blocks). At the end of the experiment, the percentage of subjects who recognised the hidden rule is calculated and the sleep group is compared with the no-sleep group. In the original publication, subjects who recognised the hidden rule reduced their solution time per string abruptly from 8.7 to 2.4 seconds.

When preparing the experiment, make sure that students do not suspect that there might be a shortcut to the solution. If a student discovers the hidden rule during initial training, his or her data should be excluded from final analysis.

Sleep-dependent memory enhancement

The effect of sleep on learning is easiest to quantify when measuring unconscious learning. This can be done with experiments to test motor skills, such as finger-tapping on a keyboard or tracing a line displayed on a computer screen, or by testing perceptual skills, such as differentiating between diagonal bars in the foreground against horizontal bars in the background.

In the finger-tapping task, subjects repeatedly type a numeric sequence, for example 4-1-3-2-4, as fast as possible (see box). They get better over the first five minutes of practice, after which they approach an asymptote of about 60% improvement over twelve 30-second trials (Stickgold, 2005). Retesting 4 to 12 hours later the same day gives no further improvement. After a night of sleep, speed and accuracy of tapping is enhanced on average by 20%. After another two nights, a further increase of 26% is measured. These data clearly demonstrate the process of memory enhancement through sleep.

Interestingly, sleep only helps if we do not learn too much at a time using the same type of memory. During the finger-tapping experiment, when a second, unrelated sequence is learned immediately after the first training session, only the tapping of the second sequence improves after sleeping (Walker et al., 2003). Different time settings of training and retesting show that memory undergoes the first stabilisation phase of consolidation within 10 minutes to 6 hours after

learning and only then becomes resistant to interference from a competing memory. However, brief periods of rehearsal (as in the retest situation) return the memory to a labile state in which it again becomes vulnerable to interference from a compet-

ing motor pattern in need of consolidation.

The scientific evidence for sleep-dependent consolidation of our memory for events (what happened yesterday) and facts (name of a new colleague at work) is weaker. However, in subjects asked to memorise nonsense syllables or to find word-pair associates, early night sleep (rich in deep sleep) supports the stabilisation of this 'declarative memory' (Stickgold, 2005).

Sleep and sudden insight

Sudden insight is a form of complex cognitive learning. A prominent example of how sleep can trigger insight is given by the discoverer of the double helix, James Watson. When working in early 1953 on the base-pairing rule, an important prerequisite for solving the structure of DNA, he thought that he had found a way to pair the four bases adenine, guanine, cytosine and thymine as like-with-like structures via hydrogen bonds. Soon his crystallography colleagues pointed out that this model could not be correct for two reasons. First, Watson was told that guanine and thymine were more likely to be in the keto-configuration (contrary to textbook drawings showing the enol-configuration); second, he was reminded of Chargaff's Rule, that adenine equals thymine and guanine equals cytosine in the overall distribution in DNA.

Equipped with this new knowledge, Watson still did not find the right solution that day, although he cut out cardboard models of the bases. However, of the next morning he writes: "Suddenly I became aware that an adenine-thymine pair held together by two hydrogen bonds was identical in shape to a guanine-cytosine pair [...] All the hydrogen bonds seemed to form naturally [...] Chargaff's rule then suddenly stood out as a consequence of a double-helical structure for DNA" (Watson, 1980). The Watson-Crick double helix was born.

Wager and co-workers have devised a test that determines exactly when such abstract insight occurs in the time course of learning (see box; Wagner et al., 2004). Subjects apply a standard algorithm (consisting of two simple rules) for reducing an eight-digit sequence to a final answer. They do not know that a simple shortcut exists. The percentage of subjects who discover this shortcut or 'hidden rule' when they are retested is 22% in the awake group versus 60% in the sleep group. Thus, the discovery of a complex rule, one of the most sophisticated human cognitive activities, becomes much easier after a night of sleep even if the test person did not know that there was a rule to be discovered.

Conclusion

Recent research on sleep and learning has put my grandmother's saying on a sound scientific footing. Combine this with the clear indicators of widespread sleep deprivation in our society, and we realise that it is time to re-evaluate our sleeping habits. As we profit for an entire lifetime from efficient learning strategies, an insight into the sleep requirements of our brain should teach us how to learn, work and play in harmony with – rather than against – our neurophysiological background. So, sleep on it.

Acknowledgements

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w1 – All the materials needed for the exercises can be downloaded here: www.scienceinschool.org/2006/issue3/sleep/exercises

REVIEW

This is an article that will capture the interest of pupils and teachers. It sets some complex scientific research and theory in simple terms. The article and experiments may be appropriate as part of the new GCSE courses (ages 14-16) in England, but could also be used with pupils of other ages and in other countries.

Clara Seery, UK

1000 years of missing science

Yasmin Khan from the Science Museum in London, UK, reveals how deeply our modern civilisation has been enriched by previous Muslim civilisations – and argues for a more balanced approach to the history of science.

16th century map of Cyprus by Piri Reis

Image courtesy of FSTC

Isaac Newton, Charles Darwin and Albert Einstein. The chances are that if you try to remember which scientists you were taught about at school, these names will be on your list. But how many students will learn about scholars from non-Western civilisations, such as Ibn al-Haitham, a Muslim scholar of optics who first developed the laws of light reflection and invented the pinhole camera in the 11th century? Or Ibn Nafis, who first recorded observations on pulmonary blood circulation, a theory attributed to William Harvey 300 years later? How about Abbas ibn Firnas, who made the first attempt of human flight in the 9th century, using adjustable wings covered with feathers? And how many would know of Zeng He, the Chinese Muslim admiral who used refined technology to construct fleets of massive non-metal ship vessels five centuries ago?

Many are unaware of the extent to which our modern civilisation has been enriched by a series of past great civilisations, which include a largely unacknowledged and untaught Muslim heritage. This heritage has become part of European mainstream culture over the centuries and is manifest, for example, in our treasured architectural icons such as the dome

Image courtesy of FSTC

The oldest surviving map of the Americas, by Piri Reis, 1513 CE

of St Paul's Cathedral in London, UK, and in the horseshoe arches and gothic ribs of Al-Hambra in Granada, Spain.

Even the way we speak shows the influence of languages from other cultures: many English words used in science, such as alchemy, algorithm, alkali, amalgam and zero, have their roots in the Arabic language and are a small demonstration of the cultural interconnectivity that has enriched Western civilisation over many centuries. The history of astronomy also reveals conspicuous examples of Muslim influences, such as in the naming of stars. Betelgeuse, Rigel, Vega, Aldebaran and Fomalhaut are among the names that are directly Arabic in origin or are Arabic translations of Ptolemy's Greek descriptions. Other terms, such as azimuth (al-sumut), nadir (nazir), and zenith (al-samt), are also derived from Arabic.

The discoveries described above were made during a period commonly misconstrued in history textbooks as the Dark Ages. In fact, in the Muslim world, the period from circa 600-1600 CE was a prolific era of creative enquiry into science, technology and engineering and a time of advancement in civilisation, which would later act as a catalyst for the Western Renaissance. Amongst European scholars who were profoundly influenced and inspired by Muslim scholars were Roger Bacon, Leonardo da Vinci, Kepler, Michelangelo, Copernicus, Andreas Veselius and Galileo.

There has been much study of Muslim contributions to science and

Image courtesy of FSTC

Pendulum in mosque, a miniature showing students studying astronomy with their teacher, reading measurements from an astrolabe. From the 15th century Persian manuscript number 1418 in the University Library, Istanbul, Turkey

civilisation, yet research findings have until recently been confined to academia, a major barrier for teachers and students who seek easy-to-understand material. Four years ago, the UK-based Foundation for Science, Technology and Civilisation (FSTC), began a mission to popularise the Muslim contributions to civilisation through its Muslim heritage website[w1]. For the first time, thanks to the Internet, information about this neglected period of history was readily and freely accessible to the wider public. The website has rapidly become a popular source for information on the Muslim contribution to science and a key resource for teachers and educators who wish to incorporate links to the history of science in their lessons. After the launch of the website, the demand for more materials and resources on the subject increased rapidly. To address this gap, a touring, interactive educational exhibition was developed on Muslim scientific and technological discoveries, contributions and inventions. This exhibition, entitled *1001 Inventions*[w2], was launched in the UK at the Museum of Science and Industry in Manchester[w3] earlier this year.

Image courtesy of FSTC

Taqi al Din and other 16th-century astronomers working in the observatory of Muradd III in Istanbul. From the Shahansani-namah, 16th century, manuscript number FY 1404 in the University Library, Istanbul, Turkey

For the first time, museum visitors, including vast numbers of school groups, had the opportunity to discover innovations from Muslim heritage, many of which still have an impact on our lives. These range from the discovery of coffee as a recreational beverage to the development of sophisticated mechanical devices, as well as basic jet propulsion and rockets. We could all learn much from the Muslim scientists, scholars, polymaths and pioneers of the past, such as the 10th century medic Abul Qasim Al-Zahrawi (known in the West as Abulcasis) who dedicated his life to a multitude of indispensable inventions and innovations that still benefit humanity today. His discoveries include the use of catgut in surgery such as caesarean sections and an array of surgical instruments, including the forceps used in childbirth. A favourite part of the exhibition is a picturesque manuscript illustrating Muslim astronomers working in a 16th century Turkish observatory, clad in traditional robes, turbans and beards. These men are forgotten role models: dutifully star-gazing, making and recording observations, taking precise measurements and performing scientific experiments as a sincere expression of their faith, searching for knowledge to benefit humanity.

Such was the degree of altruism and philanthropy that the golden age of Islamic science lasted for more than 1000 years. There is much debate about what caused the decline of this period in the 17th century, but we would benefit from encouraging students, Muslim and non-Muslim alike, to draw inspiration from this rich civilisation and heritage.

I once overheard a science teacher describing the complaints of her students: they were bored with being taught about scientists who were mostly men and of Anglo origin. This is symptomatic of the existing orthodoxy, which views history and science with a Eurocentric lens, ignoring contributions from other civilisations. Teachers recognise the importance to a student's development of accessible role models to identify with and

relate to. Young female students who aspire to careers in science, particularly those of ethnic origins, could find inspiration from unsung heroines of the past. For instance, Miriam al-Ijli al-Astrulabi, who hand-crafted intricate astrolabes, an early type of global positioning system, or entrepreneur Fatima al-Fihri, who in the 9th century founded the world's oldest university in Morocco.

Initiatives such as the *1001 Inventions* project can encourage young people to participate in and contribute to society. These programmes can have a lasting and positive impact on this and the next generation of entrepreneurs, scientists, engineers and doctors from all communities. The current exhibition has already shown the positive outcomes of constructive representations of historical Muslim achievement. In June 2006, journalist David Bocking, who shadowed a school group visit to the *1001 Inventions* exhibition, reported in the UK's *Times Educational Supplement* the poignant comments of a young Muslim boy:

"This has taught us a lot," said Hassan Zaffar. "I'm a Muslim and it gives me inspiration. It makes you look up to these people, and feel proud of them. It makes you want to go and do something like that yourself."

Educators and policy-makers are gradually realising the need for a more accurate and inclusive account of the history of science as part of school education, which includes an appreciation of the contributions of civilisations that excelled long before our own. The future challenge will be for science curriculum developers to find ways of integrating this into mainstream school science lessons.

Instilling our children with a more inclusive and balanced world-view through our education system is fundamental to maintaining a harmonious co-existence in our society. A shift towards a more balanced account of the history of science is a step in the right direction. Students might thrive if they are exposed to ideas and knowledge that will help to cultivate their identity and to remind them of the different legacies that have shaped their world. These legacies include a shared and rich Muslim heritage, still visible in Europe and the rest of the world. This particular heritage might have been largely forgotten, but is now being rediscovered by all those with an interest in human civilisation and progress.

REVIEW

This article is interesting to and appropriate for science teachers working with students of all ages. There is little of the history of science integrated into science lessons (certainly in the UK), and it is an area in which many teachers have limited subject knowledge. This article helps teachers think beyond the regular scientists that most students will have come across.

Further information, and interesting stories about these Muslim scientists would be a great help. The *1001 Inventions* website has an excellent teacher's pack allowing discussion of Muslim scientists to be brought into everyday science topics, such as acids and alkalis, light and pressure, through a series of lesson plans. As the lesson plans include such regularly used science topics, it will be easy to fit these into a busy timetable. However, don't try to download the resources if you don't have a broadband Internet connection.

Sam Hollis, UK

Web references

w1 - The Muslim Heritage website is an online education community that brings together Muslims and non-Muslims seeking to advance civilisation through the study of our Muslim heritage: www.MuslimHeritage.com

w2 - An extensive website containing much of the information from the *1001 Inventions* exhibition is available here: www.1001inventions.com

w3 - Information about the Museum of Science and Industry in Manchester is available here: www.msim.org.uk

Resources

The Foundation for Science Technology and Civilisation is a not-for-profit organisation which seeks to popularise the Muslim contribution to the West: www.fstc.co.uk

1001 Inventions was displayed at the Museum of Science and Industry in Manchester until 3 September 2006 and will tour the UK and Europe. For more information and to download a free teacher's pack, endorsed by the British Association for the Advancement of Science, visit: www.1001inventions.com

A supporting book is also available for purchase:

Al-Hassani S (2006) *1001 Inventions: Muslim Heritage in Our World*. Manchester, UK: FSTC. ISBN: 09555242606

Yasmin Khan was the project manager for the *1001 Inventions* exhibition.

What Europeans really think (and know) about science and technology

How much do Europeans really know about science and technology? What do they think about it? Do they even care? **Russ Hodge** from the European Molecular Biology Laboratory reports on one of the Eurobarometer surveys.

It's easy to see that science and technology are racing along faster than ever – visit a big electronics store; zoom in on your house with Google Earth[w1]; test one of those talking navigation systems that make you think you could drive with your eyes shut (don't try it). In the face of these developments, you'd think that people's knowledge of science and technology – and their interest in them – would be keeping pace. Unfortunately, that isn't the case. Over the past few years, Europeans' overall interest in science and technology has decreased – just one pattern shown by a series of recent major surveys, the Eurobarometers[w2]. The results of these surveys will surely be of interest to teachers, who are probably our best hope of changing the situation. The complete surveys and a careful analysis of their results can be found online[w2]. This article presents a few highlights.

For more than a decade, the European Union (EU) has carried out regular surveys, called Eurobarometers, to measure public opinion and knowledge on a variety of themes across its member states. One reason is to find common ground as the EU makes policies for countries with diverse cultures; another is to evaluate the effects of past EU programmes. The results are also used to decide what sorts of projects – in education and other areas – the European Commission will support in the future. Two special Eurobarometers carried out in early 2005 should be of particular interest to science teachers: 'Europeans, Science, and Technology' and 'Social values, science and technology'. This article focuses on the first.

The goal of the Eurobarometer on 'Europeans, Science and Technology' was to determine:

- European citizens' interest and level of information
- Their image and knowledge of science and technology
- Their attitudes towards science and technology
- Their ideas about the responsibilities of scientists and policy-makers
- Their perception of scientific research in Europe compared with other parts of the world.

The analysis looks at trends across Europe as a whole, and then breaks down the answers to reveal some fascinating differences between countries, genders, and other types of groups. The results are compared with past surveys to see how Europeans' attitudes to these issues are evolving. Below are some of the questions and a brief analysis of the results.

These are the results for Europe as a whole (1000 people surveyed in each

Question: "Let us talk about those issues in the news which interest you. For each issue I read out please tell me if you are very interested, moderately interested or not at all interested in it."

Themes	Very interested			Moderately interested			Not at all interested		
	2005	1992	Diff.	2005	1992	Diff.	2005	1992	Diff.
Environmental pollution	38%	56%	-18	49%	38%	+11	12%	6%	+6
New medical discoveries	33%	45%	-12	50%	44%	+6	16%	10%	+6
New inventions and technologies	30%	35%	-5	48%	47%	+1	21%	18%	+3
New scientific discoveries	30%	38%	-8	48%	45%	+3	20%	16%	+4
Sports news	26%	29%	-3	42%	38%	+4	32%	33%	-1
Politics	22%	28%	-6	49%	52%	-3	29%	20%	+9

of the 25 EU member/candidate states). On the whole, there is a noticeable drop in the number of people who claimed to be 'very interested' in scientific themes between 1992 and 2005. Additionally, there are interesting differences between individual countries. In an attempt to pin down the reasons behind these trends, interviewers combined the first four themes into a general category ('new inventions and technologies') for a country-by-country analysis. Respondents in Cyprus show the highest interest: 54% said they are 'very interested', far above the European norm. At the other end of the spectrum, only 14% of Lithuanians said they are 'very interested', along with 15% of Romanians, 16% of Italians, 17% of Bulgarians, and 18% of Portuguese.

Breaking the answers down into different groups reveals some other interesting trends:

"Very interested" in new inventions and technologies	
Males	40%
Females	21%
Ages 15-24	38%
Ages 55+	24%
Finished education after the age of 20	41%
Finished education by the age of 15	19%

Those who were very interested or moderately interested were asked to rate the themes they were most interested in. They answered:

Medicine	61%
The environment	47%
Humanities (history, literature, theology, etc.)	30%
The Internet	29%
Economics and social sciences	24%
Astronomy and space	23%
Genetics	23%
Nanotechnologies	8%

There are also some surprising differences in how various groups rate these themes. With medicine, for example, the results are:

People ranking medicine as one theme they are most interested in	
Males	50%
Females	73%
Ages 15-24	40%
Ages 55+	73%
Finished education after the age of 20	73%
Finished education by the age of 15	61%
Still studying	38%

3951 people are 'not at all interested' in new inventions or technologies or new scientific discoveries, and the survey asked them why. The most common answers are:

"I don't understand it"	32%
"I don't care about it'"	31%
"I don't need it"	16%

Why don't people understand? Surveyors asked their subjects, "Do you feel very well informed, moderately informed or poorly informed about these issues in the news?" The results are listed below:

Issues	Very well informed			Moderately well informed			Poorly informed		
	2005	1992	Diff.	2005	1992	Diff.	2005	1992	Diff.
Environmental pollution	15%	25%	-10	61%	60%	+1	23%	14%	+9
New medical discoveries	11%	12%	-1	59%	59%	0	28%	28%	0
New inventions and technologies	11%	9%	+2	53%	53%	0	35%	36%	-1
New scientific discoveries	10%	9%	+1	51%	51%	0	37%	37%	0
Sports news	28%	26%	+2	41%	41%	0	29%	32%	-3
Politics	20%	20%	0	55%	60%	-5	24%	19%	+5

The survey then asked where people get their information about science. The results are the following:

How often do you...	Regularly	Occasionally	Hardly ever	Never
Read articles on science in newspapers, magazines, or on the Internet?	19%	40%	20%	20%
Talk with your friends about science and technology?	10%	37%	26%	27%
Attend public meetings or debates about science or technology?	2%	8%	19%	71%
Sign petitions or join street demonstrations about nuclear power, biotechnology or the environment?	2%	11%	14%	73%

People were then asked about the types of institutes they visited:

Which of the following have you visited in the last 12 months?	
Public library	34%
Zoo or aquarium	27%
Art museum	23%
Science museum, technology museum or science centre	16%
Science exhibition or science week	8%

Interestingly, in Sweden a much higher percentage of the population visits science centres or science and technology museums: 36% of the people interviewed had made such a visit within the past year. Overall in Europe, there is a strong correlation between the level of education a person has attained and such visits: 25% of people who finished their studies after the age of 20 had visited one of these places, compared with just 7% for people who had finished by the age of 15.

CLASSROOM ACTIVITY

Answers from page 23, 'The joy of discovery: a personal experience'

The trail from which Comet West was discovered is indicated by an arrow

Image courtesy of ESO

Another part of the survey concerns people's knowledge of scientific facts. Thirteen statements were made, and the participants were asked to determine whether they were true or false. The chart below shows the overall results.

Quiz statements	True	False	Don't know
1. The Sun goes around the Earth.	29%	**66%**	4%
2. The centre of the Earth is very hot.	**86%**	7%	7%
3. The oxygen we breathe comes from plants.	**82%**	14%	4%
4. Radioactive milk can be made safe by boiling it.	10%	**75%**	15%
5. Electrons are smaller than atoms.	**46%**	29%	25%
6. The continents on which we live have been moving for millions of years and will continue to move in the future.	**87%**	6%	8%
7. It is the mother's genes that decide whether the baby is a boy or a girl.	20%	**64%**	16%
8. The earliest humans lived at the same time as the dinosaurs.	23%	**66%**	11%
9. Antibiotics kill viruses as well as bacteria.	43%	**46%**	11%
10. Lasers work by focusing sound waves.	26%	**47%**	28%
11. All radioactivity is man-made.	27%	**59%**	14%
12. Human beings, as we know them today, developed from earlier species of animals.	**70%**	20%	10%
13. It takes one month for the Earth to go around the Sun.	17%	**66%**	16%

Of the 25 countries tested, Sweden has the highest percentage of correct answers (79%); Cyprus has the lowest (49%). In several countries, the percentage of correct answers has risen appreciably since the same questions were asked in 1992: Belgium (13%), Germany (10%), Ireland (10%), Luxembourg (17%) and the Netherlands (11%). There are large differences between the answers given by various groups:

Group	Average of correct answers
Male	70%
Female	62%
Ages 15-24	70%
Ages 55+	59%
Finished education by the age of 15	53%
Finished education after the age of 20	76%
Attend religious services more than once a week	54%
Never attend religious services	70%

A major part of this Eurobarometer focuses on public attitudes towards science: issues of trust and optimism regarding science's ability to improve society and the world.

To the question, "Among the following categories of people and organisations, which three are best qualified to explain to you the impact of scientific and technological developments on society?", participants responded:

Scientists working at a university or government laboratory	52%
Television journalists	32%
Scientists working in an industrial laboratory	28%
Newspaper journalists	25%
Medical doctors	23%
Environmental protection associations	21%
Consumer organisations	16%
Writers and intellectuals	10%
The industry	6%
The government	6%
Politicians	5%

Respondents were then asked to respond to the following statement: "One day, science will be able to give a complete picture of how nature and the Universe work." The average response across Europe is: 50% agree; 26% disagree, and the rest neither agree nor disagree (or don't know). But here the responses from country are extremely different. In Malta and Greece, more than 70% of the population agree, whereas only 27% of the Swedish people surveyed agree (54% disagree), and results are almost the same in the other Nordic countries and Iceland.

The overall optimism about the potential of science was also measured, by asking for responses to the following statements:

Statement	Agree	Disagree
Scientific and technological progress will help to cure illnesses such as AIDS, cancer, etc.	88%	4%
Science and technology make our lives healthier, easier and more comfortable.	78%	6%
Thanks to science and technology, there will be more opportunities for future generations.	77%	8%
The benefits of science are greater than any harmful effects it may have.	52%	14%
Science and technology will help eliminate poverty and hunger around the world.	39%	37%
Thanks to scientific and technological advances, the Earth's resources will be inexhaustible.	23%	54%
Science and technology can sort out any problem.	21%	58%

The remainder of the respondents answered "neither agree nor disagree" or "don't know". Here, too, there are interesting differences between countries, which would be worth investigating further.

The survey went on to ask about specific technologies and applications. People were asked for their opinion on the following statements:

Statement	Agree	Disagree
Science and technology are responsible for most of the environmental problems we have today.	57%	20%
Food made from genetically modified organisms is dangerous.	54%	14%
Science and technology cannot really play a role in improving the environment.	28%	50%

These questions show some of the widest differences between attitudes across Europe. Cypriots (88%) and Greeks (80%) are most worried about genetically modified foods, whereas there is much less concern in the United Kingdom (33% agree; 23% disagree with the statement that they are dangerous) and the Netherlands (30% agree; 39% disagree).

The survey included a small grade card on science teaching throughout Europe: people were asked to respond to the statement, "Science classes at school are not sufficiently appealing." Here are some of the responses:

Country	Agree	Disagree
25 EU members/associated countries	50%	15%
Turkey	**66%**	**9%**
Sweden	**64%**	**6%**
Slovenia	**63%**	**10%**
Austria	**61%**	**8%**
France	**60%**	**10%**
Portugal	**60%**	**6%**
Malta	39%	21%
Germany	36%	36%
Czech Republic	36%	11%
Cyprus	29%	30%

This is only a small taste of an extensive survey that gives many more insights into the state of knowledge and perceptions of science among the population of Europe. Such numbers are good to have; the real question is what they mean. Answering that question is the challenge that faces the European Commission, national governments, ministries and others as they define policies and decide what types of projects should be supported to improve people's perceptions and knowledge of science. These figures can also be used to reinforce the case for new ideas and initiatives, particularly in applying for educational grants.

Web references

w1 – Google Earth combines satellite imagery, maps and the power of Google to put the world's geographic information at your fingertips: http://earth.google.com

w2 – Eurobarometer survey website: http://ec.europa.eu/public_opinion

Memories of a very special teacher

Fay Christodoulou, a Greek PhD student at the European Molecular Biology Laboratory (EMBL), is an example that shows not every researcher is born with a passion for science. She describes to **Anna-Lynn Wegener** from EMBL how her biology teacher inspired a long-lasting interest in science.

Did you always want to become a biologist?

To tell you the truth, it was a very spontaneous decision. Initially I wanted to go into economics, which might seem a bit strange because the fields are not very related. I had already finished the first year of my international baccalaureate and had chosen those subjects that would lead to a career in economics when I suddenly changed my mind and decided to study biology. It was really difficult to convince the head of my school that I was serious about this change. I had missed a whole year's worth of biology lessons while I was studying economics and I had to catch up with all the material by myself. So biology wasn't an easy option.

So, what happened in the last year of school that made you change your mind? Was there a specific event that awoke your interest in biology?

Not an event, but a person: Dr. Alexander Alevizos, my biology teacher at school in Athens, Greece. He was the one who made me realise my passion for biology. The interest

came from the material that biology offers, but he was the one who contributed the inspiration.

And what was so special about him and his lessons?

Sometimes teachers come into the classroom and give a 45-minute lesson out of the textbook. But my biology teacher was special in that he was very well informed: he followed cutting-edge science as well as the news

and he knew about the applications of science. He chose thrilling examples to illustrate the material: one day he told us about the Gene Police that had been established in Canada when the first transgenic crops emerged. Farmers were very concerned that the modified plants could contaminate their natural crops and many of them tried to sue companies working with the modified crops. So the Gene Police were established to screen the crops genetically to see if contamination had actually occurred. Dr. Alevizos used the story to explain the science underlying genetic modification and cross-pollination and we absorbed this information without really realising it because we were so fascinated by the story. And he did not stop at the science: he also involved us in a discussion about bioethics based on this example. That is something I really liked, that he gave an overview of all aspects of science, from molecular details to moral implications.

Another thing that made his lessons really interesting was that he always tried to put science into a wider context. He would, for example, talk about the history of a scientific breakthrough or the political consequences that a discovery can have. And he painted a very human picture of the personalities behind science, which made it easy for us to identify with them.

Judging from your enthusiasm about his lessons, all your classmates should be biologists by now.

Some are. Others have of course chosen a different path, but even they must have gained a lot from Dr. Alevizos' lessons. He never pushed us to become scientists, instead he tried to show us how useful a basic knowledge of biology can be for all sorts of things. For example, he used to tell us that people in the marketing or advertising sector are always looking for candidates who can understand science, because they need to promote products based on science. Similarly, in law and the patenting business he said that a background in biology can open many doors. By acknowledging that not every student wants to become a scientist, he also reached and inspired those students who had no interest in biology at all.

But you clearly had an interest and decided to become a molecular biologist. What exactly are you doing now?

I have just finished the first year of my PhD studies in Detlev Arendt's group at the European Molecular Biology Laboratory in Heidelberg, Germany. We are trying to understand how the brain evolved. The human brain is very complex with many subunits, but it started off as a simple organ and gradually evolved into something more complex. The last ancestor of humans (and many other species) that had this simplistic brain is what interests me, because I would like to know how it all began. This is why I am working on a sea worm called *Platynereis dumerilii*, which we think is quite similar to this last ancestor. In particular I am looking at the hypothalamus, a part of the brain that is very ancient in terms of the functions that it controls: thirst,

hunger, sex drive, reproduction, aggression and other basic functions. I want to find out how a chemical pathway that is crucial for the development of the brain in the embryo works in this worm. We can then compare it with the pathway in other organisms to see what has changed during evolution.

Are you happy with your choice to go into research?

I love what I am doing and I really like the room for creativity in science. You get to design your own experiments, and obtaining a result from an experiment that you designed yourself is very rewarding. This is also what keeps me going in periods when I am working hard but getting no results at all. This can be a bit frustrating sometimes, but the feeling when you achieve what you are aiming for is so great that I would never exchange my work for any other.

And what are your plans for the future?

If everything goes well, I would love to lead my own laboratory at some point and also to teach students, either at university or even at school.

That sounds like another thing that might have been inspired by your biology teacher.

Yes, definitely. This man has influenced my life so much and helped me to find my way. I would love to be able to do something similar for other people one day.

REVIEW

For me as a primary school teacher constantly trying to find different and creative ways to inspire my pupils, the article was a refreshing read. So often in teaching, amidst all the planning, marking and assessment, it is possible to lose sight of the wider goal of developing a child's curiosity about and engagement with their environment. Fay's experience served to give me a welcome reminder.

Without too much science terminology, it hits a satisfying target in giving the view of teaching from the other side. To read about the inspiration given by one teacher – inspiration that changed lives and widened horizons – makes me aim to do this in my own teaching. I will continue to grasp the moment, to stray a little from the formal curriculum, and to tell the story around the science, reinforced by the knowledge that it can and does make a difference.

Andrea Goetzee, UK

Handstands and ties: a career in teaching

The author, John Watson

John Watson, "the teacher who does handstands in class", reminisces about what drew him to teach biology, shares memorable moments from his 38-year teaching career, and explains how scientists can help to inspire science teaching.

Why did you decide to become a science teacher?

I have always enjoyed working with children. When I was at school, I became a very active member of a children's theatre group set up by my drama teacher. We were called the Pied Piper Players because we would parade through a park or an inner city housing estate to collect an audience and then perform a play with a lot of improvisation and audience participation, using the characters of the Commedia dell'Arte.

After university, with an MSc in applied genetics, I was qualified as a plant or animal breeder. After a quick search, though, the only job I found was breeding tomatoes. I hate tomatoes! So I decided to use my biology training in teaching instead – and I have never regretted my choice.

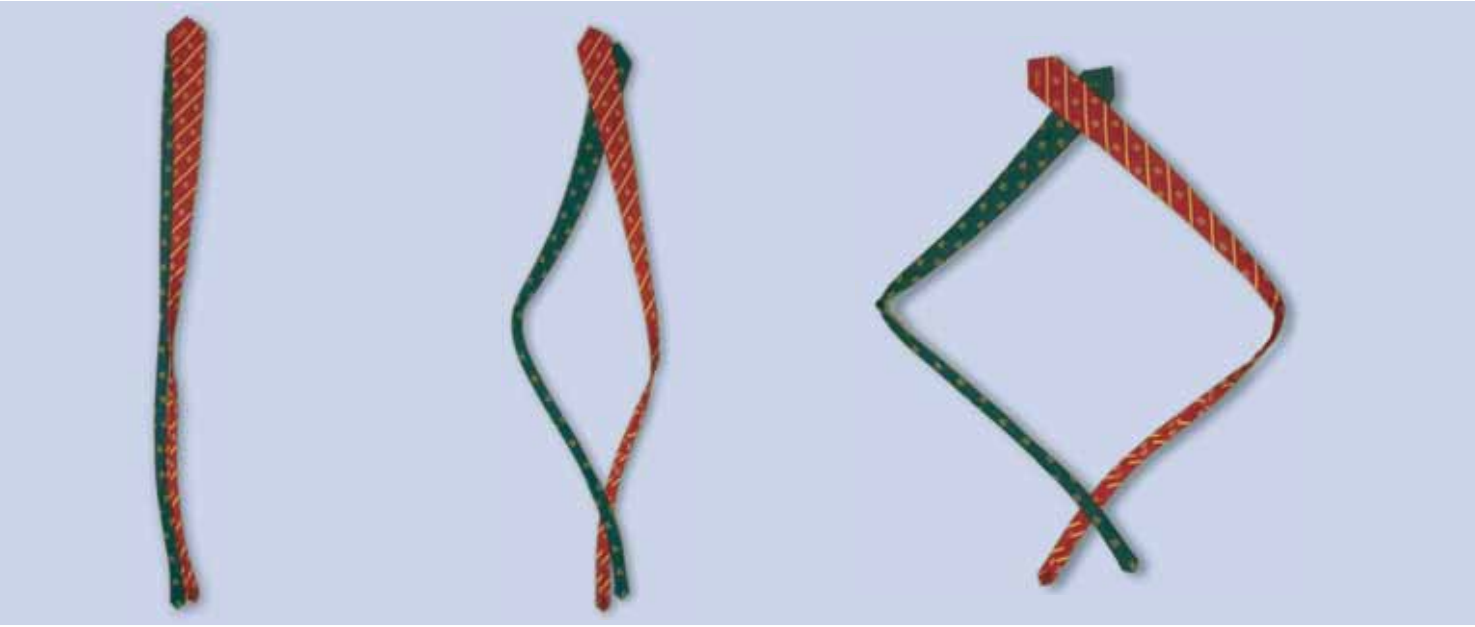
Can you tell us about a particularly memorable moment in your career?

I arrived at my classroom a few years ago to find an unexpected inspector who wanted to see what I was doing. Obviously, I invited him in and got on with the lesson. I was teaching mitosis, a topic I love, and the blackboard was covered in diagrams. To demonstrate the separation of chromatids at anaphase, I like to take two ties that are a little intertwined and pull them apart at the middle on a desk. The ties make a wonderful 'V' shape just like the chromatids as they are pulled to the poles. I was wearing a tie but I needed another, and the only other person in the room with a tie was the inspector. The students were delighted when I asked him to "undress" and he went along with the fun with a big smile on his face.

You've been involved in developing the science syllabus and a textbook to teach the syllabus. Could you tell us about it?

Currently, I teach in Luxembourg at the European School. The European Schools are unique: we have teachers and students from every country in the European Union and we teach sciences in 11 languages, but we all use the same syllabus. Obviously writing the syllabus is complicated, and requires teachers and inspectors of different nationalities to find a European compromise about what should be taught. I personally find the process very stimulating, though it can be long and discussions do sometimes go round in circles.

At a meeting of biology teachers in 1993, we had a big discussion about the diagrams to use in the baccalaureate exam. We decided that the only way to make the exam fair for all students was to produce our own diagrams. This idea developed into a project to produce our whole biology syllabus in diagram form with annotations in all languages. We called the book *Eurobio* and it has proved very popular (especially with new teach-



ers) and is used in all 13 European Schools.

Since 1978, I have been a member of the biology commission, which is the group responsible for writing the biology syllabus for the European Schools, and have been involved in the writing and development of the syllabus for almost 30 years. Additionally, I have organised all the in-service training courses for biologists in the European Schools since 1980. These responsibilities add to the variety and satisfaction of my job – and I believe that interested teachers can, with a little effort, put themselves in a position to advise and even take part in policy making.

What do you think scientists most need to know about science in the classroom?

Science is moving at a tremendous pace and much of what is new cannot be done in schools; there is just not enough money. But if scientists could develop simple simulations so that we could teach the principles in an exciting and stimulating way, some of this progress in science would make its way into schools faster. A good example is the virtual microarray game from the European Learning Laboratory for the Life Sciences. In the laboratory, DNA chips trace the activity of genes by detecting the mRNA they produce; the virtual microarray simulates a DNA chip using a mat and lots of coloured lights[w1]. For my lessons, I adapted the simulation slightly by replacing the coloured lights with discs that fluoresce red and green under a screened UV lamp.

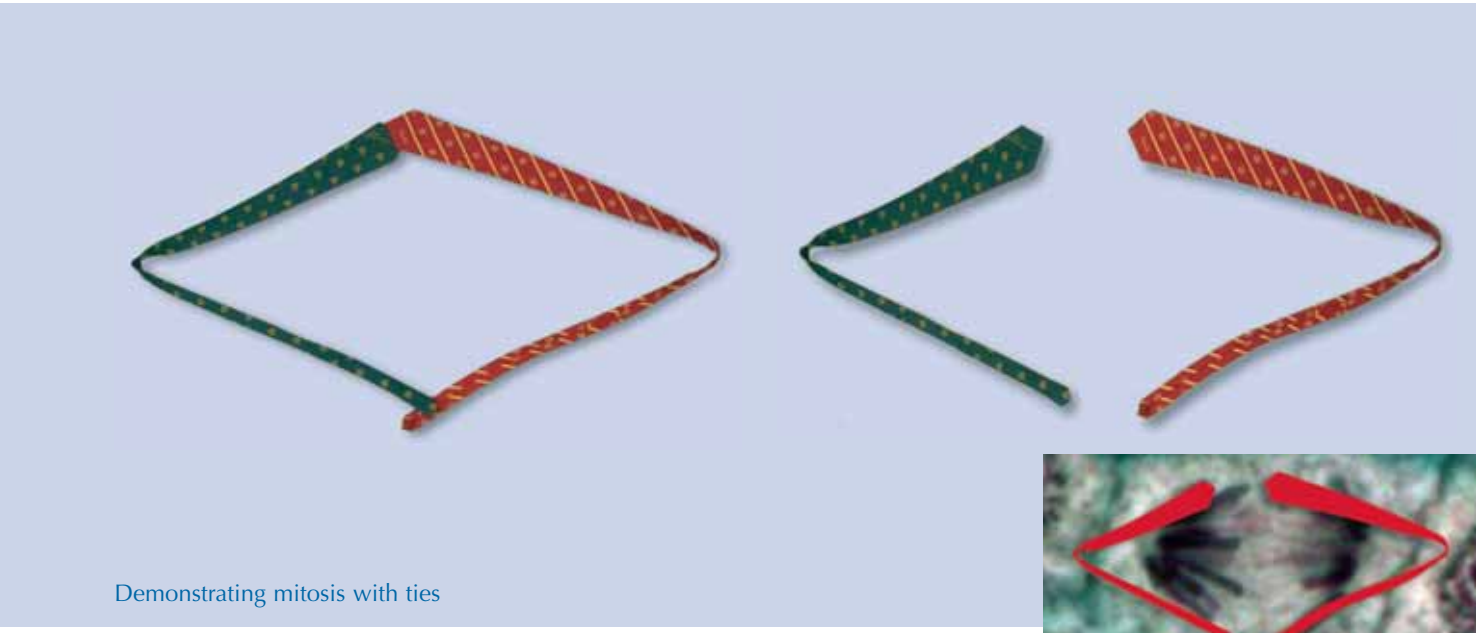
The other problem with introducing scientific developments into school is time: students are only in the classroom for a short amount of time each week. So we need protocols that can be completed in one or two lessons.

BACKGROUND

Demonstrating peristalsis

The teacher who does handstands...

I met the daughter of a colleague recently, outside school. She was not a student I had ever taught and when her mother asked her if she knew me, she said, "Yes, he is the teacher who does handstands in class." Whenever I teach peristalsis to a new class, I do a handstand and drink a glass of water 'upwards'.



Demonstrating mitosis with ties

REVIEW

This is an excellent article for inspiring new teachers and improving science teaching. Such memorable teachers make a difference not only in the classroom but also to long-term educational programmes. Teaching sciences in an exciting and creative way involves students and makes them love science. Being a good teacher is like being a good actor; an actor who makes the audience part of the play. Good teachers like John Watson are working towards better global education, curricula and teaching materials.

I wish all teachers and scientists inspired their students like John Watson!

Myrto Pouangare, Cyprus

If the European Union gave you the money, what kind of project would you design to make a significant difference to teachers and their students?

Volvox![w2] This is a network of teachers, scientists, educational specialists and science communicators, established to share teaching resources between countries. It will provide biology teachers with laboratory protocols, classroom activities on the social impact of bioscience, accounts of the careers of young scientists and other resources to help motivate teachers and their students.

I also have an idea for a project to bring researchers and teachers together to develop protocols that will work in the classroom with the limited materials and time that are available. The researchers would supply the practical expertise and the teachers would know the limits of what can and cannot be done; this is how the virtual microarray game and other materials from the European Learning Laboratory for the Life Sciences were developed. If other research centres and universities around Europe set up programmes like this for local teachers, I am sure we would have lots of new materials in a short time.

Web references

w1 - The European Learning Laboratory for the Life Sciences (ELLS) is an education facility to bring secondary school teachers into a research laboratory. Based at the European Molecular Biology Laboratory in Heidelberg, Germany, ELLS welcomes European teachers to its free three-day practical workshops. Instructions for the virtual microarray are available in the ELLS TeachingBASE. See www.embl.org/ells/ for further details.

w2 - For more details about Volvox, see www.eurovolvox.org

Forensic entomology: activities for schools

Many of you were fascinated (and disgusted!) by the article about forensic entomology in our last issue. Paula Starbäck, the reviewer, suggested that it would be a fascinating activity for students, if only someone could find a way to avoid the terrible smell. We challenged you to come up with a solution – and **Martin Hall** from the Natural History Museum in London, UK, who wrote the original article, promptly responded.

Image courtesy of Martin Hall

Life cycle of a calliphorid fly (clockwise from bottom left): adults, eggs, first instar larvae, second instar larvae, third instar larvae, puparia containing pupae

Despite the smelly conditions to which adult blowflies are attracted and in which they lay their eggs, working with the larvae need not be an olfactory torment. Towards the end of the larval period, the maggots finish feeding on animal tissues and search for a suitable site to pupariate. It is this post-feeding stage that is sold as fishing bait in angling shops, and is suitable (not smelly) for use in classroom activities. They are easy to keep: they do not need food and can be kept for one to two weeks in a fridge before they start to pupariate.

Here are some ideas of how to use blowfly larvae to investigate the behaviour and physiology of blowflies. How do your results in the laboratory relate to the ecology of the insects?

Responses to light

Construct simple arenas with different levels of light (e.g. cover half the arena with a piece of card) and see how much time the larvae spend at

the different light levels (they usually prefer the dark). What do they do in the dark areas; for example, do they change their speed of movement (slow down), or rate of turning (change direction more often) or do they only change direction at the light/dark edge, so as to stay in the dark?

Effects of temperature

How long does it take larvae to pupariate (become pupae) at different temperatures? You would need an incubator of some sort that could be set to different temperatures. Plot temperature against the time taken to pupariate. Note that the larvae might be at different ages when purchased, so you would need to compare different temperatures using larvae from the same batch, rather than buying one batch and testing it at one temperature and then buying another batch and testing it at another temperature.

This investigation could be extended by looking at the effects of temperature on time spent as pupae and, if a more complex dissection study were required, students could record the morphological changes in the pupa as metamorphosis proceeds (e.g. onset of segmentation, the first appearance of legs and wings, the first appearance of eyes, then body coloration and so forth). Do these occur at the same intervals in development (e.g. at 25%, 50% through the pupal period) at different temperatures?

Effects of substrate texture

How far do larvae migrate in different media? This can be measured by how long it takes them to pupariate. Test larvae with a hard surface and compare with larvae in sawdust and in sand/soil, both of which they can burrow into.

Effects of substrate moisture

Do larvae select soil with a different moisture content to burrow into? You could set up a chamber, offering larvae a choice of dry, damp and waterlogged soil to burrow into. Measure dampness by some easy system, e.g. volume of water per volume of soil.

Other influences

You could also measure what factors influence the length of time that the larvae spend wandering and burrowing, e.g. light, temperature, gradient, objects on the surface under which they can rest.

Available species

Different shops sell different species, but usually the largest larvae are *Calliphora vomitoria* (bluebottle fly), the intermediate sized ones are *Lucilia sericata* (greenbottle fly) and the smallest are *Musca domestica* (housefly). Different responses may be observed with the different species. A few could be reared to adulthood to facilitate identification.

Safety note

Students should take care when handling larvae to avoid contamination (the larvae have, after all, fed on decomposing animal tissues). Wear rubber gloves and wash hands afterwards with disinfectant soaps. Although teachers and students should not be complacent, the risks are low: after all, many millions of fly larvae are sold each year to anglers with no health and safety warnings.

Lucilia sericata (Meigen)

Image courtesy of insectimages.org/Joseph Berger

Does Anything Eat Wasps? And 101 Other Questions

By *New Scientist*

Reviewed by Michalis Hadjimarcou, University of Cyprus, Cyprus

Does Anything Eat Wasps? is a user-friendly, easy-to-read collection of questions and short answers that covers a wide range of science topics, from galaxies colliding in outer space to the amount of fat necessary to render a human bulletproof. These questions and their corresponding answers were published over the last 11 years in The Last Word, *New Scientist* magazine's weekly column of everyday science questions. Both the questions and the answers have been provided by the readers of the column.

As is clearly stated in the introduction, this book is not an attempt to solve the big mysteries of life, such as the meaning of human existence or the nature of God. Instead, it is an effort to answer the small questions of everyday life, the kind that arise while watching a bartender pour a beer or pondering the flight pattern of migrating geese. Some of these questions are quite common and are probably shared by many people, whereas others are somewhat strange. The topics addressed in the book are from a wide range of scientific disciplines, including biology, chemistry, physics, astronomy, geology and oceanography.

The type of answers is also broad, ranging from the strictly scientific to the simple and humorous. The latter might not provide the reader with many answers, but will at least give reason to smile or even, in some cases, have a good laugh.

Some of the topics in the book require substantial scientific knowledge and an excellent understanding of English to appreciate fully the information provided in the answers. However, in the majority of cases, the general scientific knowledge that any science teacher should possess is more than adequate. In fact, this book would be suitable for most people with a minimal scientific knowledge.

Most certainly, this book is not something a science teacher can expect to use as a main teaching tool. However, it includes a large enough selection of useful and interesting information to provide any science teacher with the appropriate material as well as a good excuse for an exciting break during teaching. Furthermore, the book can prove an invaluable pool of truly unique ideas that a teacher can draw from to stimulate small-scale investigations by students.

Details

Publisher: Profile Books Ltd
Publication year: 2005
ISBN: 1861979738

Kleine botanische Experimente

By Hilke Steinicke and Imme Meyer

Reviewed by Friedlinde Krotscheck, Internationale Gesamthochschule Heidelberg, Germany

The book, written in German, describes a great variety of experiments using plants. The experiments are at different levels of difficulty and often explain everyday observations. The chapter titles focus on certain parts of plants and provide detailed information on plant physiology. The required materials are easy to obtain and mostly free; the equipment can be found in any household.

For any age and any level, this is a very good source of experiments for biology, natural phenomena, physics, chemistry or biotechnology. It could be used at home, on field trips or in the classroom. Teachers are, of course, good at using materials like this to tailor worksheets.

Unfortunately, in contrast to the complete and detailed descriptions in the book, the drawings are unhelpful. Furthermore, the book would be greatly improved if the useful chapter titles were complemented with graphic information on characteristic features, such as flowers and their different shapes.

Kleine botanische Experimente addresses a very neglected area – plants as producers, as models for technical projects, and as the source of life on Earth. This book belongs in the library of every (German-speaking) school.

Details

Publisher: Verlag Harry Deutsch
Publication year: 2005
ISBN: 3817116977

The Poison Paradox: Chemicals as Friends and Foes

By John Timbrell

Reviewed by Angelika Börsch-Haubold, Germany

"All substances are poisons; there is none that is not a poison. The right dose differentiates a poison from a remedy." Thus wrote the physician and scientist Paracelsus 500 years ago, and this is also the point of view of the English toxicologist John Timbrell. For him, all chemicals have both good (wanted) and bad (unwanted) effects, which he calls the "paradoxical" nature of poisons. As the subtitle of *The Poison Paradox: Chemicals as Friends and Foes* states, chemicals are our friends as drugs, pesticides and cleaning agents, and our foes as environmental pollutants, natural poisons and harmful food additives.

After a short historical outline of the concept of poisons, Timbrell introduces the reader to the physiological mechanisms of the uptake of a substance into our body, of its fate there (metabolism) and of individual differences in these mechanisms due to genetic factors and lifestyle. He continues with a survey of pharmacological concepts such as the dose-response relationship and receptors, explains mutagenesis, teratogenesis, and carcinogenesis, and describes tissue degeneration and cell death. He then contrasts the benefits of common medicines such as aspirin, paracetamol and penicillin with their adverse effects. The mechanisms of drugs of abuse (cocaine, morphine/heroin, and ecstasy) are also explained. As virtually all of us will take some form of medication in our lifetime, and almost nobody is in a position to second guess the doctor's prescription, this alone makes these two chapters on medicines worth reading.

Throughout his account, Timbrell is anxious to display the positive aspects of chemicals. One prominent example is DDT, successfully used as an anti-louse powder during World War II and also to combat malaria. The extensive spraying of forests against bark beetles, however, had detrimental effects on wildlife which were triggered by an accumulation of DDT in the food chain. Timbrell blames this overuse for our loss of a chemical that was relatively safe for humans.

One does not need to agree with this point of view to learn a lot from the book. Timbrell moves methodically from the small scale – household poison cabinets with cleaning agents, gardeners' tools, and "our favourite drug: alcohol" – to the large scale – the deliberate release of industrial waste products into the environment, as well as industrial accidents in which cities or whole populations are exposed to toxins. But it is not always humans who damage nature with synthetic chemicals: it works both ways. We all teach our children to eat only berries that are known as "safe", because plant toxins are among the most deadly compounds in the world.

Timbrell aims to teach the lay reader about poisons. He avoids complicated scientific terminology, places detailed information for advanced readers in separate boxes, and defines toxicological jargon in a glossary at the end of the book. What is more, he knows how to entertain. Headlines such as "Ricin: a molecular Trojan horse from the castor bean" or "Lucy in the sky with diamonds: hallucinogenic compounds" catch the reader's attention. Case notes in the style of newspaper clippings vividly describe the action of a poison, and the accounts of serial killers and political murder juxtapose historical anecdotes ("Was Napoleon poisoned?") with toxicological facts. Figures such as the photograph of an alcoholic's liver say more than a thousand words.

There are a few unfortunate errors, however. The repeated misspelling of Nobel laureate Paul Ehrlich's name and inconsistencies in the botanic names of plants and families should have caught a careful editor's eye. In addition, a number of pharmacological details are irritatingly mistaken; for example, the former use of atropine-containing plants for the treatment of Parkinson's disease (and not epilepsy), or the case note on herbal-tea poisoning in which the pyrrolizidine alkaloid-containing plant coltsfoot is more likely to be the culprit in the liver disease than alpendost. A number of repetitive phrases should also have been cut before publication.

Nevertheless, *The Poison Paradox* is a good source for teachers in search of examples to enliven chemistry, biology or ecology lessons. I also recommend it to older school students with an interest in chemistry and the life sciences. The manifold involvement of poisons in our daily life and Paracelsus' principle of the right dose is bound to be an eye-opener for them.

Details

Publisher: Oxford University Press
Publication year: 2005
ISBN: 0192804952

A Stem Cell Story

By the European Consortium for Stem Cell Research

Reviewed by Philipp Gebhardt, European Molecular Biology Laboratory, Germany

A Stem Cell Story portrays scientists from the field of stem-cell research, their individual research interests and the potential applications of their work. The DVD is aimed at the public, to shed light on stem-cell research and on the science behind the headlines and public debate of the last few years.

Even though research on stem cells has been going on for 40 years, another level of controversy was added when researchers derived the first human embryonic stem-cell line in 1998. The hopes associated with this cutting-edge technology are as diverse as the production of replaceable tissues, the repair of defective tissues using healthy cells and the treatment of a broad spectrum of diseases.

The film begins by comparing the complex processes in the microscopic world of our cells to the hustle and bustle of modern city life. The fast-changing scenery makes it very appealing to an audience used to the style of contemporary music videos. At the beginning of the documentary, the filmmakers introduce the importance of stem cells for the generation and maintenance of a multiplicity of specialised cells in our body, and the natural role of embryonic stem cells in development.

The underlying science is communicated with very creative cartoon-like animations, which are integrated nicely into the plot and illustrate the plasticity in the system of differentiating cells. This is highlighted during interviews with scientists, who explain their strategies for inducing isolated embryonic stem cells to specialise; one scientist describes it as a "battle of wills" to induce cells to follow a particular pathway of differentiation. Examples of the clinical applications of stem-cell research are reviewed, such as skin transplantation, and the generation of neural stem cells and insulin-producing cells for the treatment of diabetes.

With its beautiful pictures of fluorescently labelled cells and its modern, informative and very appealing look, this educational film is a valuable resource for people who want to go beyond the headlines on this controversial topic. The DVD offers a captivating insight into the world of stem cells, but at the same time does not go much beyond pure knowledge transfer. Its main goal is to demonstrate the fascinating possibilities of this branch of biomedical research, which is probably why the relevant ethical questions are to a great extent left out. Furthermore, although the very fast turnover of the illustrations maintains a high attention level, it can make it somewhat difficult to follow the theory.

The original soundtrack is in English, but voice-overs and subtitles are available in other languages (see below for details). Its short format makes this film ideal for use in the classroom, for example as an introduction to stem cells. It is recommended for audiences aged 14 and older.

Details

Technical details: DVD PAL, all zones

Producer: EuroStemCell, European Consortium for Stem Cell Research (www.eurostemcell.org)

Publication year: 2005

Running time: 15 min

Soundtrack: English

Voice-over and subtitles: French, German, Italian

Subtitles: Swedish, Dutch

Ordering

Within Europe, the first copy costs £4, including postage and packaging. Additional copies cost £2.50 each; up to five copies can be ordered. For further details, see www.eurostemcell.org/Outreach/outreach_film.htm

Resources

The website of the European Consortium for Stem Cell Research has additional information about stem cells. In its outreach section, it offers a jargon-buster (definitions of key stem-cell terms), information about the legislation of human embryonic stem-cell research in different countries, and other interesting facts: www.eurostemcell.org/Outreach/outreach.htm

Science podcasts

The worldwide web is a wonderful source of information, but the sheer amount of content can be overwhelming. Where do you start looking for science news? In each issue of *Science in School*, we will suggest useful websites for particular purposes.

Whether you are looking for a quick snippet about stem cells or dark matter to use in a lesson, or want to inform yourself regularly about developments in science, podcasts could be the answer. You can subscribe (free) to these radio programmes on the web, automatically download new episodes, and listen to them when and where you like: on the train, in the gym, in the garden....

The files can be played either directly on your computer, or using an MP3 player or iPod. iTunes and other similar software allow you to search the vast range of topics available, download individual episodes or subscribe to regular podcasts, play them, read reviews by other listeners and leave your own comments. iTunes can be run on an Apple Mac or a PC, and is free to download: www.apple.com/itunes/download

Below is a selection of the many science podcasts available. Most of those listed are in English, but if you tell us about your favourites in any European language, we'd be happy to mention them on the *Science in School* website.

Podcasts in English

Current Science and Technology: feed://www.mos.org/cst/?cat=7;feed=rss2

Weekly interviews with guest researchers and staff from the Museum of Science in Boston, USA.

- 20 October 2006: How the deadly toxin botulinum (botox) can be used to limit facial scarring, and how melanoma can be detected by listening for cancer cells. (14 min)
- 13 October 2006: How anthrax spores can be detected and caught using sugar-coated carbon nanotubes, and why one researcher is studying ants by filling their nests with molten metal. (23 min)

Ecogeeks: www.thewildclassroom.com/home/nav/subscribe.html

Aimed at science teachers and supported by lesson plans, further online information, and terrible music, these short video podcasts are presented by young biologists.

- 1 October 2006: Everything you wanted to know about alligator snapping turtles. (2 min)
- 31 August 2006: Grasslands and prairies – why do grasses dominate? (4 min)

ESApod: esamultimedia.esa.int/multimedia/esc/esapod.xml

The European Space Agency brings audio and video news from space to your desktop.

- 16 October 2006: The Mars Express investigates water on Mars, demonstrating that it was once covered by vast oceans. (7 min)
- 10 October 2006: Life on the International Space Station, carrying out scientific experiments as part of the AstroLab mission. (5 min)

Fraunhofer podcast (also in German): www.fraunhofer.de/fhg/EN/press/audio/2006/Audio-magazine_ 2006s.jsp

Short podcasts presenting research from Germany's Fraunhofer institutes.

- 4 October 2006: Applications of nanotechnology range from car manufacture to medicine. (7 min)
- 20 September 2006: White biotechnology – using plants to manufacture raw materials. (4 min)

Microbe World Radio:
http://feeds.feedburner.com/microbeworld

Daily 90-second podcasts from the American Society for Microbiology, USA.

- 20 October 2006: Astrobiologists from NASA speculate that a group of salt-loving microbes called halophiles once existed on Mars. (2 min)
- 19 October 2006: Producing electricity – by feeding microbes on chocolate waste. (2 min)

Nature podcast:
www.nature.com/nature/podcast/subscribe.html

By the Naked Scientists team, this weekly podcast highlights contents from the journal *Nature*, sets the research in context and allows the scientists to explain the significance of their work in their own words.

- 4 October 2006: The evolution of insect eyes, five-billion Jupiter-sized exoplanets, a scientific pub guide to zoology (fish that fake orgasms, kidnapping among penguins), climate change regulation, and more. (32 min)
- 7 September 2006: Cancer and unintelligent design, methane emissions from the permafrost, chiral-selective catalysts, and more. (26 min)

Science@NASA:
feed://science.nasa.gov/itunespodcast.xml

Frequent short podcasts about recent space research at NASA, USA.

- 3 October 2006: Climate scientists are learning new things from an old and very powerful Alaskan volcano: Novarupta. (4 min)
- 1 September 2006: With astronauts returning to the Moon, reliable forecasts of space weather are more important than ever. A new proposed mission called Solar Sentinels would surround the Sun with spacecraft to monitor solar activity. (5 min)

Science magazine podcast:
www.sciencemag.org/about/podcast.dtl

This bi-weekly podcast presents research from *Science* magazine and its news website.

- 13 October 2006: Cancer therapy with monoclonal antibodies, building the world's biggest fusion experiment (ITER), the neurobiology of face recognition, and more. (30 min)
- 15 September 2006: The oldest writing from the New World (1000 BC), the most precise test yet of relativity, geo-engineering to prevent climate change, and more. (34 min)

Science Talk, the podcast of *Scientific American:*
www.sciam.com/podcast/

This weekly podcast of *Scientific American* covers cutting-edge developments and controversial issues with leading scientists and journalists. A useful resource is the list of related websites.

- 4 October 2006: Court cases increasingly deal with complex science and technical issues. Shouldn't judges be trained in cutting-edge science? (20 min)
- 6 September 2006: MIT astrophysicist Paul Schechter discusses recent research into dark matter. (23 min)

sciPod, the *New Scientist* podcast:
www.newscientist.com/podcast.ns

This podcast from the popular science magazine *New Scientist* reviews the week's science stories and interviews scientists.

- 6 October 2006: Confabulation is a tendency among some brain-injured patients to create fictional memories. What can it tell us about the way the human mind separates fact from fiction? And more. (29 min)
- 4 August 2006: Increased carbon dioxide levels in the atmosphere are acidifying the world's oceans. What are the consequences for marine life? And more. (26 min)

60-Second Science, from *Scientific American:*
www.sciam.com/podcast/

In this daily, one-minute commentary, *Scientific American* casts a brief look at some of the most exciting scientific developments.

- 5 October 2006: Did the Ancient Greeks use nanotechnology to conceal grey hairs? (1 min)
- 20 September 2006: Discrimination against women academics is still depriving American science of an important source of talent. (1 min)

The Naked Scientists:
www.thenakedscientists.com/HTML/Shows/streaming_media.htm

In this weekly UK podcast, Cambridge University's Naked Scientists answer your science questions, interview top scientists and cover the latest science news.

- 1 October 2006: Would you invest in an allergy-free cat, what stimulated life's diversity, how are magnets made, why is blood red, and how are leeches used in medicine? And more. (57 min)
- 17 September 2006: Peruvian mummies, why exercising can keep your guts healthy, environmental clues in 10 000-year-old pollen, and how to make your own futuristic forcefield. And more. (56 min)

The Science Show:
www.abc.net.au/rn/scienceshow/subscribe/

A review of this week's news about scientific research, scandal and discovery, from the Australian Broadcasting Corporation. A table of contents allows you to skip directly to the topic of interest.

- 13 October 2006: Ancient coral reefs, how our ancestors lived 3.5 million years ago, the applications of RNA interference, other Nobel-Prize winning research, and more. (49 min)
- 29 September 2006: The environmental cost of your PC, what affects Australia's climate, whether the dinosaurs died of constipation, and more. (49 min)

Teachers' TV News:
www.teachers.tv/podcasting

The weekly Teachers' TV News video podcast covers the latest UK education news stories, interviews and analysis.

- 22 September 2006: Schoolgirl violence, primary school truancy, school meals, and other news stories. (25 min)
- 15 September 2006: Is modern life poisoning childhood, does drug education work, compulsory language learning, how war is robbing children worldwide of education, and other news stories. (25 min)

The Week from *The Scientist*:
www.the-scientist.com/xml/podcasts/theweek/index.xml

This weekly podcast from the popular life science magazine, *The Scientist*, presents recent science news and research.

- 13 September 2006: Nutrigenomics: why what your grandmother ate when she was pregnant with your mother may affect your children's health. (18 min)
- 2 June 2006: RNAi toxicity, blood diseases involving SNPs and how Italy should fund its research. (15 min)

Woods Hole Oceanographic Institution podcast:
www.whoi.edu/services/graphics/WHOIPodcast.xml

Scientists from the Woods Hole Oceanographic Institution, USA, describe their research in marine science and the fascinating, scary and beautiful moments involved. Choose between video or audio-only podcasts.

- 30 May 2006: Rhian Waller describes – and shows – deep sea corals and investigates how they reproduce. (6 min)
- 20 March 2006: Susan Humphris explains what hydrothermal vents are and why they are important. (4 min)

Podcasts in German

dradio Wissenschaft und Forschung:
www.dradio.de/rss/podcast/sendungen/forschak/

Science news from Deutschland Radio.

- 1 November 2006: To make more use of wind power, new methods of storing energy are necessary. (3 min)
- 27 October 2006: What happens to our rubbish after it is collected for recycling? A new Dutch robot demonstrates just how finely the different types of rubbish can be separated – with sufficiently high-tech equipment. (4 min)

Fraunhofer podcast (also in English):
www.fraunhofer.de/fhg/data/pub5/dcp/jsp/dcp67165_67166.jsp

Short podcasts presenting research from Germany's Fraunhofer institutes.

- 4 October 2006: Applications of nanotechnology range from car manufacture to medicine. (7 min)
- 20 September 2006: White biotechnology – using plants to manufacture raw materials. (4 min)

Helmholtz Schongewusst podcast:
www.helmholtz.de/audio/schongewusst.xml

These short podcasts present gems from the wide range of research carried out at Germany's Helmholtz institutes.

- 10 October 2006: Acid bath or swimming lake? How bacteria can make the difference. (3 min)
- 4 October 2006: Deep-frozen history in the Antarctic. (3 min)

Pisa Polizei:
www.ndr.de/podcastlink/pisa.xml

Not always science, but definitely education-related. These daily podcasts from the Norddeutscher Rundfunk investigate the general knowledge of Hamburg's teenagers. Scary and hilarious.

- 12 October 2006: What is the Periodic Table? (1 min)
- 17 August 2006: What is 3% of 100? (1 min)

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The neutron teaspoon

Jonathan Swinton pushes back the frontiers of knowledge – in his kitchen.

It is well known that a teaspoonful of neutron star is really quite heavy[w1]. This would provide a way to estimate the density of a neutron star, in units of 'really quite heavy' per millilitre, were the volume of the teaspoon known in millilitres. We report the surprising results of a series of determinations here.

The Crab nebula, hiding a rotating neutron star

Literature review

Estimates of the volume of a teaspoon vary from 1.5 ml (NASA[w2]) to 5 ml (author's spouse). However, both sources have been known to be in error: the Hubble Space Telescope for the former, and an unpublished occasion for the latter.

Materials

All identifiable teaspoons were gathered from two locations (author's dishwasher and cutlery drawer, including the rarely seen spot right at the back with the pastry crimper) containing teaspoons believed not to have been previously used to unscrew things. These comprised: in shiny metallic (steel), five wedding-list teaspoons, acquired at time of marriage to teaspoon expert, with subsequent resupply at time of critical inability to find any teaspoons at all in this bloody house (Lim *et al*, 2005), two Ikea teaspoons, two unbranded spoons (made in China), and two Winnie the Pooh spoons (superior E. H. Shepard version); in plastic, three spoons from technical suppliers (Teletubbies, Mothercare, and Heinz Baby Basics), and the measuring spoon from the breadmaker. A 5 ml medicine spoon was used as a positive control.

Methods

Preliminary studies revealed surprising differences between the volume in a level teaspoon and a heaped teaspoon. Assessment of level loading was subject to parallax errors when evaluated from the height of the 6-year-old technical assistant, although these were minimised by the beginning of *The Simpsons* and the subsequent author-only experiments. Assessment of maximum loads was performed by watching for the first drip, and required a steadier hand than likely available. Replications were not performed so as not to complicate the analysis of variance.

Results

Plastic teaspoons were found to be consistently smaller level loaders than steel spoons and were discarded from subsequent analysis on the grounds that no one visualises a Teletubbies spoon full of neutron star. The plastic spoons did have heaped loads comparable with the metal spoons, possibly because of increased surface tension. The 11 steel teaspoons had a mean level volume of 2.66 ml (standard deviation 0.37 ml) and heaped volume of 4.2 ml (standard deviation 0.46 ml). Intriguingly, the positive control had a level load of only 3.2 ml and was reclassified as a vacillating control.

Conclusions

- Teaspoons do contain about 5 ml, but only when you heap them.
- Although NASA is wrong and author's spouse may *appear* to be right, power effects mean that acknowledgement of this from such a small sample size is unlikely.
- Water in surface tension looks rather beautiful close up.
- Where's the rest of the breadmaker?

References

Lim MS, Hellard ME, Aitken CK (2005) The case of the disappearing teaspoons: longitudinal cohort study of the displacement of teaspoons in an Australian research institute. *British Medical Journal* **331**: 1498-1500. DOI: 10.1136/bmj.331.7531.1498

Web references

w1 - *The Wow of Physics: the Amazing Variability of the Neutron Star Teaspoon:* www.swintons.net/deodands/archives/000075.html

w2 - *A Teaspoon of Starstuff* http://imagine.gsfc.nasa.gov/docs/teachers/lifecycles/LC_main_p11.html

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