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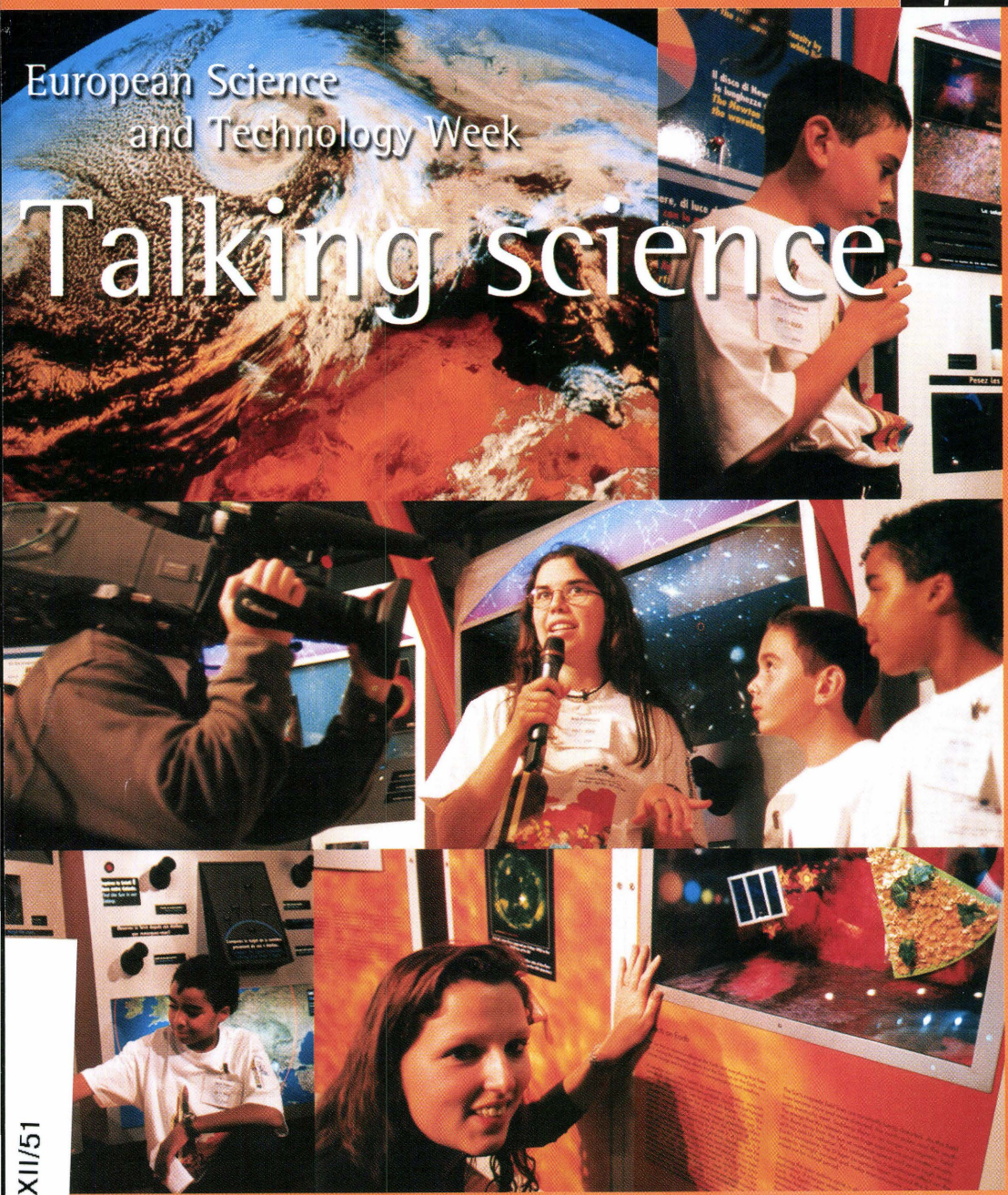

European Science and Technology Week

Talking science

FIFTH FRAMEWORK PROGRAMME

RTD *info*

Contents

RTD *info* is a magazine on research and technological development supported by the European Union. It covers general aspects of Community research such as project results and research policy, as well as practical information including dates of calls for proposals, events, conferences, publications, and so on. RTD *info* is aimed not only at current and potential participants in Community research programmes, but also at a wider public of industrialists, decision-makers, students, and others who are interested in developments in European research. Published quarterly, RTD *info* is available in English, French and German. Subscription is free. To subscribe, fill in the form below.

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Talking science

'The public understanding of science' is not a new concern. But the accelerating progress of scientific knowledge, its growing impact on society's development, plus the questions - and sometimes the fears - aroused by its influence are giving this a new urgency. Consequently, over the past two decades, a number of European countries have organised annual science and technology 'weeks' or 'fairs'. These events invite the general public, and young people in particular, to develop an interest in the constantly unfolding adventure and progress of research - and to discuss it.

Since 1993, the Commission has organised a similar event on a European scale. A series of attractions involving participants from different countries is held in November each year and puts the spotlight on the European dimension of research in Europe. During these few days, museums, universities, scientific institutions and schools become a showcase of European cooperation in the pursuit of knowledge.

This special issue of RTD info presents the many facets of *European Science and Technology Week 2000*, during which the European Union supported seven major initiatives presented in various forms (exhibitions, debates, video productions, conferences, new information tools for the Internet, etc.).

Hopefully the pages of this issue will convey the dynamism and diversity of the occasion. This immersion in 'Week 2000' also has the more specific aim of presenting examples of events which could in turn stimulate new ideas and give rise to other projects on the occasion of future Science Weeks (see box). Many of these initiatives also remain on-going, whether in the form of travelling exhibitions or a continuing communication on the Internet.

Inauguration of the 'Fly me to the sun' exhibition in Noordwijk (NL).

The trans-European actions presented at the 2000 event reflect a shared desire: to communicate advances in scientific knowledge. A desire now clearly laid down in the creation of the European Research Area. This also implies communicating the culture in which this progress is made, the joys which can come with a passion for research, the benefits of these discoveries, the aims it pursues and the questions it raises. ■

A project for 2002

Conducting chemistry experiments in a circus tent, organising Internet debates between teachers and pupils from secondary schools all over Europe, presenting an exhibition on the relationships between man and animals, inviting the experts to unveil the car of the future or the latest progress in environment technologies... Any project with a European approach and the objective of demystifying science and technology for the general public - especially young people - can be submitted in response to the next call for proposals from the *European Science and Technology Week* and will, if accepted, receive financial support from the European Commission.[1]

The projects to be realised in 2002 must reply to the forthcoming call for proposals. Information on this call is available on the Internet site or by e-mail at:
www.cordis.lu/improving
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Stephen.Parker@cec.eu.int

(1) This support is granted under the 'Raising public awareness of science and technology' section of the 'Improving Human Potential' programme.

Returning science to society

Having itself been shaped by the progress of knowledge, society has a paradoxical relationship with science, one of hope mixed with fear. An increasingly complex science remains unfamiliar and distant to the general public. What is more, young Europeans are increasingly shunning science when it comes to study options and career choices. RTD info speaks with Philippe Busquin, Member of the Commission responsible for research, for whom the reconciliation between science and society is a priority.

European initiatives for a 'public understanding of science' are now a clearly defined priority reflected in particular by the relaunch and reinforcement of the 'European Science and Technology Week'. What were your feelings when you visited CERN during 'Science Week' last November?

Philippe Busquin: The *Physics on Stage* event held there showed remarkable creativity. It sought to focus attention on – and develop responses to – two extremely worrying but related problems. These are the way in which young people are losing interest in studying science subjects, and the need to take a critical look at how an essential science, such as physics, is being taught today. *Physics on Stage* was a rewarding event. It gave young people the opportunity to discover many fascinating concepts on the knowledge of matter in a way which was both fun and interactive, and allowed teachers from all over Europe to compare their teaching experiences.

A key question was asked: at what age should scientific ideas be introduced and how? Many people - and I share this view - believe it should all begin in primary school by developing curiosity. Our teaching methods are too concerned with the need to fill minds rather than to stimulate them. But school is not everything. Parents must also be made aware of the need to stimulate interest and, outside school, educational infrastructures, such as science centres and museums, must be developed which also include a 'play' element. Curiosity is what drives the acquisition of knowledge.

But how do you explain the worrying trend at Europe's universities in general whereby – at a time when science and technology are playing key roles in the global economy – young people are turning away from science subjects?

The trend seems to be linked to two causes. Not only do these subjects seem progressively to be losing their attraction, but fewer among those who do opt for sciences go on to enter the world of teaching and research. Some, in fact, choose careers which have nothing to do with the knowledge they have acquired. This is a very serious problem and we are sounding the alarm. The future of research is already under threat from an unfavourable demographic trend and, when this is combined with a lack of interest, there is a risk of creating a serious gap between two generations. This problem has been resolved in the United States by attracting researchers from abroad - from Europe and Asia in particular.

The average age of science teachers in Europe is around 50, and not enough young teachers are coming into the system. The teacher's job does not receive the recognition it deserves. Too few resources are devoted to their ongoing training. Financial support is inadequate. Where are the secondary school classes where the teacher is accompanied by a lab assistant, as in my day? Pupils must be placed in laboratory situations where they carry out experiments and use their intuition. Science is not all theory.

Philippe Busquin during his visit to CERN during 'Week 2000'. 'Many people - and I share this view - believe it should all begin in primary school by developing curiosity. Our teaching methods are too concerned with the need to fill minds rather than to stimulate them.'

Is it not also true that science as a profession has lost its attraction?

In this global society, in which everything is seen in terms of its monetary value and science is becoming increasingly ordinary due to its ubiquity, the moral and social status of science as an occupation is no doubt declining. But although it can be a motivating factor, financial success is not usually the engine of research.

Are there a lack of role models, such as Einstein or Marie Curie?

Perhaps. It is a pity - and worrying - that famous scientists seem limited to the beginning of the 20th century. I do not know what young people today would say if we asked them to name well-known scientists. I fear some of them would cite Bill Gates and would not have heard of Crick and Watson, who discovered DNA. But is not the identification of myths an element of the culture? Perhaps if Harry Potter were to meet scientific heroes in his future adventures, it would restore science to its mythical status. Science must be shown to have a human face. It is not all about rigour and cold calculation. Doubts, mistakes, controversy, dreams... they are all part of science too.

Are you saying that scientific culture is not lively enough?

I do not believe that Europeans, especially young Europeans, really lack interest in science - quite the contrary. I believe that they are increasingly questioning the changes science is bringing to their everyday lives. The increased rate of progress of knowledge is pushing society to the limit of its ability to absorb. Also, some developments are calling into question fundamental ethical principles.

Science must once again become an integral part of culture - which used to be the case. Unfortunately, scientists themselves do not experience their discipline as a culture, and they bear an enormous responsibility for this. Society too; for example when any of your domestic appliances breaks down, the notice warns you not to try and solve the problem yourself. In a way this is a means of discouraging people from investigating the tools which are all around them. There is a need to re-ignite a certain scientific curiosity, first of all to understand the world around us – and then to be its partner.

Should the media play a different role in communicating this kind of message?

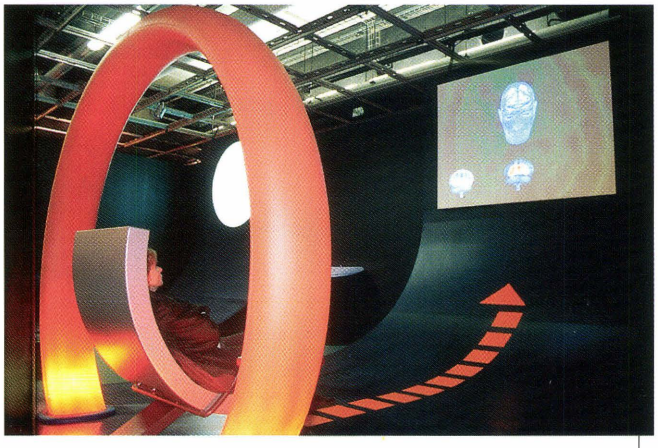
The image we give of science through various media is often misleading or, in any event, incomplete. The cinema, for example, continues to convey the image of the scientist as something of a Frankenstein figure, with a devilish and frightening appearance, when science is in fact an aspect of peace. Israelis, Jordanians and Palestinians are all involved in the scientific programmes supported by Europe in the Middle East. During the Cold War years, European and Russian physicists continued to pool their knowledge. These aspects are not often highlighted by the media.

At present, the public tend to associate anything scientific with mad cow disease.

Yes, and unfairly so. If cows have become carnivores, it is primarily the industrial practices which have shown too little regard for a solid scientific approach which should be called into question. People forget that it is the scientists who carried out painstaking research and sounded the alarm. The same is true of climate change. It is science that is pushing society to look at the necessary changes which must be made in the light of this threat, the causes of which are primarily economic, industrial and demographic. Science is often wrongly perceived as being the cause of the problems, when in many fields it is science that is the safeguard and society's recourse for solving its problems. There is thus a need for a wide-ranging study and debate on science and society, and education is part of this.

Why is it so important to have a European dimension to this debate, which you have made a key component of the European Research Area?

Because increasingly, due to the very existence of the Union's internal market, it is at this level that scientific and technological developments impact our continent. It is only by means of common regulations that we can govern the use of biotechnologies, food safety, energy policy, and environmental protection. This is why the debate between science and society must be a European one which integrates all the differing opinions linked to cultural and ideological identities – especially in terms of ethics – which form the fabric of our continent. The mission of the European Science and Technology Week is to shed light on this drive for greater awareness. ■



Cité des Sciences et de l'Industrie - Paris - 'The desire to learn' exhibition. 'Curiosity is what drives the acquisition of knowledge.'

Nature, a breeding ground for science

What do a firefly and a super-flat computer screen have in common? How do earthquakes lead us to new oil deposits? What do radioactive particles tell us about works of art? In what ways are computer systems modelled on the human brain? These and other questions are symbolic of the role of observing nature as a permanent source of inspiration for science. The Leafon project, initiated by scientists at the European Physical Society (EPS), explores this special dialogue between science and nature through images. 'Inspired by Nature' is the first in a series of films intended for the public in general and teachers in particular, with supporting educational material available on the Internet.

Inspired by Nature is the point of departure for a huge educational project conducted by the EPS. This 30-minute video - of which nearly 900 copies[1] have already been produced and which is available free of charge - was made for and launched during 'Week 2000'. A committee of European scientists from private research centres and academic circles was consulted on the choice of subjects and proposed the concrete examples which illustrate them.

The film focuses on five topics in turn to illustrate the lessons man has been able to draw from natural phenomena as diverse as radioactivity and earthquakes, animal behaviour, and the human voice and brain. Filmed at universities, research centres and companies[2] in five countries (Italy, the United Kingdom, the Netherlands, Germany and France), *Inspired by Nature* is the first in a series of six half-hour programmes provisionally entitled *Bridges from Physics*. The EPS hopes that this initiative to produce popular science programmes inspired by scientists themselves will encourage European television stations to make a similar effort.

'The EPS has about 80 000 members and we are counting on them to spread the message and increase awareness among the media, schools and science education circles and, as a result, reach the widest possible public,' explains Brian Davies, coordinator of the Leafon project. 'The video is a flexible educational tool which is ideal for teachers who can either show it in full or concentrate on certain themes. We are also aiming to follow up on the subjects covered with developments at our Internet site.'

Meteorologists are using more and more parameters in an attempt to model all the subtleties of the atmospheric system, taking advantage of the impressive computing power provided by modern computers. When all the forecasts agree, Dutch skaters can set off on their famous annual race without fear of a thaw.

In presenting the Leafon project at the Brussels Royal Museums of Art and History, Sir Arnold Wolfendale, the EPS' president, showed himself to be an ardent defender of the cause and a man determined to break out of the ivory towers. 'There is an increasingly urgent need for scientists to meet the obligation of communicating their work to society,' he points out. 'Not only because it is partly the public who finance research, but also because science is increasingly affecting the lives of citizens. It is also essential to educate young people if we are to avoid the serious shortages predicted for a number of scientific disciplines.' ■

(1) This film is currently available in English only, although it has been designed to allow easy dubbing into other languages.
(2) All the illustrations in this article, except for the one at the top of page 8, are taken from *Inspired by Nature*.

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EPS Internet site: www.eps.org

To obtain a free copy of the video, please contact
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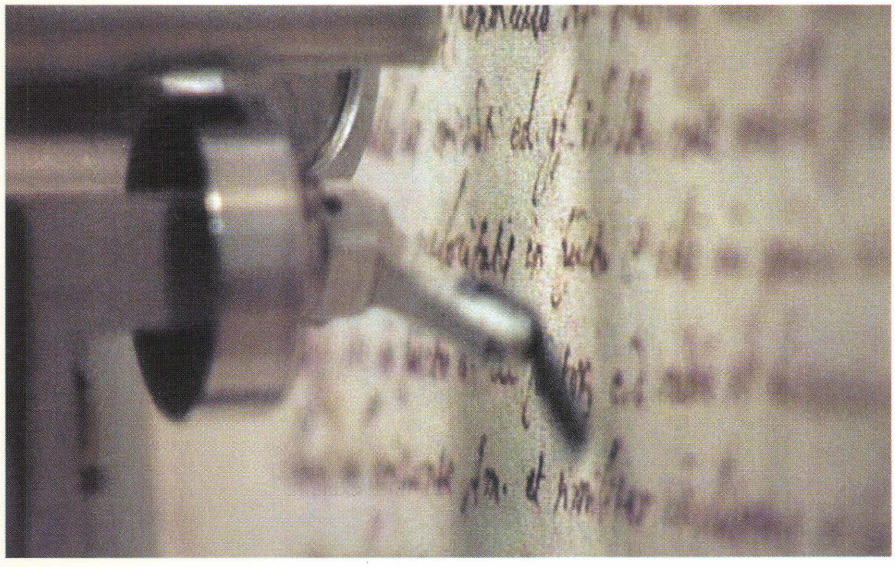
34 rue Marc Séguin BP 2136
F-68060 Mulhouse Cedex, France
Fax: +33 389 31 94 49

The day it struck Galileo

In the 17th century, ink was made in small batches whose composition varied from one pot to another. The differences, which can be identified using this device which emits fast protons and detects the resulting X-rays, make it possible to date Galileo's manuscripts precisely by comparing them to his dated household documents. This allows us to date his writings promoting Copernicus' revolutionary idea that the earth rotates around the sun to within a day or so.

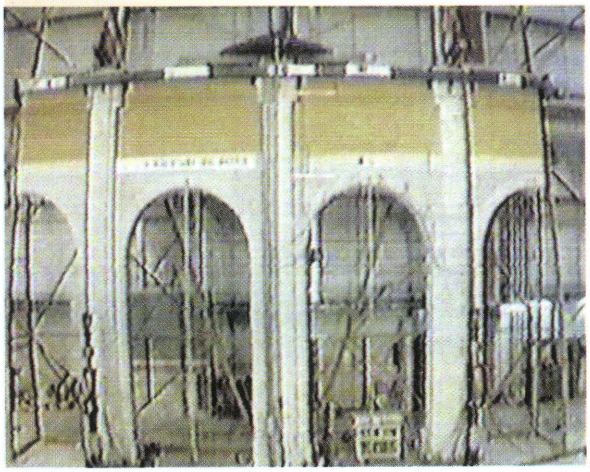


From neurons to intelligent cars

A complex organ, with a fascinating ability to learn, the brain is a constant source of interest to scientists. Its workings can be simulated - albeit in a much simplified form - on a computer as the neural networks modelled on the brain share this capacity to learn. It is by using such systems that objects as familiar as cars are likely to become 'intelligent'. Not only will vehicles be able to recognise situations already encountered, but they will also adapt to new events or driving behaviour. 'The system will modify certain vehicle characteristics (consumption, suspension, transmission, etc.) and could even switch between internal combustion and electric engines, depending on the performance required in different circumstances,' explains Werner Huptmann of Siemens' Munich-based neuro-informatics group in *Inspired by Nature*. The vehicle of the future will thus be made in our own image, that is, it will be intelligent. It will also produce much less pollution than today's cars.

Earthquakes and oil

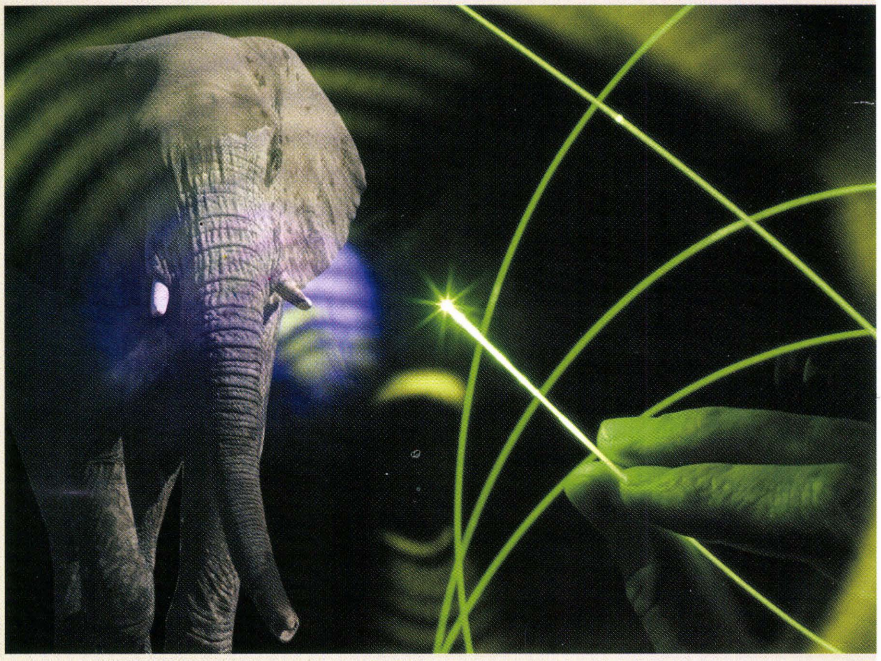
Although the intensive studies carried out by seismologists are mainly aimed at detecting the early-warning signs of an earthquake, their understanding of the physics of shock wave propagation can be valuable in exploring the substrata. 'By studying the propagation phenomena triggered by artificial mini-explosions, we can locate possible faults in the upper levels of the ground which could contain oil deposits,' explains David Kerridge of the Seismology Centre in Edinburgh. This technology is particularly useful for optimal exploration of known deposits.



From monkeys and whales to fibre optics

At dawn or dusk, some animals, such as howler monkeys in the tropical forests and elephants on the savannah, are able to communicate over surprisingly long distances. They do so by using the physical phenomena of the reflection and propagation of sound created by small differences in temperature between relatively homogeneous atmospheric layers. Whales are able do the same thing as a result of differences in sea temperature and salinity at different depths.

The revolutionary invention of long-distance data transmission with minimal losses using fibre optic technologies applies the same principles of reflection and propagation to light.

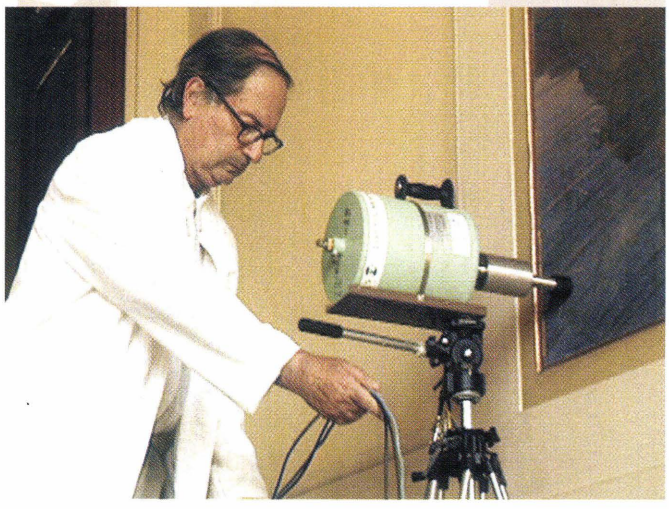


The arts

The natural and invisible phenomenon of radioactivity is not just for the important fields of medical diagnostics and cancer treatment; this Italian Renaissance painting is benefiting from it too. 'Low energy α particles which pose no threat to the works of art are aimed at the material to be analysed,' explains Professor Papparlado, of the University of Catania (Sicily). 'After half an hour of taking measurements we are able to determine the composition of a pigment or coating.'

In an altogether different field of art, the world of sound is used for analyses carried out by physicists and acousticians. An in-depth knowledge of sound is clearing the way for researchers to develop new virtual instruments: 'By combining vibrating structures formed from masses linked according to a certain model, we have created a sound network which can be controlled by a computer and even linked to animated images. Computing is opening up a whole new field in the exploration and creation of virtual audio-visuals,' explains Claude Cadoz of the Acroe Institute in Grenoble.

These examples are among those explained in *Inspired by Nature.*



A celebration of physics

About 400 participants were expected, but 550 showed up. All of them teachers (from primary to university level), from 22 countries (*), who gathered in Geneva at one of the most prestigious sites in the world of fundamental science. CERN, the European Laboratory for Particle Physics near Geneva, a 'monument' to high energy physics, opened its doors between 6 and 10 November to become the forum for passionate debate. The aim was to find out why young people are shunning science courses - and in particular physics - and to think about ways to reverse the trend. The approach was to make it all a festive occasion, presenting knowledge in a most attractive, lively and playful light. As a result it scored a double success: the style detracted nothing from the content, and the debates never got bogged down in academism.

For five days, the main CERN building became a place of celebration, the relaxed atmosphere in marked contrast to the greyness of the surroundings. Stands were set up on both sides of the aisles, on two floors. Everybody was free to browse - for ideas, for images, for new contacts. Meanwhile the main amphitheatre, with its succession of events and conferences, played to a full house. But the good humour was certainly not at the expense of serious - and multilingual - debate.

The various demonstrations clearly conveyed the common concerns. The notion of physics as 'boring and difficult' seemed to hover in the air, like a spectre to be banished from these innovative surroundings. But how? How can young people be motivated to train as the engineers, technicians and researchers - or even Nobel prize-winners - of the future? The challenge is formidable in the light of the growing trend, seen on both sides of the Atlantic, for students to turn away from physics courses. While the answers were many and varied, one seemed to be as obvious as it was essential: it is up to education to adapt to the students, as the opposite approach is a lost cause.

Imagining and understanding

Discovery, imagination, creativity: concepts which can be expressed in many ways. For example, take the curious clocks invented and produced by a group of Czech children aged between 11 and 13. Irena Koudelkova, their teacher, had simply asked each child to make a mechanism using whatever means they liked. One result consists of a cardboard cup, into which sand is poured, placed on a pivoting plank (like a see-saw) which tips down when it reaches a certain weight, thereby completing an electric circuit lighting up a bulb. Like an hourglass, this 'clock' measures intervals of three minutes. 'Having assembled the mechanism, the pupil then explains it to the others. That is when he has to learn to organise his thoughts,' explains Irena Koudelkova.

At the Portuguese stand you enter a completely different field. 'Holography is a very effective way of teaching both geometric and wave optics,' explains Pedro Pombo, who is a physicist at Aveiro University, which does not prevent him from cooperating with the high school in Covilhâ, about 200 kilometres away, where he completed his secondary school studies and began his teaching career. Passionately interested in holography himself, Mr Pombo wants to

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(*) The countries of the European Union plus Bulgaria, the Czech Republic, Hungary, Norway, Poland, the Slovak Republic, and Switzerland.

Plastic + adhesive tape = music. Gordon Douglas, Irish flute player. Who said physics was boring?

share this enthusiasm with others. 'When I suggested to my classes of 15- to17-year-olds that they make a hologram, they tried, failed, tried again and finally succeeded. That is how to develop the scientific spirit.'

tional game or an experiment on the subject and take it to the classroom.' At which point Mustapha gives us a demonstration which is almost like a magic act. He runs his hand along a transparent, U-shaped tube

ing of research and to work on how to present the sciences, which are often portrayed in a way which is too formal and abstract,' commented Philippe Busquin during his visit to *Physics on stage*. This is exactly how

In addition to the debates and discussions, and before the evening shows, the two floors of CERN were filled with stands presenting 'physics' in all its infinite variety. With pupils displaying their projects, researchers giving demonstrations, and 'magicians' performing their experiments before a live audience. The theme for this bustling marketplace? Science is fascinating.

For my next trick...

A few metres away is the French stand of the *Petits Débrouillards*, an association of 500 clubs in 14 countries covering both schools and educational leisure activities. 'We visit schools on request,' explains Mustapha Waffa, one of its organisers. 'If a teacher tells us he wants to work on the concept of pressure, we prepare an educa-

containing water. As he does so, so the water moves along the tube with his hand. Quite simply, he had covered the end of the tube with his other hand where he worked a kind of sucker to control the internal pressure. This device allows children to experiment with the relation of cause and effect between the pressure and the movement of the liquid.

'There is a need to rediscover the mean-

the participants at this November event intended to communicate their knowledge - and their passion.

Time for reform

Thirteen workshops, 100 recommendations: national and European education policy-makers are going to have to listen to the message from more than 500 primary and secondary school physics teachers who took a long hard look at science education reform during 'Week 2000'.

Why has physics lost its pulling power since the 1960s? Is the subject austere by its very nature - or is it the way it is taught that needs to be reviewed? Can its teaching begin in primary school, or should the subject only be introduced in the final years of secondary school?

Above anything else, *Physics on Stage* gave teachers the opportunity to discuss these questions openly, compare teaching practices and approaches, and establish contacts enabling them to continue this exchange of experiences after the Geneva meeting. This joint study was carried out within the 13 workshops[1] which analysed physics education from very specific angles and then produced a number of recommendations.

Knowledge and appreciation

Some of the recommendations concern teachers' social status and working conditions. Teachers throughout Europe feel they do not receive appropriate recognition. 'The job done by teachers needs to be reappraised,' stresses Philippe Busquin. Specifically, they want to be able to benefit from continuous training to update their knowledge in their subject, and to acquire skills in the new communication technologies and incorporate these in their teaching. One of the proposals is for the Commission to set up a resources centre that is accessible via the Internet.

In terms of the teaching itself, the workshop on the importance of the evolutionary aspect of science placed particular emphasis on the need to place physics in a wider social and historical context. The participants suggested that teacher training should include courses on the history and

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(1) See the complete list on the Internet site: www.cern.ch/pos - the topics for discussion included the link between physics and other subjects, the role of women in physics, the link between physics and the contemporary world, and new teaching tools offered by telecommunications.

Physics and music

Songs, gags, shows... CERN was almost unrecognisable when physics took the stage. Take Mike and Wendy Glues, for example, and the success of their *Adventures in Sound*. Mike is a retired physicist, and Wendy an English teacher. During their voyage of discovery through the world of sound - with bird song, musical instruments, body noises and electronic sound - they provide a comprehensive picture of acoustics. The demonstration lasts one hour, with a great deal of humour and poetry.

Brigitte Van Tiggelen, who teaches the history of science in Belgium, presented *Cera una Volta ... Volta*. This is a dialogue between an adolescent (played by a pupil) and Volta (played by a teacher) in which the former relates his experiments and replies to the latter's questions. 'After the show, members of the young audience are asked to talk about their own experiments. This is not just a question of placing science on the stage, but also of giving the public the opportunity to practice it,' explains Brigitte Van Tiggelen.

For a number of years, the Technische Universiteit Eindhoven (NL) has involved its physics students in putting on a show entitled *Circus of Physics*. 'Once a month, we put on a show to which we invite all the lower-level schools,' explains the event organiser, Fons de Waele. In creating a living dialogue with the public on the nature and objectives of experiments, this interesting theatrical approach is also rewarding for the student-actors who act out situations in communicating science.

Cera una Volta ... Volta. Presenting a discovery. The show was produced by Brigitte Van Tiggelen, a science historian.

Week 2000 ended with an original presentation by Lynda Williams, a physicist from the University of San Francisco, who used the names of elementary particles in the style of a US musical comedy.

philosophy of science (see *History of physics* box), and on relations between science and society, and between science and other fields of knowledge.

From the playful to the abstract

'One of the major benefits of these discussions between people from many different regions,' stressed Richard West, who organised *Physics on Stage* for the ESO, 'is the way they produce many innovative approaches and original recommendations embracing the expectations in all the participating countries. This joint study must continue - and produce concrete results.' But of course many questions require further study. What, for example, is the ideal age to start studying physics? Richard West believes that 'physics is rather like a language' and that an awareness of the subject should begin at an early age not through traditional 'lessons' but through an intuitive approach involving the actual handling of objects and observations of the natural world. Through, in fact, the very approach

'Physics involves thinking before going on to the equations and calculations to which it is often reduced.'

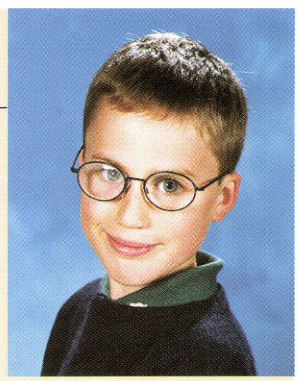
The history of physics

We put two questions to Nicolas Witkowski, who teaches in France and edits books on the history and philosophy of science, and who was the rapporteur for the workshop on this subject at Physics on Stage.

How do you include the history of science in your teaching?
Nicolas Witkowski: I present famous experiments - Franklin's experiment for measuring the size of an oil molecule or Eratosthenes' experiment for measuring the circumference of the earth. I also draw on historical facts when introducing a new concept, such as the controversy between Newton and Descartes on the nature of light. History is also a source of documentation from the writings of Galileo to others that are older still. This approach has the major advantage of justifying to pupils the relevance of the problems before going on to solve them. It also provides an opportunity for highlighting the cultural aspect of the sciences. Physics involves thinking before going on to the equations and calculations to which it is often reduced.
It would also be good to encourage interdisciplinary cooperation within schools. Between physics, history and mathematics, of course, but also with French. Teachers must be encouraged to open up their teaching to what is going on in the world around and not to compartmentalise physics. The questions it raises are universal.

Have you noted significantly different teaching methods in different parts of Europe?
There is a marked difference between northern and southern Europe. In the north, optimism reigns. There is an almost unconditional confidence in progress and technology, and the emphasis is on experimentation. In the south, more emphasis is placed on metaphysical reflection as well as mathematic formalism. The interesting thing about these international meetings, such as those at CERN, is that all these ingredients can be brought together and compared for the benefit of the pupils.

Romain's projects (age 10)



Are you interested in science?
Yes. Especially astronomy and chemistry. I like looking at the stars and comets. I also like doing experiments on matter and seeing the changes that happen when you mix things together. And I like history (especially the Middle Ages) even if it is not always a science.

Will you choose to study science at secondary school?
Yes, I think so. I would like to learn in detail about astronomy and chemistry. But I am a bit frightened that it will be too difficult. I am interested in chemistry but I am afraid I will make mistakes in my experiments when the teachers think I am too slow. You can't make mistakes in science. In other subjects mistakes are not so dangerous.

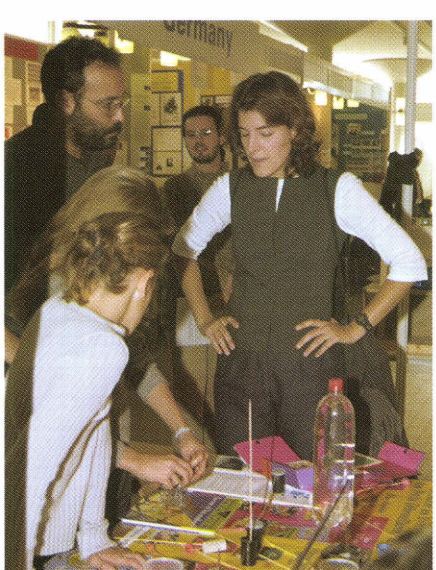
And what would you like to be when you grow up?
I would like to be an astronomer. If I can't find a job in Belgium, I will go to France or somewhere else. If I can't be an astronomer, I might be a doctor.

Not a chemist?
No, because you have to be too accurate. I would be afraid of making a mistake and causing an accident.

found at the stands, where many of the demonstrations were designed to show that physics can be fun.

Don't jump to conclusions

However, although there was general agreement on the need to adopt an approach which includes a practical or even playful dimension, that still leaves the question of how to develop the ability to think abstractly, which is essential to scientific activity, in school physics lessons. Catherine Cesarsky, General Director of the ESO, warns against an apparent trend in many European countries - but not in the United States - to specialise too early. A premature 'split' between science subjects on the one hand and arts subjects on the other has two undesirable effects. First, it presents the sciences as selective subjects, thereby discouraging many young people. Secondly, it tends to dissuade girls, as the prevailing culture continues to see it as more important for boys to be successful at school and in a career than for girls. In fact, the under-representation of girls on science courses was frequently stressed during Week 2000.



Making friends with physics.

At the end of the day, the general message was that active teaching methods should be given priority. 'I benefited from an experimental approach at school in Denmark,' relates Richard West. 'We learned to discover the natural world, we carried out craft activities, and today I am very good with my hands.' This is certainly food for thought at a time when the growing use of computers could perhaps entail the risk of losing contact with physical reality. Subjects for further study have certainly not been exhausted. ■

Physics on Stage was the result of close cooperation between the European Space Observatory (ESO), the European Space Agency (ESA), and CERN, with support from the European Association for Astronomy Education (EAAE) and the European Physical Society (EPS).
www.cern.ch/pos
www.estec.esa.nl/outreach/pos
www.eso.org/outreach/spec-prog/pos/

Journey to the heart of the sun

The atmosphere was electric, on 8 and 9 November 2000, at the Space Expo in Noordwijk (NL). Five teams of young people from five countries - France, Germany, Italy, Belgium and the Netherlands - came together to present a joint exhibition. The common theme was the sun. Helped by their teachers and experienced events organisers from science museums, they worked for months on presenting a particular aspect of our star, about which many of them previously knew very little. Such an event gave us all the chance to discover some of its secrets.

'I see this operation as having certain similarities with European space research. Elements are manufactured at various locations - such as the Airbus or Ariane rocket - and then brought together, clipped into place like a Lego set, and it all works. A wonderful example of European cooperation,' believes Walter Staveloz, director of Ecsite (European Collaborative for Science, Industry and Technology Exhibitions) and the EPOS (European Project on the Sun) coordinator.

Choosing the teams

It all started with the national selections, organised by a science centre or museum. In each country the project promoters recruited 'their young people' in schools and science clubs. 'When we spoke of EPOS at the schools we work with, the response was immediately enthusiastic because this is very different from the usual educational project,' explains Bérangère Gueguen, events organiser with Pastel, the French astronomy association. In Toulouse, a group of youngsters aged between 12 and 14 from two different classes came to the Cité de l'Espace to work on the subject of 'The sun as a star'. 'This was an opportunity to present notions such as the colour, life cycle and mass of stars in a very concrete manner,' comments Arnaud Carcon, coordinator of the Cité project. 'As the youngest in the group had no preconceived notion of astronomy at all, we had to focus on making sure the message we wanted to communicate was one that could be understood.'

Imagining, searching, creating

'A lot of searching was involved: Internet surfing for documentation, choosing the photos, etc. It is also a competition, of course, and now we have all come together here, we are curious to see what the others have done. Which is not bad either,' admits Esther, a Dutch participant. 'All the teams made good use of the assistance offered by the European Space Agency (ESA) in contacting researchers and finding scientific or more general information, technical pictures and unique photos of our star,' notes Hugo Marée, communication officer for

'The stars have a colour'. For the youngest EPOS entrants (aged 12-14), from Toulouse, the challenge was to analyse the sun as a star, and to present the results of their investigations in English.

The aim of the ESA's Cluster mission is to study, with unrivalled precision, the interaction between the charged particles emitted by solar winds and the earth's magnetosphere.

ESA's scientific programmes. ESA also participated directly in the exhibition, presenting the results of its scientific missions on the sun, in particular the Ulysses, SOHO and Cluster projects.

In Italy, seven boys and girls aged between 16 and 18 from four classes at the same school in Naples looked at 'how the sun works'. The Italian school system supports initiatives of this kind by granting 'educational credits' for the study of certain disciplines such as astronomy. 'The young people were very keen. It was they who decided what information to present, after studying in class the somewhat taxing scientific content of the subject. They produced a very accomplished project and our job was mainly to check the educational aspects of their proposals with the exhibition visitors in mind,' says Alessandra Zanazzi, project coordinator for the Città della Scienza - Fondazione IDIS in Naples.

Museum involvement

In Germany, the team was coordinated by the Deutsches Museum in Munich, which possesses a wealth of documentation, photographs and observational data. 'We were right in the area which experienced a total eclipse of the sun in 1999,' explains the museum's scientific officer, Thomas Kraupe. 'That means we were very well placed to tackle the subject of observing the sun.' The German group consisted entirely of amateur astronomers, all aged between 16 and 18 and members of the same club. 'We saw the eclipse, and it is really something you will never forget,' says Markus, a team member. 'We worked for EPOS at the weekend, during the holidays, and after school. We had to really investigate the subject in depth, make lots of observations and closely study all the eclipses. We wrote all the texts ourselves, and chose the photos and films placed in the interactive module.'

It was not just the motivation of these young people that struck Thomas Kraupe, but also their computing skills and ability to cope on their own. 'Our intervention was limited because we wanted it to be their project. In fact, in future I believe it would be advisable to concern young people at an earlier stage in the process, getting them

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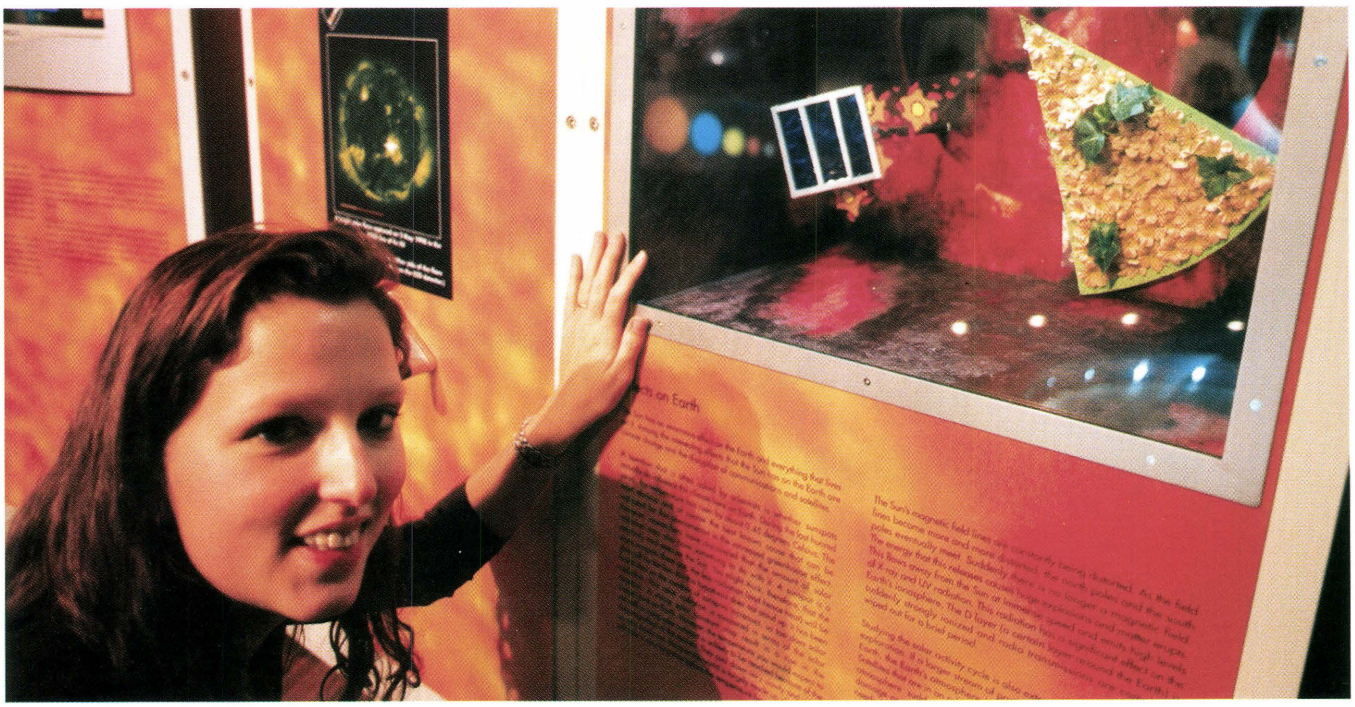

The sun's cycles, sunspots, interference between this star and our planet... just some of the elements analysed by the Dutch team which used original and visually striking documents to present information about solar activity.

involved in developing the concept behind such initiatives.'

From mythology to remote sensing

In Belgium, another museum - the Musée des Sciences et des Technologies in Parentville - coordinated the project on the theme 'The sun, myths and realities'. In this case pupils from a school in Jodoigne decided to produce a CD-Rom of their work. For the Noordwijk presentation, they dressed up in brightly coloured clothes with some original hairstyles to embody the various civilisations in whose myths or religions the sun plays an important role. 'We had a threefold aim,' explains Laurent Thomas, the scientific coordinator. 'We wanted to give these young people the opportunity to get their first taste of research, to think about how to present a scientific project to a jury, and to use new information technologies.'

'Producing a CD-Rom was really interesting. You had to know all about the technical and computing side of it, which wasn't always easy, and then there was the more artistic side of integrating all the cartoons,' explains Gregory, a pupil. 'Those better at science looked for the information on the Internet and prepared the presentation, while the more artistic did the costumes. That way we complemented each other.'

All members of the same astronomy club, for the German team this was not the first contact with the sun. Apart from closely watching the 1999 eclipse, they are also regular visitors to Munich's Deutsches Museum.

'For a relatively small organisation such as the Space Expo Foundation, the EPOS project was a big adventure,' explains Wouter Van der Kwaak, the Dutch scientific coordinator. 'We had been running an educational project on remote sensing for three years, and we drew on this experience to tackle the subject of solar activity. It was through this channel that the participants, aged between 16 and 18, were chosen.'

'We met with scientists from ESA and Leiden University, which is not far away, attended conferences about sun, and visited a telescope,' explains a team member. 'And at school we manufactured the prototypes illustrating the effects of solar activity on the earth.'

A trip to the space camp

After making final adjustments to the computers, repairing the interactive elements and sorting out any last-minute hitches, the hour of the competition arrived. All the modules were combined in a joint structure presented at the Space Expo in Noordwijk (see box) and each team in turn presented its contribution to the jury which was charged with the difficult task of judging the entries. Jury members included representatives of European science and technology museums, ESA officials, a scientific journalist and two real astronauts, Frank De Winne and André Kuipers. Understanding of the subject, scientific precision,

Sun worship throughout civilisation, the fears and wonder it has instilled in time and space. 'Humans and the sun', presented by a group of young Belgians, unrecognisable on this occasion. Also available on CD-Rom.

museological quality, the degree of involvement on the part of the young people... all these elements and more were carefully considered by the jury and pertinent questions asked. 'One of the key elements in the EPOS initiative was the relationship between the coordinating museums and the young people. These were clearly excellent. We saw this during each team's presentation. The collaboration was evident,' believes Hugo Marée. 'The success of the enterprise was based on the professionalism of the participants. The museums did an excellent job and all the elements just slotted into place,' adds Wouter Van der Kwaak.

The youngest participants, aged 12, presented their work in English with the attractively lilting accent of their native Toulouse. Bilingualism was the rule, and all the posters, CD-Roms and other supporting material were presented in the participants' national language together with an accompanying English version. The Belgian entry - the only one to have approached the sun from the perspective of the human sciences - was congratulated for its originality. The Dutch contribution was judged very interesting educationally, as it focused on varied presentations to reach a wide audience. The Germans produced a very clear synthesis based on the juxtaposition of images which were as eye-catching as they were instructive - in particular, the speeded up images of the solar eclipse. And the Italians were pronounced the winners! 'We gave it all we had right from the start. Before making the modules we repeated all the experiments at the Città dellà Scienza,' explains Luca, a team member. 'The idea of a competition is very stimulating, and I enjoyed presenting and explaining our work to the jury,' adds Maurizio. The prize? A weekend at the Redu Space Camp in Belgium. Where better to whet the appetite of the astronauts of the future? ■

'How does the sun work?' presented by the Italian team. Feeling the stress before the verdict that pronounced them winners. Their prize is an introductory weekend to science at the Redu Space Camp in Belgium.

Astral quintet

The exhibition entitled *Fly me to the Sun* is based on five themes and presented by five teams. The Germans focused on observing the sun, the Belgians on myths surrounding the sun, the French on the sun as a star, the Italians analysed how it works, and the Dutch explored the mysteries of solar activity. The assembly system could not have been simpler, with each team 'filling' a module, in the form of an orange segment, with screens, interactive elements, posters, etc. When placed together these five segments formed a dome, reinforced with a tubular structure, and illuminated by an overhanging sun. When assembled, the modules resembled the command station of a space shuttle, packed with screens, and easy to dismantle and transport. But the life of *Fly me to the Sun* will not end with 'Week 2000' - its first mission is as a travelling exhibition. After its inauguration at the Noordwijk exhibition, it will be on show at each of the partner science centres and museums before hopefully being launched into a wider orbit. 'The idea of developing and jointly managing European initiatives between the museums has not yet been universally accepted,' admits Walter Staveloz, chief coordinator of the EPOS project. 'My hope is that experiences of the kind held during Week 2000 will serve to convince the sceptics.'

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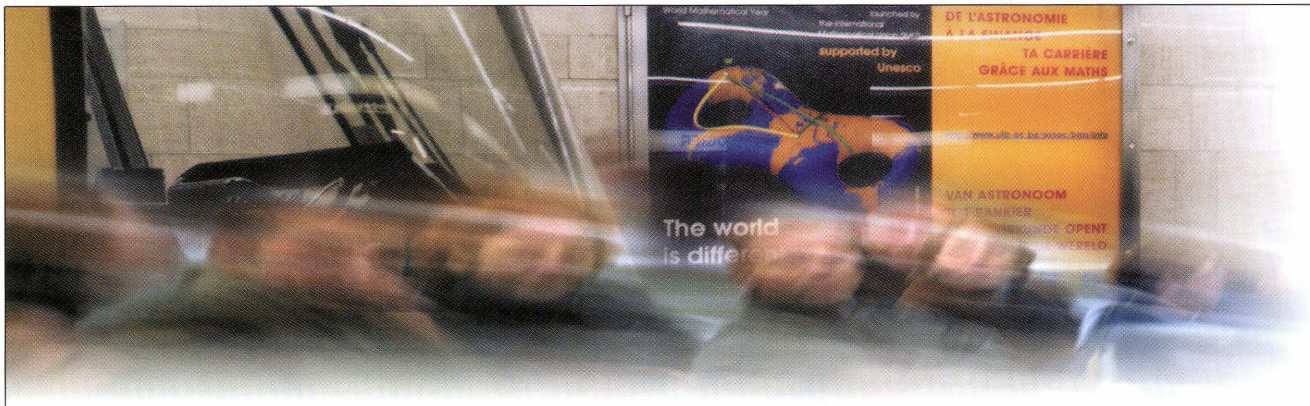
Fax: +32-2-647 50 98
wstaveloz@ecsite.net

To find out more:
The EPOS project site: http://www.ecsite.net/epos/public/homepage.htm
General ESA site: http://www.esa.int
The ESA's 'solar season': Ulysse, SOHO and Cluster
http://sci2.estec.esa.nl/specialevents/solarseason
The ESA's scientific programmes: http://sci.esa.int

When maths comes out of the shadows



Maths is adopting a higher profile, with an eye-catching poster campaign aimed at people on the move. For four days, a series of posters on the Barcelona, Paris, and Brussels underground systems have posed a number of problems to passengers. Is it possible to make a tour of Königsberg by passing only once over each of its bridges? How can you mix oil and water? Why do tigers have stripes and panthers patches? What do sailors' knots and the actions of viruses have in common? In just a few words, the posters explain the structure of proteins, the secret code of bank cards and the relationship between a mobile phone and a satellite. 'It's a change from advertising and makes you think,' was one student's verdict. Meanwhile, secondary school teachers have been busy writing to the initiative organisers asking for copies of the posters to display in their classrooms so that they can 'try and interest the pupils in mathematics in this way'.

'The visual approach to mathematics by poster campaigns is seen as a means of capturing attention, arousing interest, and of stimulating the desire to investigate further,' explains Mireille Chaleyat-Maurel, the coordinator of the Maths in action project and a professor at the Université René Descartes (Paris 5). 'Investigating further can mean, for example, going to a science museum to watch a demonstration, picking up an explanatory leaflet, or visiting the project's Internet site.'

On each occasion the objective is the same: 'to render visible the hidden fabric which intertwines mathematics at one level or another with our daily lives'. A mathematics which is as discreet as it is omnipresent. QED.

Turbulent weather!

The growth and track of a storm, the geometrical structure of a cloud and its role in absorbing solar and terrestrial radiation, the optimal integration in a numerical weather forecasting model of measurements made by different instruments operating at different locations (weather stations, satellites, ships and planes) ... There is no doubt about it: mathematical modelling plays a central role in all aspects of modern meteorological science. Essential for describing and understanding the mechanisms of weather and climate, it is used for both analysis and prediction.

Turbulent flows - and atmospheric movements are certainly that - can be modelled by the Navier-Stokes equations. However, since meteorologists cannot always solve these equations, they must use digital simulation using the most powerful computers, and the most sophisticated numerical schemes. Also of use is the mathematical theory of dynamic systems.

It was a meteorologist, E. N. Lorenz, who in 1963 demonstrated that even a simple dynamic system can evolve chaotically, its trajectory highly sensitive to initial conditions. According to his well-known metaphor, the disturbance of the air's flow due to the flight of a butterfly can ultimately lead to a cyclone on the other side of the planet.

Based on an idea of Philippe Courtier (Météo-France) and Claude Basdevant (ENS-Ecole Polytechnique-Paris).

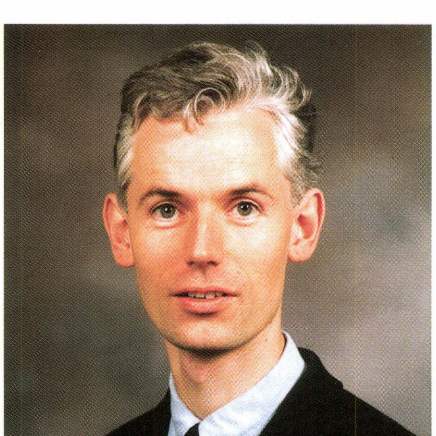
Mathematics and non-mathematicians

Is mathematics a waste of time? What is it for? Why is it so difficult to explain? How can we make it more attractive? The thoughts and suggestions of British mathematician Timothy Gowers, the winner 1998 of the prestigious Fields Medal.

Mr Gowers, do you feel that young people dislike science in general, or maths in particular?

It is hard to generalise. There will always be some young people attracted to science, and others repelled by it. One problem is that people's stereotypical view of a scientist - male, eccentric, unfashionably dressed, obsessed with very abstract problems - is hard to correct.

Mathematics suffers relative to the other sciences from being harder to explain to the general public. A physicist might be able to say that he or she is trying to understand what happened in the first few milliseconds after the Big Bang. Non-scientists, not realising that this actually means playing with equations, studying computer printouts from particle accelerators and so on, will have the illusion of understanding what is being studied. Most mathematicians, on the other hand, work in areas that cannot be explained in a sentence or two, even in a loose way, and most non-scientists start to lose interest after more than this.



Timothy Gowers – 'Mathematics is a tiny oasis in a huge desert of unsolved, and mostly insoluble, problems.'

How has your vision of mathematics evolved since you were at school?

Perhaps the main difference in my perception now, as a professional mathematician, is an awareness of just how big the subject is, of how much is not known and of what a tiny fraction of mathematics any one person can hope to understand. At school one is given the impression that mathematics is a body of knowledge - addition, multiplication, geometric figures, calculus and so on - which is neatly organised and well understood. It is hard to imagine what research is like since there does not seem to be much scope for unsolved problems. A professional mathematician feels exactly the opposite: mathematics is a tiny oasis in a huge desert of unsolved, and mostly insoluble, problems, and it is almost miraculous that we know as much as we do.

Maths teachers are often asked by their pupils: 'What is this useful for?' How should this be answered?

To summarise a long answer, which I believe to be satisfactory, most mathematical

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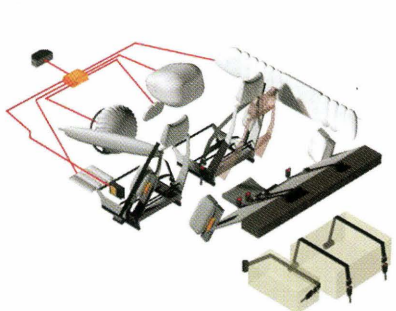
No damage!



The development and testing of new cars is increasingly carried out by virtual experiments using computer simulations. For this purpose, engineers develop virtual vehicle models described through equations, the solution of which requires advanced mathematical methods and powerful computers. Virtual models also allow cars to be tested at a lower cost.

A virtual prototype of a car requires a global mathematical model incorporating the vehicle characteristics as well as its interactions with the road and the air, the description of any obstacles, etc. This results in a system of equations which is solved on a computer using numerical methods.

The complexity of these models generates vast quantities of calculations requiring the use of parallel computers.

Based on an idea of Andreas Frommer – University of Wuppertal, Germany.

works will never have direct practical applications. However, they contribute to a body of very interlinked knowledge, and this knowledge as a whole has had very important applications; it underpins the whole of science. If the question is asked in a school classroom, then the mathematics being discussed may well have direct applications. It is easy to think of applications of calculus, or matrices, or complex numbers. Teachers should also not be afraid to use the argument that struggling with mathematics is excellent training for the mind, as one learns how to come to grips with difficult concepts.

Is it possible to popularise mathematics? Do you think it is important?

Many areas of current mathematics are almost impossible to convey to a general audience. However, this is certainly not true of all mathematics, and even the more difficult areas tend to have their roots in problems that can be explained more directly. In many ways mathematicians and the general public can happily coexist without communicating with each other. However, it is important that scientists, engineers, economists, computer programmers and others should have some conception of what mathematicians can do. It frequently happens that people in other disciplines come up against mathematical problems that are difficult, but already solved. Good communication can therefore avoid much duplication of effort.

Finally, since most mathematicians depend on public money, they should make some effort to explain why this money is not wasted. ■

Participants, initiatives

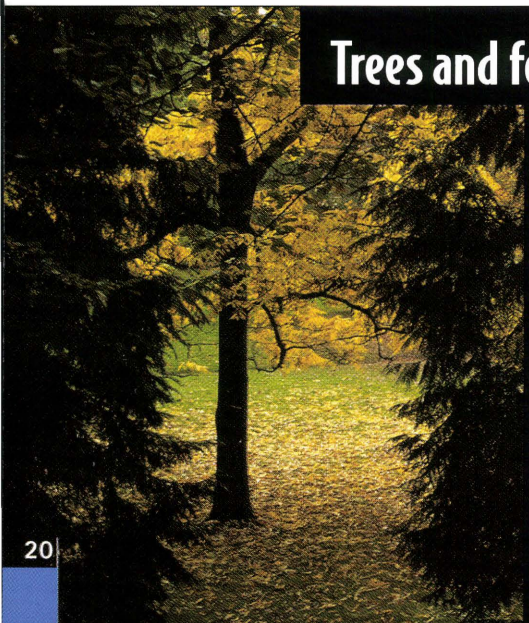
Germany
In Berlin, the launch of the website 'mathematik.de', a platform for a professional/public dialogue; various exhibitions, conferences, etc., particularly in Berlin and Munich.

Belgium
Posters on the Brussels underground.

Finland
Helsinki University presented two exhibitions, one on the visible phenomena in the sky and the other on mathematical modelling. A number of specialised seminars and conferences were also organised during the All Saints' Day long weekend in 2000.

France
'Maths in everyday life' exhibition at various science centres, universities, schools, etc. Posters on the buses in Pau. A day devoted to the winner of the European Mathematics Society Prize.

Portugal
Launch of the *Genesis* CD-Rom by John Robinson in Obidos, 11 November 2000, and an exhibition of posters and CD-Roms at the national history of mathematics seminar (Obidos, 16-18 November).



Trees and forests

One way to approach the effects of climate change on trees and forests is to try to simulate their development by using models incorporating a large number of parameters while remaining simple enough to be used in practice. This demands close cooperation between mathematicians and forest experts.
The main difficulties stem from the fact that there are different levels of structural hierarchy (forest, tree, leaf, molecule, etc.) all impacting on growth and also different time scales which coexist (forests which may be hundreds of years old, compared to just a few seconds for the metabolism).

Competition for light

Recent years have brought enormous progress in modelling trees and forests. A dynamic model, based on vital and environmental processes, has been successfully applied to the analysis of climate change effects, including forest management in different regions and improving the wood quality.

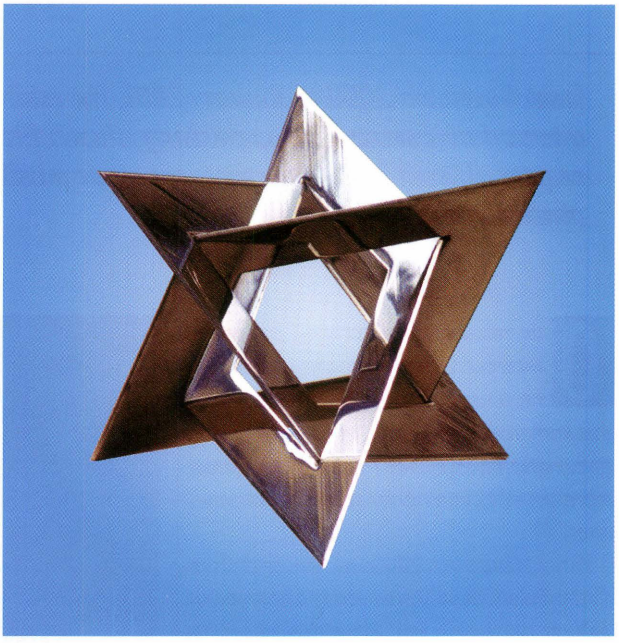
New models describe tree growth during the year and also make it possible to predict how different trees will compete for light.

Idea and illustrations by Marjo Lipponen.
MaDaMe programme - Turku University (Finland).

Art and mathematics – *Genesis - John Robinson*

The sculptor Max Bill was fascinated by the Möbius strip, a surface with only one side formed by joining the ends of a rectangle after twisting one end through 180°. Other artists have been similarly fascinated by other mathematical theories, such as those about knots. One of them is John Robinson, whose work is being followed with interest by researchers at the University of Wales. Where possible, the expression of mathematical concepts in material form can be a major aid to their understanding.

A professor at the University of Wales, Ronnie Brown has designed a CD-Rom on which art comes to the aid of mathematics. It was launched during 'Week 2000' at Obidos (Portugal). A piece of work by John Robinson, entitled *Genesis*, illustrated on the sleeve, represents the Borromean Rings. 'The Borromean Rings were originally a set of circles which the Borromea family from Italy adopted as their coat of arms. The Borromean Rings occur in subtle ways in mathematics, and also in physics, for describing the interactions of three particles,' explains Ronnie Brown. 'This form illustrates the fact that the whole is not the pure sum of its parts. Robinson shows this by experimenting with squares, triangles and lozenges, as in *Genesis*. This clearly shows how an artist's imagination can accentuate our perception of a mathematical reality.'



Genesis - John Robinson

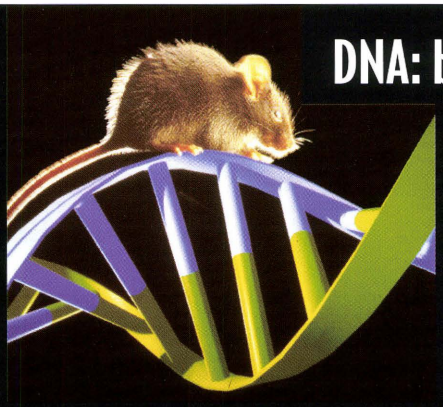
And on the Net?

The project site
www.sees.bangor.ac.uk/public/cpm/rpamath/

Site of the Centre for the Popularisation of Mathematics
www.sees.bangor.ac.uk/public/cpm/

Interface platform between the experts and the public
www.mathematik.de

World mathematics year
http://wmy2000.math.jussieu.fr



DNA: beyond the sequence

Over the past 20 years or so, new techniques (DNA sequencing, DNA chips, etc.) have opened up revolutionary perspectives in biology. These techniques generate huge amounts of extremely diverse data (sequences, images, texts, experimental data, bibliographies). Mathematics plays a central role in processing these data, making it possible to extract relevant information. The subject areas most useful to this are algorithms, probability theory, and statistics.

Proteins are long three-dimensionally folded amino acid chains. Their activity essentially depends on the protein form after folding. A knowledge of this three-dimensional structure is necessary for many applications (pharmacology, agriculture, etc.). The most accurate method is to use crystallography techniques, but they are very time consuming. This explains the many attempts to use mathematical or computer models to 'calculate' this form.

Idea and illustrations by Francois Rodolphe, Jean-François Gibrat and Pierre Nicolas - INRA unit - Versailles 'Mathematics, Computing & Genome'.

The *radiating* heart of matter

From November 2000 to January 2001, the exhibition entitled 'Radioactivity, a facet of nature', proved a remarkable success in popularising science. Presented simultaneously in Paris, Wiesbaden and Milan, as part of Week 2000, the event was made possible thanks to the efforts of a consortium of European physics institutions. (1)

'One may wonder whether it is in man's interest to know nature's secrets, if he is ready to benefit from them or if this knowledge will harm him.... I am among those who believe that humanity will draw more benefit than harm from these discoveries.' (2)

Paris, November 2000, on the first floor of the Palais de la Découverte, displayed to visitors as they leave the exhibition, this quotation by Pierre Curie sums up what may well be on the visitor's mind at the end of a fascinating tour of the progress made by 20th-century science in penetrating matter's most intimate secrets.

Unfortunately, Professor Curie's prediction of the potential dangers proved correct, and nuclear weapons no doubt represent the embodiment of knowledge used for evil purposes. But this exhibition also shows to what extent the researcher's ultimate optimism was well-founded. Man's understanding of radioactivity - this 'signal' sent by the ballet of tiny elementary particles, charged with mass, electricity and energy, and gravitating to the heart of certain mutating unstable atoms - has permitted a triple scientific revolution. This was expressed in the three sections of the exhibition - entitled α, β and γ - with reference to the three principal types of radioactive radiation.

Artist's impression of the interaction between an alpha particle and an atom.

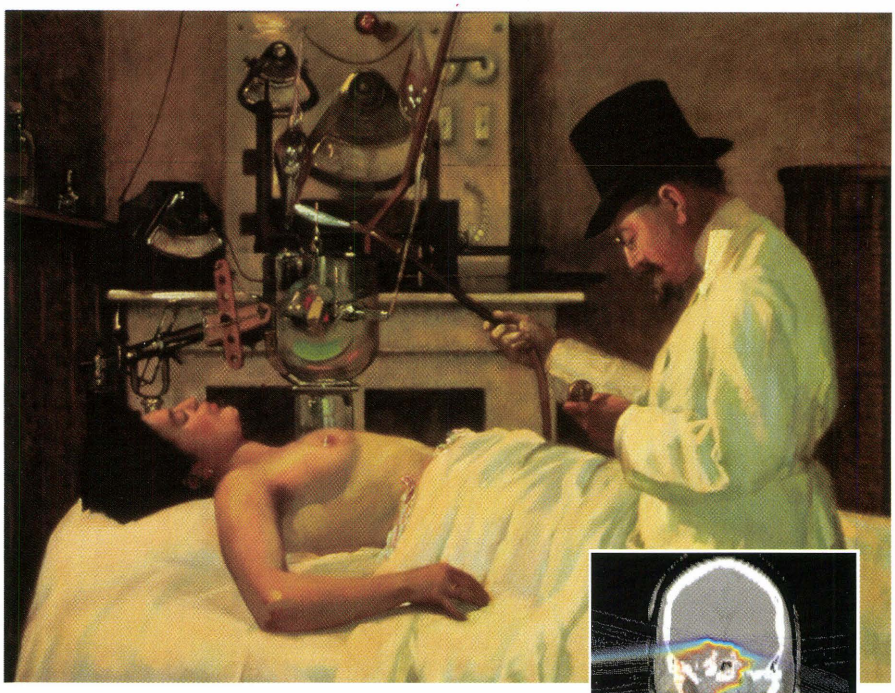
α - *The universe*

To understand the nature of matter is also to enhance one's understanding of the universe. Increased understanding of the radiation created by the action of the disintegration and transmutation of atoms results from a twofold investigation: into the infinitely small and into the infinitely large.

On the one hand, physicists have made constant progress in identifying elementary particles and the fundamental forces by which they interact. On the other, in the vast expanses of the universe, astrophysicists have been tracing the mutations of matter since the original Big Bang.

(1) The Institut National de physique nucléaire et de physique des particules (FR), the Istituto nazionale di fissica nucleare (IT), the Gesellschaft für Schwerionenforschung (DE) and the University of Vienna (AT), under the aegis of the NuPECC (Nuclear Physics European Collaboration Committee) and the Société européenne de Physique.

(2) Speech given by Pierre Curie at the award-giving ceremony for the Nobel Prize for Physics in 1903, presented to Pierre and Marie Curie for the discovery of radium.



A portrait of Dr Chicotot, a pioneer of X-ray treatment for cancer, in 1908.

β - *Nature*

Since life first appeared on earth it has evolved not just in an ocean of radiation coming from the cosmos, but also in the natural radioactivity of a planet which, like any other, was born as a result of the laws and randomness of this cosmos. Volcanic eruptions, geysers and earthquakes are all reminders that, in bowels of the earth (just 4.5 billion years old) is also a 'nuclear machine' in which the transmutations of matter release vast quantities of energy.

At the same time, intense radioactivity can be a threat to life, its power of penetration being such that it attacks the very heart of the cells of which we are composed. And the reason our planet has succeeded in being hospitable to life is also because it is an oasis in the universe where the ambient radiation level allows it to be sustained. Meanwhile, all around us, the rocks of the earth's crust (from which we

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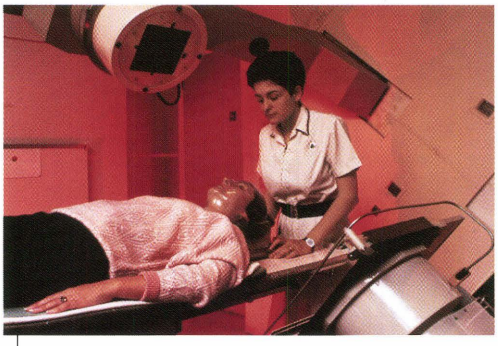
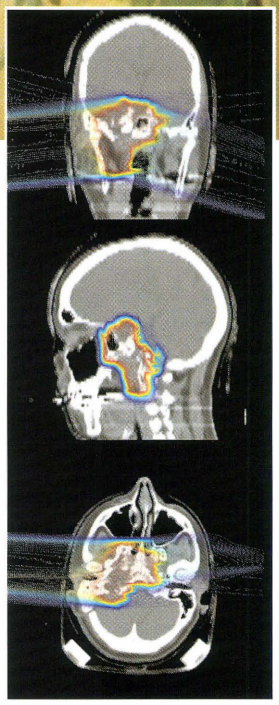
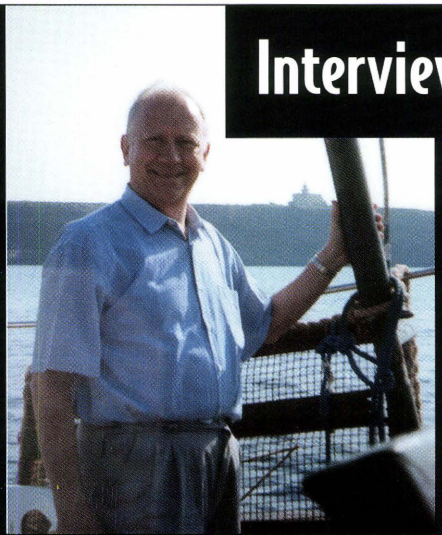




Today's treatment. Beams of protons and carbon ions, produced by accelerators, permit the effective treatment of eye cancer and deep tumours. Such technologies originated in the nuclear sciences which continue to make a major contribution to progress in medicine.



Interview: the physicists' point of view

Professor of nuclear and sub-nuclear physics at Milan University, Ettore Fiorini is one of Europe's foremost researchers on particle physics. Among other things, he coordinates a European research network on cryogenic detectors with the aim of measuring the mass of neutrinos.

The mention of radioactivity more often frightens rather than fascinates people...

Ettore Fiorini: It is true that the term *radioactivity* immediately arouses feelings of concern and threat. This reaction is because the word is associated in people's minds with the terrible devastation caused by the atom bomb dropped on Japan and, more recently, the Chernobyl disaster - the only major nuclear accident we have seen. As a physicist, I share the same sense of dread at such a mortally dangerous use of scientific knowledge, whether for military

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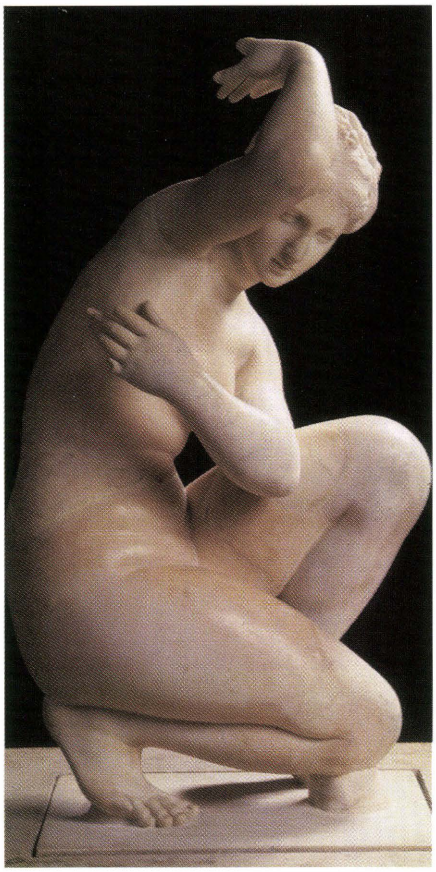
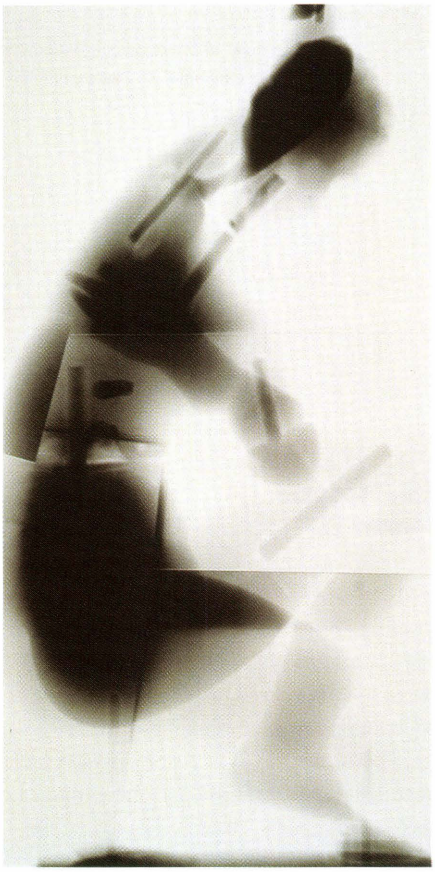


Crouching Aphrodite - The Louvre Museum
Radiation with gamma rays is able to eliminate fungi, larvae, insects and bacteria, and to protect works of art against deterioration.



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extract the fuel for nuclear power plants) retain the memory of this transmuting activity. The most notorious phenomenon, linked to the nature of the local geology, is radon, a gas emitted by the breakdown of uranium 238, which can be found in the cellars of houses.

As a result of the knowledge acquired, science has become highly sophisticated in the field of radioprotection, allowing us to determine reliable limits for natural and artificial radiation, which, in guaranteeing the effectiveness of the defence mechanisms of living cells when faced with radioactive attack, do not pose a danger to health.

γ - *In practice*

Progress in fundamental physics over recent decades has permitted the creation of irreplaceable scientific tools which can be used for a vast range of activities. We have become so used to their presence that we are usually unaware of their origins or of the principles by which they operate. In dentists' surgeries and museums, supermarkets and airports, technologies drawing on our knowledge of radioactivity are all around us. Medical imaging, the identification of gene sequences, the piloting of biological markers aimed at destroying cancerous tumours, the analysis of the atmosphere's chemical composition, smoke detection, food conservation, the inspection

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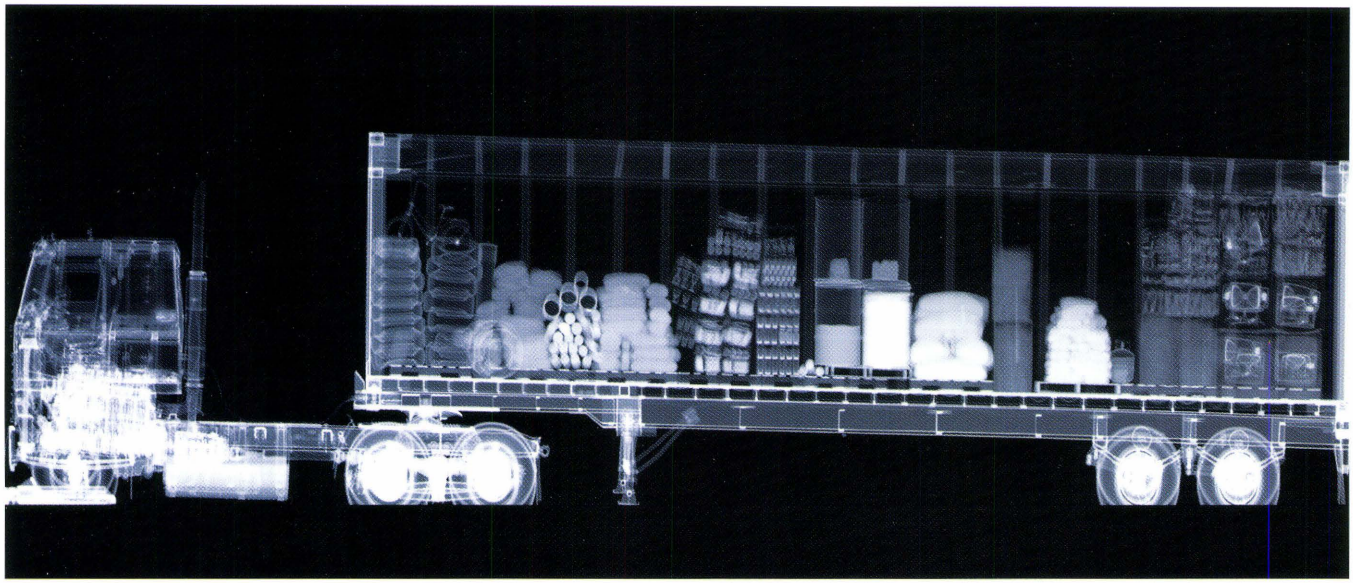
purposes or due to the evident and irresponsible mistakes in terms of the security measures which caused the Chernobyl disaster.

But the fact that we discovered radioactivity means that it does exist and has always existed in nature. This discovery has been the source of formidable progress in our knowledge of particle physics and all the very beneficial applications which have derived from it. The general public must be reconciled with this essential scientific knowledge by making the effort to explain to them in detail what this knowledge consists of and the many extremely useful applications it enables - provided all the safety measures are applied to ensure that the radiation, limited to very low doses, is free of danger. It is up to the physicists to do this explaining.

What are the principal - or the most unexpected - fields in which you believe the control of radioactivity is able to bring essential benefits?

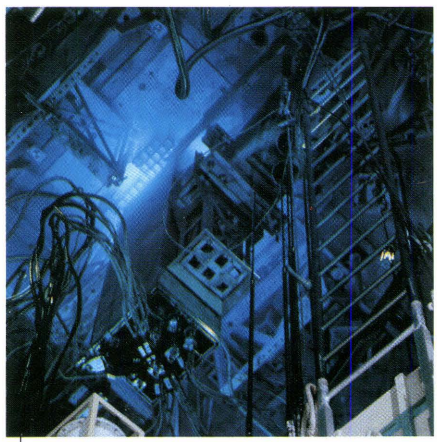
The list of the remarkably positive applications of nuclear physics would be too long to give. But let me just remind you of the impact of nuclear medicine and radiotherapy on the treatment of cancer, and the powerful nuclear magnetic resonance tool for many kinds of medical diagnostics. Environmental sciences is another key application of the study of radioactivity: the detection of radon, for example, and the applications that have followed, or the identification of very low levels of contamination by analysing neutron activation. The applications of radioactivity and the associated detection techniques are also very important in the new discipline of archeometry.



The inside of a truck can be inspected by X-rays.

of the wear on materials, the luminosity of information panels, the dating of works of art, the detection of anti-personnel mines... The list is seemingly endless.

And that is without including the key question of the role of nuclear physics in energy production. Nuclear fuel currently meets 35% of European needs, principally in France, the United Kingdom and Belgium. In the nuclear industry, radiation had in theory been effectively and safely harnessed - until the Chernobyl disaster proved otherwise. What is more, the crucial problem of nuclear waste remains unsolved. But then again, in the light of the threat of global warming, does nuclear energy - which emits no greenhouse gases - deserve to be ranked among the discarded technologies? ■



Inside a nuclear reactor.

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Harnessing the energy produced by nuclear fusion is often cited as a potential source of genuinely clean energy which could become available at some distant point in the future. In what way would this be radically different from the present nuclear power industry in terms of radioactivity?

The possibility of supplying vast quantities of energy by harnessing nuclear fusion is an option which for some years now has not appeared to be entirely beyond our reach, but it is difficult to predict when it could become a reality. However, as you are dealing with an energy based on the control of nuclear reactions, it is premature to say that it would be completely free of risk. What is clear is that the fusion reaction cannot get out of control and can, in the event of a problem, be stopped immediately. As to waste products, if any - produced by neutron activation for example - they are certainly going to be less dangerous and complex to manage than fission products.

The genome: neither angel nor devil

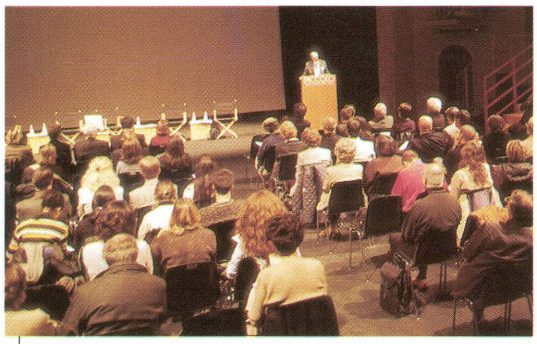
Milan, Barcelona, Heidelberg, London, Brussels - in these five cities, the European Genetics Foundation sought to initiate a parallel dialogue. At issue was one of the most fascinating fields of contemporary research, the results of which are posing new questions for society. 'Is the human genome the new name of the soul?' asked Alexander Mauron, of the University of Geneva, in the title of his address in Heidelberg. RTD info reports on a multifaceted approach.

'We wanted simultaneously to gauge attitudes to genetics in five distinct European areas. In each of the countries participating in these Genetics in Europe Open Days (GEOD), the partners organised their own style of debate. This diversity of approach was deliberate in the sense that it reflects the many very different ways of approaching the debate on the genetics revolution,' explains Guido Romeo, who is responsible for communications and popularisation of science at the *European Genetics Foundation* and the project manager of GEOD.

A complex subject requiring careful preparation

In Barcelona, 2 000 young people aged between 14 and 16 from 98 schools packed the building (5 000 applications were received). The organisers had selected six subjects related to the human genome for study. The students already had certain items of information and preparatory discussions had been organised in the classroom. 'It was clear during the talks and discussions that these young people were much more interested in new research than the generation of 40-year-olds. This is not surprising when you consider that over the next 10-30 years the applications of current research will become a reality,' explains Xavier Estivill, the event organiser and director of the Centre for Medical and Molecular Research at the Institute for Oncological Research in Barcelona. 'That is when the new drugs based on gene research will become available and gene therapy will be current practice for certain diseases.'

During the same week, Milan's Piccolo Teatro was also the forum for lively debates on medical progress. The discussion among the public actually present was widened to include very active, live and on-line contributions from a virtual auditorium. A great many questions were asked on the progress of research and the hopes and fears it arouses. This was hardly surprising given that none other than Craig Venter himself - the star of the human genome sequencing adventure - was among the guests.



GEOD, Milan, 12.11.00

The impact of discussions

'To have a lively debate, you need an open approach to the subjects, in scientific and ethical terms,' believes Mr Romeo. 'You must also choose speakers who are not only reputable scientists but also excellent communicators, able to listen, discuss and "confront" the public - which a scientist may view as a somewhat irrational approach. This year we invited a celebrity in the form of Craig Venter, who welcomes such a status and uses it to advance the cause of science. We believed it interesting, in a public debate, to show both the scientific and media explanations for this success and to place it in its historical context. It is a way of highlighting the cultural dynamics which come into play at the time of a major scientific or technological innovation.'

In London, an evening of conferences, ending with a discussion, focused in particular on the issue of patenting the living organism. In Heidelberg, ethical questions and public debate on genome sequencing were the subjects of much interest, with two days devoted to the 'new dialogue' which must be established between science and society. One discussion panel looked at ways of restoring public confidence in science while another dealt with the question of understanding information on genetics.

This latter theme was also discussed at a study day in Brussels, at which the GEOD prize was awarded to journalists for their work in communication on genetics. 'To meet the needs of contemporary society and above all to avoid a dangerous reversal of roles, it is essential for science and the media to approach the subject of the popularisation of knowledge in a spirit of open cooperation,' stressed Claudio Lombardo, scientific attaché at the Italian Embassy, who coordinated the event. ■

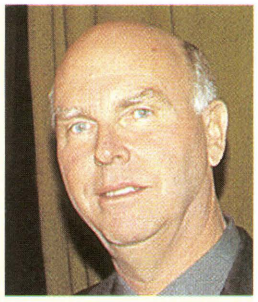
Genetics and medicine

Victor McKusick

'The principal changes genetics will bring to medicine are in diagnosis. A current trend is to study predisposition to common diseases rather than to diagnose rare genetic diseases. Rather than concentrating solely on case studies, attention will also focus on the analysis of mechanisms (pathogenesis). Predisposition to certain diseases will be identified with increasing precision in order to obtain a targeted and effective preventive treatment. Pharmacogenetics will not only endeavour to develop new medicines, but also to adapt existing medicines to the particular characteristics of the patient's metabolism and specific genic mutations. We will probably see a major personalisation, in genetic terms, of the dosages and active agents of medicines. The large quantity of personal data that genomic technology could provide will raise the practical problems of protecting this information and confidentiality, as well as the risk of discrimination at work or by insurance companies.'

Victor McKusick, professor of medical genetics at the Johns Hopkins Hospital in Baltimore, at GEOD in Milan.

State of research



Craig Venter

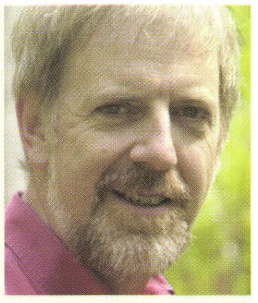
'We already have results at the clinical level, for example, for colon and breast cancer. A lot of pharmaceutical industries already use information on the genome. The first diagnostic applications are already a reality. The challenge for the future, apart from diagnostics, will be to develop new treatments.

'But more than three billion letters which compose the human genome must still be interpreted. Apparently, the body has about one million different proteins and fewer than 50 000 genes. The role of half of these is unknown to us and it will require many years of research to understand them. Moreover, each gene has several functions and the old dogma of "one gene, one protein, one disease" is no longer valid. Researchers will have to make a major effort which will require the participation of scientists from every country.

'Genomics represents a major change, because it makes it possible to study not just one gene at a time, but all the genes, all the proteins and all their functions together. In the future it may be possible to treat all human disease differently and sooner or later this change will be applied to each sector of human biology.'

Craig Venter, director of Celera Genomics, Rockville. At the Piccolo Teatro in Milan, Craig Venter and Victor McKusick (see above) participated in the debate entitled 'Post-Genomic Year 0', during which they discussed the scientific, medical and industrial prospects after the sequencing of the human genome.

The need to listen

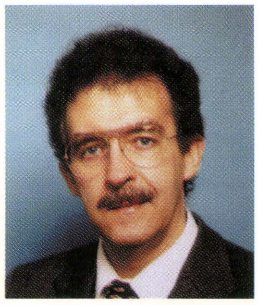


Frank Gannon

'In a changing environment, the scientist has to perform not only as a professional researcher but also increasingly as a professional communicator. Scientists cannot ignore the environment in which they are working nor the public opinion that insists on some limitations which may not even be scientifically well-founded. The words dialogue, discussion, interaction, communication, ethical concern, deliverables, product driven, applicable, and strategic are part of the vocabulary which all scientists must integrate into their professional lives today. The success of science has brought with it ever increasing responsibilities and scientists have no choice but to engage in discussions with and to listen to society in order to ensure that the promises of science will be delivered and welcomed by all.'

Frank Gannon is director of the European Molecular Biology Organisation. His speech at the Genetics Open Day in Brussels was entitled 'The wider responsibilities of scientists'.

Safeguards



Gert-Jan Van Ommen

'In the wake of the rapid advances in discovering new genes, a fierce debate has developed on public versus private aspects of our genome heritage. The question is as follows: how do we give maximum opportunity for scientific progress - and its benefits for citizens - while preserving the right to protect inventions for those who invest in the development of new medicines? The existence of an independent international organisation like the Human Genome Organisation (HUGO) plays an important role in this respect by offering advice during international negotiations.

'At the same time, the scientific community has an obligation to inform the public, especially young people, who will be the first to benefit from new treatment and preventative methods. It is essential for the public to be informed of the consequences of and limits to progress in genetics. Attention must also be paid to ensuring that our societies assimilate this change, while not overestimating their ability to adapt. In Western countries, citizens fear interference in their private lives. They also fear unequal access to care, and discrimination by employers or insurers. And there is the problem of health inequality at global level. The establishment of rules of ethics and morality acceptable to all cannot be left solely to Western scientists, industrialists and politicians.'

Gert-Jan B. Van Ommen, professor at the Department of Human Genetics at the Leiden University Medical Center (NL), vice president of HUGO (Human Genome Organisation). In London, he spoke in particular of the problems of intellectual property and ethics linked to human genome sequencing.

Science and the citizen

Sheila Jasanoff

'As citizens, we should be more attentive to the social and institutional context within which science and its uses develop. This context will partly determine the type of research which is carried out, and the way in which this research is used for the benefit of society. We must also demand more information on financing policies and the direction of research, as well as more transparency in scientific decision-making in the industrial sector. This latter point is particularly important when governments delegate important issues of public health and safety to the private sector (pharmaceutical industry, agricultural production). Decisions in this respect may determine possible winners and losers in relation to the benefits of new technology. This example clearly illustrates what I mean by my refusal to view science as autonomous of any system of values.

'Scientists are also citizens, so they should be sensitive to these issues. They need to think more seriously about the way their own practices may prejudge certain questions that ideally should be debated openly in a democratic society (such as cloning). Scientists also think that the public may reasonably assess what is uncertain and what is known. But disagreement about the meaning of these uncertainties does not mean that the public is being irrational. It simply means that the public does not think there are enough safeguards in case things go wrong.'

A lawyer by training, and a professor at Harvard University (USA), Sheila Jasanoff has devoted her career to the study of interactions between law, the sciences and politics. Her talk in Heidelberg was entitled 'Debating human identity: institutional commitments and consequences'.

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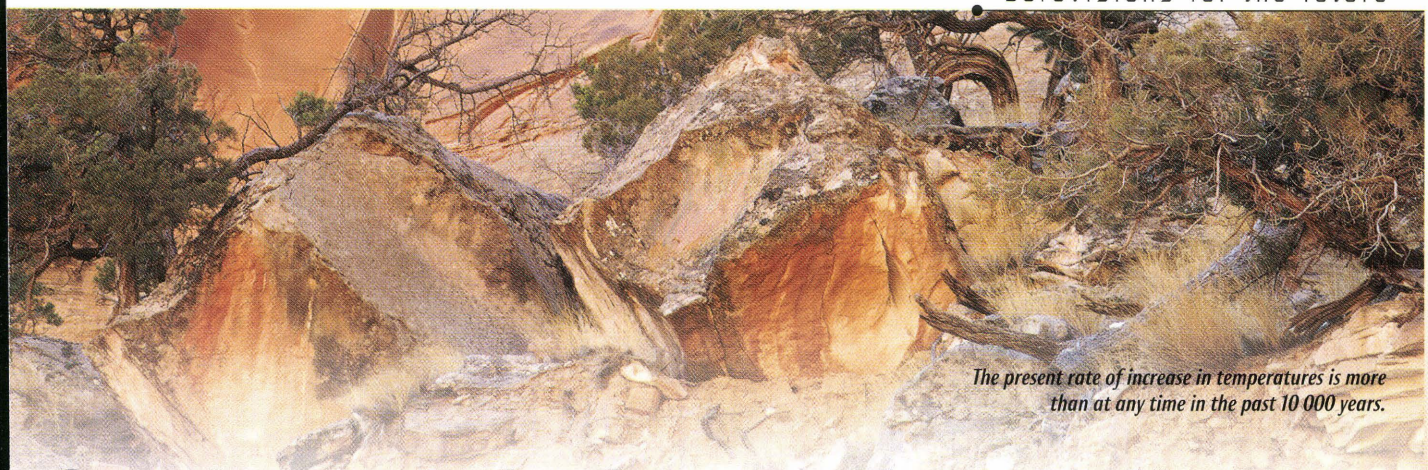


The present rate of increase in temperatures is more than at any time in the past 10 000 years.

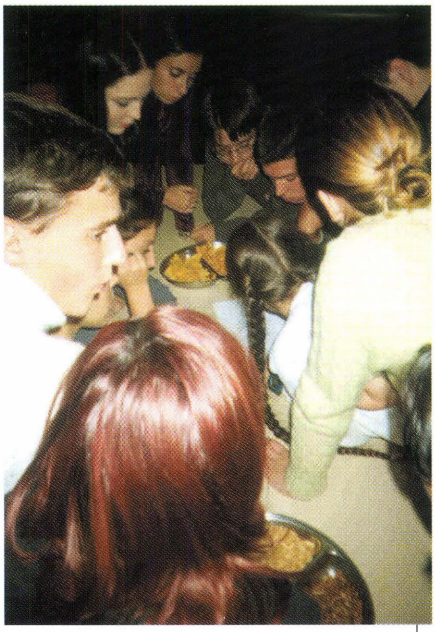
On the panel: those who shall inherit the earth

Thirty-six pupils from six countries were invited to spend two days at the famous Meteorological Centre in Reading (UK). They saw some of the world's most powerful computers modelling weather forecasts for the whole of the European continent. They listened to explanations by climatologists on global warming and the role played by human activity. And they held group discussions on the possible implications of these questions for their future and on the response to adopt. RTD info reports from the Reading meeting.

The need to react to global warming is confronting society with problems as crucial as they are new. It involves responding to a threat - and no doubt a very serious one - on the basis of forecasts characterised by uncertainty. What is certain, on the other hand, is that the inhabitants of the planet are far from equal in the face of this threat and that some will suffer more than others. We also know that the measures to be taken will require radical changes to the way we use energy, with implications which will affect the very bases of society and transform the way we live.

A generation takes the initiative

Climate change thus requires a wide-ranging democratic debate. Investigating every possible alternative to protect ourselves and/or to adapt requires the effort and participation of us all. Although the debate must engage all society's players, it is of particular pertinence to younger generations who will bear the full brunt of the phenomenon.



Memories of the Reading Eurovisions.

It was this desire by young Europeans to take the initiative that lay behind the *Eurovisions for the Future - Climate Change* meeting held in the United Kingdom, during 'Week 2000', at the initiative of the British Association (BA). The Reading meeting was more than a year in the making. It was in the summer of 1999 that the BA first sent out invitations to secondary school teachers from all over Europe asking them to submit essays from their pupils on global warming. The work of six schools in six countries (Italy, Spain, France, Poland, United Kingdom, Austria) was finally selected, each of them being invited to send six delegates to the meeting.

Finding out

First of all, four experts working in the United Kingdom provided scientific explanations. Pierre Philippe Mathieu, a climatologist at the *Centre for Global Atmospheric Modelling* at Reading University, repeated the point that the greenhouse effect is primarily a natural phenomenon without which life on earth would not be possible. It is the result of an extraordinarily complex balance created by the interactions between the sun's rays, the atmosphere, the ocean, the cryosphere (glaciers and ice floes) and the biosphere. However, greenhouse gases produced by human activity have had an adverse effect on the biosphere over the

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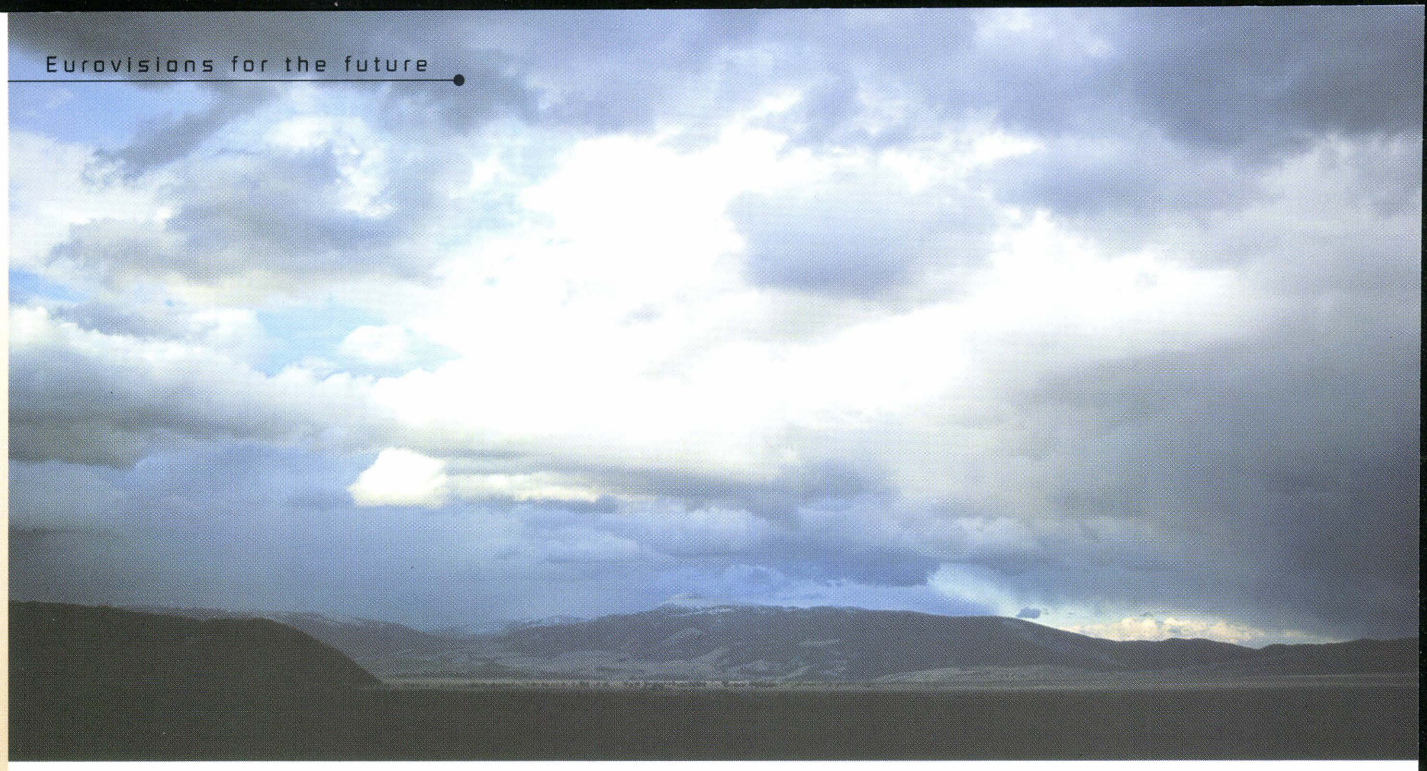

From north to south, on the coast and in the interior, the effects of climate warming will be very different depending on the region. The various regions must anticipate and avert the impact of these changes from both a socio-economic and environmental point of view.

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past 150 years and have upset the balance of the climate machine. 'All the many scientific observations confirm an average increase in temperature of the earth's surface of around 0.6°C over the past 130 years. What is more, the present rate of increase is more marked than at any time during the past 10 000 years.'

Understanding

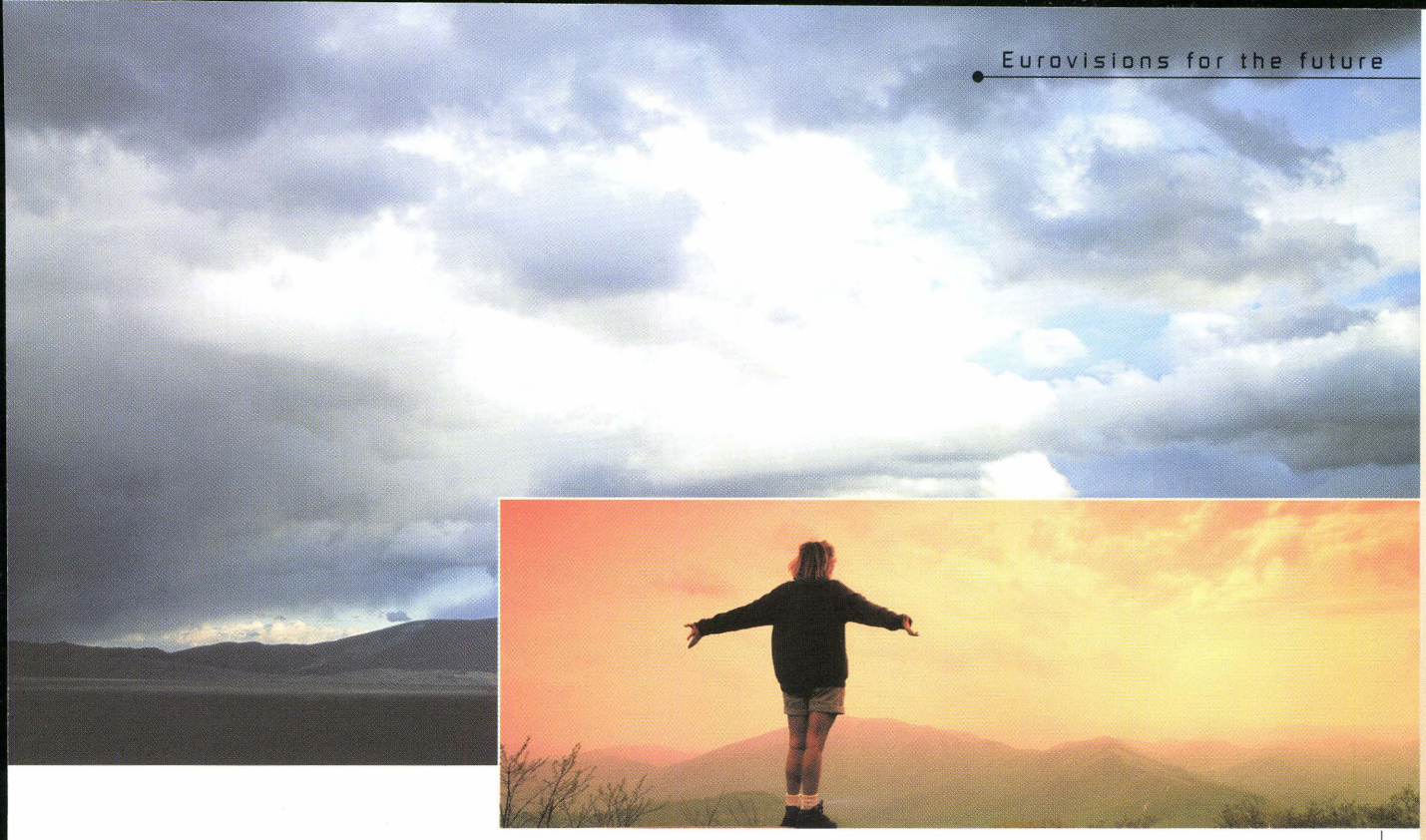
But how are scientists able to predict that the earth will heat up by x or y degrees over the coming decades? 'Our tool is the models we can run on our computers, and on the basis of which we can make forecasts,' explains Howard Oliver of the Centre for Ecology and Hydrology in Wallingford. Citing the well-known maxim among computer experts of *garbage in - garbage out*, Dr Oliver explained how research by climatologists needs to be increasingly precise if it is going to understand the vast quantity of interactions and data which must be taken into account. He gave the example of the many projects undertaken by the British programme entitled *Terrestrial Initiative in Global Environmental Research* (TIGER), also making the point in passing that this field of research has created many new jobs for young scientists.

But what exactly will happen in Europe if the earth's global climate heats up? Julia Vowles, of the Climate Impacts Programme (Oxford), explained the principal conclusions of the major ACACIA study[1], carried out by a network of European researchers with EU support. 'On our continent, the effects of climate warming, of between 1°C and 4°C during this century, will be felt very differently depending on whether you live at the coast (with the threat of a rise in sea-levels of between 13 cm and 68 cm), the southern regions or the north-east plains (with very hot summers and increasingly severe drought), or northern Europe (with increased rainfall). Each region must therefore anticipate the specific impact this will have on its society, economy and environment.'

But is it possible to change the course of events? Irène Lorenzoni, of the Centre for Social and Economic Research on the Global Environment (CSERGE) of East Anglia University, believes the way our activities influence the environment must be analysed. This means projecting the impact of various actions (such as reducing greenhouse emissions and optimising the rational use of resources) on the scenarios with a view to ultimately changing our behaviour. 'All the measures taken in response to the threat of climate change will also have positive effects at other levels, on the quality of the air we breathe or transport mobility, for example.'

Debating

After this first day, which provided them with the materials with which to understand the climate issue, the young people divided into three discussion groups to debate and exchange opinions among themselves. 'We now have a lot of new information and scientific arguments, but that does not mean that we interpret them in the same way, or that we will draw the same conclusions,' explains Malgosia Minta, a student from Wroclaw (Poland). 'The aircraft which brought me here to Reading emitted a quantity of greenhouse gases which amounts to all the energy I can save in several years of energy-saving measures in my day-to-day activities. But of course you can't replace an aircraft with a bicycle. So how can all these contradictions be resolved?'



'All the measures taken in response to the threat of climate change will also have positive effects at other levels, for example on the quality of the air we breathe and transport mobility.'

The discussions went well. Everyone tried to place the significance of climate warming in the geographical context of their own country or region. The Polish and Italian students, for example, are concerned by the catastrophic floods that have hit their countries on repeated occasions during recent years. The young Austrians and Spaniards spoke of the possible effects of climate change on tourism, an essential driver for their national economies. Someone also pointed out, very pragmatically, that climate warming in a region such as Scotland could boost agricultural activity and reduce heating costs, while Maiwand Halaimzai, who lives in London, argued for an alternative future: 'The ecosystem provides infinite hydrogen resources and there must be major investment in research so that this combustible and non-polluting gas can be used in the service of man.'

The Reading meeting ended with a discussion entitled *What must be done?* Citing the bargaining inspired by short-term national interests as displayed during the difficult negotiations on the Kyoyo protocol, this panel of young Europeans defended the idea that, when faced with these problems, humanity must have 'the firm individual and collective desire' to respond to them. Whatever the case, the Reading meeting showed that if such a desire is to be acted on, then education - of young people in particular - must become a priority component of strategies designed to deal with the threat of climate change. ■

(1) See RTD *info* n°27.

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'Descartes' makes its debut

Mathematician, philosopher, naturalist, inquisitive traveller, and humanist, this Renaissance man who laid the foundations of Europe's culture now lends his name to a major scientific award. The Descartes Prize is one of the most illustrious international awards in the field of scientific research.

Rewarding the excellence of teams, not individuals; highlighting international research conducted through networks; open to all scientific disciplines. This is what makes the European Union's Descartes Prize, which was awarded for the first time in November 2000, so unique.

About 100 nominations were submitted to the panels of experts for the various disciplines. Their task was to select eight finalists (see box). 'Unlike the assessment of projects submitted to the Commission, in this case it was completed research projects which were being judged. And, they had not necessarily received Union support,' explains Graham Blythe, a scientific officer at the Research Directorate-General.

The finalists included Antonio Pizzi of Nancy University, who presented an environment-friendly industrial process in the field of adhesives used for wood-based industrial composites. He sees the Descartes Prize as rewarding a double achievement: in terms of the major progress made, and in harnessing an international effort. 'The project must not only achieve a high scientific level, but also unite the human qualities necessary for the success of joint cooperation,' he said.

In the final, a grand jury of prominent figures representing a balanced mix of specialities, geographical origins and backgrounds - scientific, political, industrial, economic, etc. - selected three winners. Chaired by Yves Michot, former CEO of Aérospatiale Matra, members of the jury included Sirkka Hämäläinen of the European Central Bank, the astronaut Ulf Merbold, Nobel Physics Prize-winner Ben Mottelson, the Secretary General of the Academy of Russian Sciences, Nikolai Platé, and Anna C. Roosevelt, curator of the Field Museum in Chicago. All these people symbolise the essential link between science and society. ■

Descartes Prize 2001

Applications must be submitted before 6 April 2001. Information: www.cordis.lu/improving/src/hp_awa.html

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The eight teams in the final

Booster Battery for high power demand - High-performance batteries for hybrid vehicles (DE, AT, UK, SE).

Chemistry close to the absolute zero* - Studies on the mechanisms explaining atypical high-speed reactions of gaseous chemicals at very low temperature (UK, FR).

Cooperative research on solar thermal energy applications at the Plataforma Solar de Alméria - New technologies in the field of thermal solar energy (ES, DE).

European identities in the 20th Century - 180 researchers (mostly historians) analyse the concept of European identity (FR, ES, IT, DE, HU, CH, LU).

Plastic transistors operating at 50 Khz for low-end high-volume electronic circuits* - A new generation of transistors using the conductive and semi-conductive properties of certain polymers - Applications in the field of electronic barcodes (NL, DE, UK, DK).

Provost: Prediction of climate variations on seasonal to interannual timescales - Modelling of interactions between the ocean and the atmosphere permitting six-monthly weather forecasts (UK, IT, DK, FR, DE, ES).

Natural tannin based adhesives for wood composite products of low or no formaldehyde emissions - Technology eliminating environmental and toxic pollution when manufacturing wood-based composite materials (FR, DE, IT).

The XPD gene: one gene, two functions, three diseases* - Identification of the new properties of a gene whose malfunctioning is recognised as the source of skin cancers but with a second function which could be the cause of two different diseases - (UK, IT, NL, FR).

(*) The projects marked with an asterisk are the three winners.