EUROPEAN COMMISSION

Community research

Descartes research prize

Excellence in **scientific collaborative research**

2005

1-2 December 2005
Royal Society, London
United Kingdom

GENERAL INFORMATION

EUR 21933

SCIENCE AND SOCIETY

Royal Society welcomes Descartes Prizes to London

It is fitting and timely for the Royal Society to be hosting the Descartes Prizes Ceremony in 2005 when the United Kingdom currently holds the presidency of a newly expanded EU – a Union offering ever-increasing opportunities for scientific collaboration. As president of the Royal Society, I am delighted that the awards ceremony is taking place at our premises in London.

The Royal Society is the oldest scientific academy in continuous existence. Its first Fellows are acknowledged as having invented the scientific method still employed today. The Society was founded by Royal Charter awarded by King Charles II in 1660, with the motto *nullius in verba*, literally 'on the words of no one'. This motto signifies the commitment of the founding Fellows to establishing the truth of scientific matters through experiment rather than through deference to authority.

This commitment resonates strongly with the philosophy of René Descartes. Although he died ten years before the Royal Society was formed, his writings influenced the climate of inquiry and opinion in philosophical pursuits and this important legacy was sometimes the measure against which the Society's Fellows would test new descriptions of the workings of the universe.

Several founding and early Fellows had direct contact with Descartes. Sir Kenhelm Digby (1603-1665) met and discoursed with him several times on the continent during the 1640s and the two enjoyed mutual respect, if not agreement. Henry More (1614-1683), the Cambridge Platonist, was one of Descartes' correspondents.

The Descartes Prizes give Europe a valuable opportunity to recognise excellence in scientific collaboration and in science communication. These areas are closely aligned with the Royal Society's activities today. Through our various research fellowship schemes, international exchange programmes and discussion meetings, we support excellent individuals in their pursuit of scientific knowledge and in their collaboration with each other.

We foster excellence in science communication through programmes which encourage scientists to inspire others and to engage in dialogue with the public, social scientists, civil society groups and politicians with a view to informing policy decisions. We award prizes to authors of popular science books for children and adults, and publish seven internationally renowned journals. The oldest of these, *Philosophical Transactions of the Royal Society*, was first published in 1665 and is the world's longest running international science journal, while the most recent addition, *Journal of the Royal Society Interface*, was first published in 2004.

The Society has a close and productive working relationship with European colleagues. This is reflected particularly in our strong involvement with the European Academies Science Advisory Council (EASAC) which has published reports on themes including infectious diseases, genomics and pollution, as well as a user's guide to biodiversity indicators. We enjoy warm bilateral relations with sister academies and worked closely with several of those in Europe and further afield this year in initiating and issuing statements on climate change and Africa to influence the G8 deliberations in Gleneagles, Scotland. We have participated in the planning of EU science in society activities and our successful MP/Scientist pairing scheme will be extended to include Members of the European Parliament in 2006.

I am pleased to note that the United Kingdom has performed well in the Descartes Prizes in recent years. Past research prize winners have included teams led by Professor Alan Lehman of the University of Sussex (2000), and Dr Michael North of King's College (2001). Fellows of the Royal Society have also enjoyed success, with research prizes being won by teams led by Professor Ian Smith FRS of Birmingham University (2000) and Sir Richard Friend FRS of Cambridge University (2003). In 2004, Sir David Attenborough FRS won one of the inaugural science communication prizes and Professor Howard Trevor Jacobs of the University of Tampere, a former Royal Society University Research Fellow, led one of the teams which won a research prize.

The Royal Society is the physical and spiritual home of British science and it is most apt that we should be hosting the prizes named in honour of the man whose ideas contributed so much to modern scientific thought. We look forward to greeting our distinguished guests in London for the 2005 Descartes Prizes awards ceremony.

Lord Rees of Ludlow
President
The Royal Society

The Descartes Prizes Award Ceremony 2005

The Royal Society, London, 1-2 December

1 December

14.30 - 18.00 Opening of the exhibition

> *City of London rooms, Marble Hall*

The Descartes laureates, finalists and nominees display their work
The exhibition continues throughout the event on 1st and 2nd of December

16.00 - 18.00 Round table discussion: Whose voice counts in science?

> *Wellcome Trust Lecture Hall*

Welcome address by **Lord Rees of Ludlow**, *President of the Royal Society* and by
Jean-Michel Baer, *Director of Science and Society, Research Directorate-General, European Commission*

CHAIR **Dr David Stewart Boak**, *Director of Communications, Royal Society*

MODERATOR **Mr Ranga Yogeshwar**

16.00 Testimonies on experiences within Europe

SPEAKERS **Mr Pierre-Benoît Joly**, *Research Director at the National Institute of Agronomic Research (INRA), Director of the Research Unit TSV (Social Transformations related to Life Sciences and Life Forms), France*

Professor Mark E. Welland FRS, *Director of the Nanoscience Centre University of Cambridge, Director of the Interdisciplinary Research Collaboration in Nanotechnology, United Kingdom*

Mr Caspar de Bok, *International Science Shop Network Coordinator, Science Shop for Biology, Utrecht University, Netherlands*

Mr Mike Barry, *Head of Corporate Social Responsibility, Marks and Spencer, United Kingdom*

Dr Jasber Singh, *Deputy Director of Co-Inquiry, PEALS (Policy, Ethics and Life Sciences) Research Centre, University of Newcastle, United Kingdom*

17.00 Debate involving participants and the Descartes laureates

18.00 - 19.30 Cocktail drink and visit to the archives of the Royal Society

> *City of London rooms, Marble Hall*

19.30 - 22.30 Dinner meeting on Community Research in the 21st century

> *Wellcome Trust Lecture Hall*

Welcome by **Lord Rees of Ludlow**, *President of the Royal Society*
Interventions of the *European Commissioner for Science and Research,* **Mr Janez Potočnik** and the *British Under-Secretary of State for Science and Innovation,* **Lord Sainsbury of Turville**

MODERATOR **Mr Ranga Yogeshwar**

2 December

8.00 - 8.15 **Doors of the Royal Society open**

8.15 - 8.30

> *Wellcome Trust Lecture Hall*

Video presentation of the Descartes Prizes

Welcome and presentation by **Mr Alex Taylor**

Opening of the Ceremony by

Dame Julia Higgins, *Vice President of the Royal Society,*
Lord Sainsbury of Turville, *Under-Secretary of State for Science and Innovation,* and by
Mr Janez Potočnik, *European Commissioner for Science and Research*

8.30 - 9.45 **Descartes Prize for Collaborative Research: the 2005 winners**

Introduction by **Professor Ms Ene Ergma**, *President of the Descartes Research Grand Jury*

Screening of "The Finalists of the Descartes Research Prize 2005"

Announcement of the laureates and finalists

Award of prizes and diplomas to the laureates and finalists

9.45 - 10.00 Music interlude

10.00 - 10.45 **The Descartes Research laureates and their teams testify on: Challenges of scientific co-operation**

10.45 - 11.00 Coffee break

11.00 - 12.15 **Descartes Prize for Science Communication: the 2005 winners**

Introduction by **Mr Andrea Bandelli**, *member of the Descartes Communication Prize Presidents' panel*

Screening of "The Finalists of the Descartes Communication Prize 2005"

Announcement of the laureates and finalists

Award of prizes and diplomas to the laureates and finalists

12.15 - 12.30 Music interlude

12.30 - 13.15 **Presentations and testimonies by the Descartes Communication laureates**

Closing remarks by **Alex Taylor**

13.15 - 14.00 **Press conference**

> *Kohn Centre*

13.15 - 14.30 **Lunch and Exhibition**

> *City of London rooms, Marble Hall*

15.00 - 16.45 **Visit to the archives of the Royal Society**

17.00 **End of festivities**

Descartes Prizes highlight the strength of European research

By Science and Research Commissioner Janez Potočnik

Now in its sixth year, the Descartes Prize has done much to raise the profile of European research on the world stage. René Descartes, the inspiration behind this annual event, was himself one of the world's truly great thinkers. A towering figure of the 17th century – physicist, physiologist, mathematician and philosopher – his name has become synonymous with European excellence. His readiness to embrace new ideas and challenge conventional wisdom embody the qualities we have sought in selecting candidates for our own 2005 nominations.

The 14 projects shortlisted for their **excellence in scientific collaborative research** were chosen by an expert panel from a total of 85 submissions – three times more than in 2004 and clear evidence of the growing interest in our prize by the European scientific community. The majority of the laureates and finalists are in the basic and life sciences and, for the first time, a social science project is on the final list.

As Europe's most prestigious award for achievements resulting from transnational research, the Descartes Prize not only honours the creativity of its scientists, but also underlines the strength of a Union committed to building the knowledge society.

The high priority given to research by the European Commission is demonstrated by its proposal to double the budget for the forthcoming Framework Programme for research, as well as the creation of an autonomous European Research Council which will fund the best of European research which is pushing forward the frontiers of our knowledge.

More needs to be done to increase the level of public and private investments, in order to reach the target set by the Barcelona Council to boost spending on R&D to 3% of GDP by 2010. One way of helping to achieve this goal is to raise public awareness of the profound impact made by research on citizens' health, wealth and quality of life.

This is why, in 2004, we introduced the Descartes Prize for **excellence in science communication**. Awards are presented to individuals and organisations recognised for their ability to inform and enthuse the public about science and technology. To ensure only the 'best of the best' compete for the European prize, the laureates are selected from among winners of existing local, regional and national science communication prizes and festivals, of varying size and fame.

This year, the Commission received 65 submissions, out of which 23 were selected to attend the Award Ceremony. Five laureates – a famous author, a Belgian TV channel, a German educator and two Scandinavian science communicators – will share the top prize, while five 'finalists' will receive honourable mentions and a smaller prize amount.

I would like to express my sincere thanks to all those who have helped to make a success of this year's Descartes Prize: the expert panel, the Grand Jury – under the expert leadership of Professor Ene Ergma – who faced the difficult task of choosing the winners, Commission staff and local organisers, and to our hosts at the Royal Society. And, of course, I would especially thank all of the researchers who presented their work for consideration. Although you may not have got through to the final stages, you should know Europe values your dedication and effort.

Janez Potočnik
Science and Research Commissioner

Contents

How the **Descartes Prizes** promote excellence in European research

Achilleas Mitsos
Director-General, Research DG

The Descartes Prize is the European Union's premier award for excellence in collaborative research. It highlights the added value created by partnerships extending across national frontiers and scientific disciplines, and showcases the benefits of research and technological development to society.

Initiated as an annual event in 2000, the Prize has over the past years been awarded to 11 projects from a total of 41 finalists chosen on the basis of expert group reviews. Sharing in the honours were around 76 teams, mainly drawn from European countries, but also with some non-European partners.

As a sign of the growing stature of the Prize, this year a total of 85 proposals were submitted for consideration – more than triple the number received in 2004. They cover a range of fields of study, quite evenly distributed between basic sciences (17), life sciences (22), earth sciences (10), information sciences (8), engineering (15) and socio-economic sciences (13). This spread clearly indicates a growing awareness of the award and underlines the prestige with which it is regarded throughout the scientific community.

The expert panels first identified a shortlist of 14 nominee projects. In July, these were presented to a Grand Jury composed of renowned personalities from various academic disciplines, industrial sectors and public life, chaired by Professor Ms Ene Ergma, Vice President of the Estonian Academy of Science and Chairperson of the Estonian Parliament. The task of the Jury was to select the finalists and, ultimately, the laureates. The five laureates will share an amount of € 1 000 000 and, for the first time this year, the five finalists will also be rewarded with € 30 000 each.

The 14 nominees reflect the diversity of the submissions, while the uniformly high standard resulted in ten among them being advanced to the finalists' stage. Together, these represent the work of 78 individuals or teams from 13 countries across the EU, plus Armenia, Lichtenstein, Norway, Switzerland, Russia and non-European third countries including Namibia, South Africa, Japan, Singapore and the USA. They include:

- **Basic sciences.** Two projects relating to astrophysics, respectively investigating the origins of gamma rays in the universe and identifying hundreds of hitherto unknown pulsars – plus a collaboration to create new synthetic materials that overturn many of the accepted principles of physics;
- **Life sciences.** Three joint initiatives exploring the origins of different types of disease – cancers, immunodificiencies and chronic inflammatory conditions;
- **Earth sciences.** A comprehensive study of the effects of climate change on the arctic icecap, and its consequences for Europe's future weather;
- **Engineering.** Determining a nanotechnology route to higher density disk drives, and showing how environment-friendly adhesives from tree bark can provide healthier homes;
- **Social sciences.** Development of a survey methodology that will permit reliable long-term measurement of changes in the social, moral and political climate of the EU.

Given the high calibre of all short-listed projects, on this occasion the Grand Jury opted for five prize-winners. The identities and details of the winners are revealed in the following pages.

Finally, to all who have helped to make this event a reality, I add my warmest thanks to those of Commissioner Potočnik.

Achilleas Mitsos
Director-General, Research DG

Descartes Research Prize 2005

Who are the people making this tough decision?

As President of the Descartes Grand Jury, it is my pleasure to write a little about how we make the very difficult choice of one excellent example of scientific collaboration over another. It goes without saying that there are no losers here, so how can there be winners?

Each of the 15 jury members (from 11 different countries) is an expert in his/her respective field, and all have experience working in research teams at some stage during their career, so we understand the travails of such close collaboration. We also know that it can be greatly rewarding. During my time as an astrophysics professor of the University of Tartu, Estonia, and chairperson of the Estonian Science Foundation, I myself learned how hard it can be to assess scientific work at the highest level. But this experience also taught me the importance of working as part of a team of assessors, each contributing their own expertise to that final decision.

A rigorous, fair and transparent process was followed when evaluating the entrants. After an initial check for eligibility, an assessment of each proposal was carried out, individually, by a minimum of three evaluators who then came together to reach a consensus. Once the evaluations were completed, the presidents of the thematic panels drew up a shortlist of nominees, from which the finalists and ultimate winners were then selected by the Grand Jury.

Details of the backgrounds and achievements of the talented pool of scientists, academics and corporate leaders making up the Jury can be found on the following pages. All are respected authorities in their respective countries, and together they cover a wide spectrum of specialisations.

I share an interest in physics, astrophysics and mathematics with several of my co-members – while others bring experience in engineering, chemistry and biochemistry, climatology, medecine, palaeontology, demography and economics. Geographically, the Jury represents a large part of the world map, hailing from Member States, old and new – Belgium, Cyprus, Estonia, France, Germany, Greece, Ireland, Italy, Netherlands and the United Kingdom – as well as non-EU paticipants from Japan and the USA.

I would like to take this opportunity to thank all of the Grand Jury members – past and present – for their dedication and generous contributions to the Prizes. And I congratulate the Commission for its foresight in creating what has become an outstanding showcase for European research.

Professor Ene Ergma
President Descartes Grand Jury 2005
President of the 10th Riigikogu (Estonian Parliament)

Grand Jury members

Professor Ene Ergma

Physics and mathematics

President of the Grand Jury and Vice-President of the Estonian Academy of Sciences, Tallinn

Born in Rakvere Estonia, Ene Ergma studied physics from the University of Tartu (UT) and Moscow State University (MSU). In 1972, she was awarded a PhD in mathematical and physical sciences, Institute of Astronomy at MSU, and added a doctorate from the Institute of Space Research in 1984 with her dissertation 'Unstable thermonuclear burning at late stages of stellar evolution'. Her achievements as professor of astrophysics and member of the Highest Evaluation Committee at UT, as well as professor at Göttingen Academy of Sciences, were eventually rewarded with her invitation to join the Estonian Academy of Sciences in 1997, and later election to the position of vice-president. In 2003, she became president of the 10th Riigikogu, the Estonian Parliament.

Professor Jan Balzarini

Medicine
2001 Descartes Prizewinner

Professor at the School of Medicine, KU Leuven, Belgium

Jan Balzarini is on the board of directors of the International Society for Antiviral Research and professor at the Rega Institute for Medical Research. He studied biology and bioengineering at the KU Leuven, Belgium, and in 1984 obtained a doctorate in bioengineering. He attended the National Institutes of Health in Bethesda, MD, for a postdoctorate focusing on the discovery and pharmacology of novel medicines against HIV. Back at the Rega Institute, he further expanded his antiviral research, coordinated a variety of research networks sponsored by the European Commission, and was at the core of the discovery of an entirely novel class of therapeutics for HIV and hepatitis B. He won the EU's 2001 René Descartes Prize and the Blaise Pascal Medal of the European Academy of Sciences in 2003.

Professor Jean-Patrick Connerade

Physics

Professor at the Imperial College of Science, Technology, and Medicine, London, and President of EuroScience

Jean-Patrick Connerade's distinguished career spans nearly 40 years, starting as a State Scholar in Physics at Imperial College, London, in 1965 and culminating in his ongoing presidency of the renowned EuroScience Association. In between, he has researched atomic physics in the United Kingdom, in France and in Germany, and has taught at institutions in London, Paris and Bonn. He served on numerous committees – including the Synchrotron Radiation Committees of the Science and Engineering Research Council and of the *Laboratoire LURE* in Orsay, and has been Honorary Editor of the Journal of Physics B. He joined the Association of Scientists in St Petersburg, was elected fellow of the Royal Society of Chemistry and to the Council of Physics College of the EPSRC on two occasions, and more. Professor Connerade also serves on the External Advisory Group of the European Commission for the Marie Curie Actions.

Professor Yves Coppens

Palaeontology

Professor at the Collège de France and Chair of Palaeoanthropology and Prehistory at the Collège de France

Born and educated in France, Yves Coppens' long career includes a research stint at the National Scientific Research Centre, some 14 years at the National Museum of Natural History as professor and chair of anthropology, a directorship at the Museum of Man, membership of the French, Italian and Belgian Academies of Science, as well as other prestigious organisations. He has done wide field research in Chad, Ethiopia, the Maghreb, Asia, Russia and more, has around 800 publications to his name, has won several European and international awards, and earned honorary doctorates from universities in Italy, Belgium and the USA.

Professor Pierre Coullet

Basic sciences

Professor at the University of Nice, France, and Senior Member of the Institut Universitaire de France

Professor Coullet's association with the Descartes Prize began in 2001, as panel president for the basic sciences section. He was a researcher at France's *Centre National de la Recherche Scientifique* (CNRS) between 1975 and 1987. He co-founded the Institut Non-Linéaire de Nice in 1991, where he was head between 1995 and 2002. He also founded and heads the Insitut Robert Hooke. He has won several awards, including Germany's highest, the Humboldt Prize, and sits on several science panels, including that of the Insitut Universitaire de France. His long list of publications in the fields of dynamical systems, chaos, turbulence and self organisation (in fluids, liquid crystal, chemical reaction, biological systems includes many major peer-reviewed journals.

Professor Patrick Cunningham

Genetics

Professor of Animal Genetics at Trinity College, University of Dublin, Ireland

Patrick Cunningham was formerly Deputy Director (Research) in the Irish National Agriculture and Food Research Institute (1980-1988), visiting Professor at the Economic Development Institute, World Bank (1988) and Director of the Animal Production and Health Division, Food & Agriculture Organisation of the UN, Rome (1990-93). He has published extensively on the genetics of domesticated animals. He is co-founder and Chairman of the biotechnology company IdentiGEN. He has been President of the European and World Associations of Animal Production, and served on the European Life Sciences Group which advised Research Commissioner Philippe Busquin.

Professor Edward P.J. van den Heuvel

Astronomy
2002 Descartes Prize-winner

Professor at the University of Amsterdam (UA), Netherlands

Until recently, Edward P.J. van den Heuvel chaired Netherlands Foundation for Research in Astronomy. He has been a professor of Astrophysics at UA since 1974, and was director of the Astronomical Institute and the Centre for High Energy Astrophysics until January 2005. He has carried out astrophysical research at the universities of Utrecht, Brussels, California (Santa Cruz and Santa Barbara) and at the Institute for Advanced Study in Princeton. He led the team awarded the 2002 Descartes Prize for the discovery of the places of origin of giant cosmic explosions producing the cosmic bursts of gamma ray radiation.

Mr Ulf Merbold

Astronautics

Former Coordinator of the International Space Station at the European Space Agency, Noordwijk, Netherlands

Ulf Merbold was born in Greiz, Germany, and graduated in physics from Stuttgart University. He joined the Max Planck Institute for Metals Research in Stuttgart and in 1977 he was chosen by the European Space Agency as Payload Specialist for the first flight of Spacelab 1, launched from NASA's Space Shuttle. In 1983 Ulf Merbold became the first non-American to fly on the Space Shuttle, and in 1994 he flew a 32-day mission on the Russian Mir space station. In 1986 he moved to the European Space and Technology Centre in Noordwijk. He now works as a consultant for ESA's manned space programme. His many awards include the 'Order of Friendship', presented by President Yeltsin of Russia.

Professor Wubbo Ockels

Engineering and astronautics

Head of the European Space Agency Technical Centre's (ESTEC) Education Office, Noordwijk, Netherlands

Born in Netherlands, Wubbo Ockels holds ESTEC's professorial chair in the aerospace engineering faculty at the Technical University Delft. He completed a doctorate in physics and mathematics at the University of Groningen in 1978 on the basis of work at its Nuclear Physics Accelerator Institute. Shortly after, the European Space Agency chose him as a payload specialist to train for the Spacelab-1 mission at NASA in USA. He performed this task on the successful 1985 Spacelab D-1 mission, launched on-board Space Shuttle Challenger. In addition to his ESTEC duties, he is involved in ESA's future manned space flight activities, the Columbus programme, International Space Station, and advises the Department of Automation and Informatics (NL).

Dr Rossella Palomba

Demography

Director of Research at the National Research Council, Italy

Italian Rossella Palomba is head of the Department of Population, Social Behaviour and Policies at the National Institute for Population Research and Social Policies in Rome, Italy. Her main fields of interest are related to the analysis of changes in the family structure and behaviour, couple formation and dissolution, fertility and gender roles.

Dr Nadia Rosenthal

Biology

Head of the European Molecular Biology Laboratory, Monterotondo Outstation, Italy

Born in the United States, Nadia Rosenthal was awarded a PhD in 1981 from Harvard Medical School and trained as a postdoctoral fellow at the National Institutes of Health. She moved to EMBL from the Cardiovascular Research Center at Harvard Medical School, where she directed a biomedical research laboratory at the Massachusetts General Hospital. She served on the editorial staff at the New England Journal of Medicine, where she was a Consultant of Molecular Medicine and editor of the Molecular Medicine series. Since her arrival in Europe in 2001 to direct the EMBL Mouse Biology Unit in Rome, Professor Rosenthal has become a member of EMBO, and was awarded the Ferrari-Soave Prize in Cell Biology from the University of Turin. She has served on numerous EU grant review committees, advisory panels and editorial boards and is a member of the European Group on Life Sciences. Professor Rosenthal's research focuses on developmental genetics, the molecular biology of ageing and the role of stem cells in tissue regeneration.

Dr Ion Siotis

Engineering and physics

Research Director, National Centre for Science Research 'Demokritos', Athens, Greece

Greek born, Ion Siotis studied engineering and physics at the Ecole Polytechnique Federale de Lausanne (CH) and was awarded a doctorate in physics from Imperial College (United Kingdom) in 1972. He has carried out experimental research in particle physics at Fermilab in the USA, Deutsche Elektronen-Synchrotron (DESY, Germany) and the European Organisation for Nuclear Research (CERN), in parallel with teaching physics at Imperial College. In 1989, he became chairman and CEO at the National Centre for Scientific Research 'Demokritos', where he is currently Research Director. Before this, he was president and general manager of the National Hellenic Research Foundation.

Dr Susan Solomon

Climatology

Senior Scientist, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA

Susan Solomon is widely recognised as one of the leaders in the field of atmospheric science. Since receiving her PhD degree in chemistry from the University of California at Berkeley in 1981, she has been employed by the National Oceanic and Atmospheric Administration as a research scientist. In 1986 and 1987, she served as the Head Project Scientist of the National Ozone Expedition at McMurdo Station, Antarctica. In March of 2000, she received the National Medal of Science, the United States' highest scientific honour, for 'key insights in explaining the cause of the Antarctic ozone hole' and in 2004 she received the prestigious Blue Planet Prize for 'pioneering research identifying the causative mechanism producing the Antarctic ozone hole'. She is a member of the US Academy of Sciences, and a foreign member of the French and European Academies of Science. She currently serves as co-chair of Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC), providing scientific information to the United Nations Framework Convention on Climate Change.

Dr Georges Vassiliou

Economics

Businessman, Visiting Professor, Politician, Cyprus

Born in Famagusta, Cyprus, Georges Vassiliou has a degree and doctorate in economics from the University of Economics in Budapest. Back in Cyprus, after a few years of work in the United Kingdom as a market researcher, he established his own company, Middle East Marketing Research Bureau, which provided market research and consultancy services in the Middle East, and from 1990 onwards in Central and Eastern Europe. The company presently covers the whole area with offices in 30 countries. In 1988 he was elected President of the Republic of Cyprus, serving until 1993. In 1998 he was appointed Chief Negotiator and Coordinator of Cyprus's effort to join the EU. He established the University of Cyprus and the Cyprus Institute of Management, and is a Visiting Professor at Cranfield University, United Kingdom, since 1987.

Leo Esaki

Physics Nobel Laureate

Chairman of Science and Technology Promotion Foundation of Ibaraki, Japan, and Nobel Laureate

Leo Esaki was born in Osaka in 1925 and graduated in physics from the University of Tokyo. After working at Kobe Kogyo Corporation and Tokyo Tsushin Kogyo (now Sony), he joined IBM Thomas J. Watson Research Centre, in 1960. In 1992, he was appointed President of Tsukuba University, and in 2000, President of Shibaura Institute of Technology. Noted for his contribution to reforming the Japanese education system, his other accolades include a Nobel Prize in physics, in 1973, the Japanese Order of Culture recognizing his discovery of the Esaki Tunnel diode, the Japan Prize (1998) and other awards for his pioneering work in artificial semiconductor superlattices and other quantum structures.

During its five-year history, the Prize has also been honoured by contributions from Dr Yves Michot, President, Défense Conseil Internationale (2000-2002); Mr Rudi Thomaes President and CEO, Alcatel Bell (2001-2003); Dr Anna C. Roosevelt; Professor of Anthropology, University of Illinois (2000-2003); Sir John Maddox, former editor of *Nature* (2000-2002); Professor Margarita Salas, President, Institute of Spain (2001), Professor Helena Ilnerová, President, Czech Academy of Sciences (2001-2004); Mr Pantelis Kyriakides, Vice-President, European Patent Office (2000-2004); Professor José Mariano Gago, Minister of Science, Technology and Higher Education (current); Professor Helga Nowotny, Chair, European Research Advisory Board (2004); Professor Nikolaï Platé, Vice-President, Russian Academy of Sciences (2000-2004).

Expert panels for the Descartes Prize 2005

Panels of experts in six scientific themes were assembled by the Commission to assess the qualities of the research entries in the 2005 Descartes Prize for collaborative research excellence: Prof. Gunnar Bjursell, Prof. Andrej Jelenski, Dr Puay Tang, Ms Esther Barrutia, Jean-Marie Martin, Prof. Robert Cliquet, Prof. Becchi, Prof. Lefevre. For their part, the panels had to submit a shortlist of nominees to the Grand Jury. Each panel was headed by an eminent figure in the respective field. These presidents represent a range of countries in the EU.

Assembling the cold facts about a hot topic

Global warming is a 'hot topic' for our times – yet popular debate on the subject is often begun without full understanding of the complex interplay of factors producing climate change. In CECA, valuable input from a Russian partner has helped the European consortium to compile new evidence relating to the decreasing Arctic Ocean ice cover. The study reaches some important conclusions about the likely consequences of global change in the Arctic.

> The Arctic is a unique region, exerting a key influence on the global climatic system. Debate has raged over whether the recent progressive increase in surface air temperature and decline in ice cover is due to a natural cycle, or to the increasing greenhouse gases as a result of human activities.

Given that a continuation of this trend, whatever its cause, would have a profound effect on the strongly marine-influenced climate of Europe, considerable effort and resources have been ploughed into investigating the underlying phenomena. As part of this drive, the collaborative research collectively called CECA has been carried out in the framework of a suite of closely interrelated, European-funded projects spanning the past decade.

Added value from Russia

The CECA consortium comprises Norwegian and German institutes, working closely with a Russian partner – the Nansen International Environmental and Remote Sensing Center (NIERSC) in St Petersburg.

"The inclusion of NIERSC gave us access to data on areas of the Arctic that were not previously accessible to European researchers," observes project leader Professor Ola M. Johannessen of the Nansen Environmental and Remote Sensing Center (NERSC) and the Geophysical Institute, University of Bergen. "Furthermore, the St Petersburg centre has been active in coordinating the Russian and Ukrainian scientists and research institutions covering an area from St Petersburg to Murmansk and Vladivostok. These inputs are complemented by the participation of the Hamburg-based Max Planck Institute for Meteorology (MPIM), which is one of Europe's largest climate modelling centres. Using a combination of *in situ* observations, satellite retrievals and computer modelling, we have been able to achieve scientific breakthroughs and innovations that advance our understanding of many aspects of the Arctic climate system and its influence on Europe."

Natural or man-made?

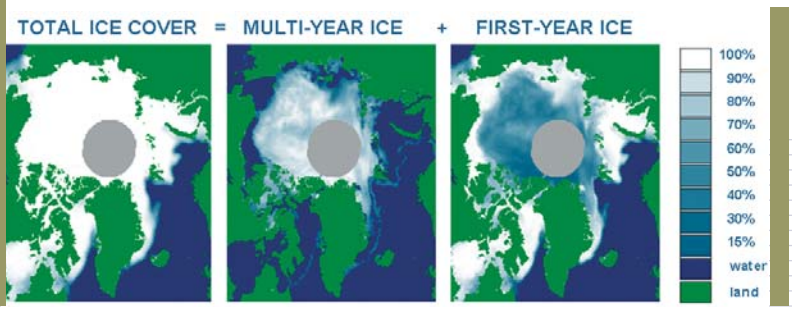
The current global temperature rise is by no means an isolated event. Considerable cyclical variations are known to have occurred throughout history. The previous most significant warming began in the 1920s, primarily in the Arctic region. During its peak period, between 1930 and 1940, the average annual temperature anomaly for the area 60°N-90°N amounted to some 1.5°C, before cooling took place towards the middle of the 1960s. This strong event was analysed by the CECA team and interpreted to be natural variability internal to the climate system. Since 1980, however, the rate of increase has been larger, global in nature but strongly amplified in the Arctic region. It has also coincided with a strong increase in the atmospheric concentration of the greenhouse gas CO_2, which thus is likely to be a prominent contributory factor to the observed warming, the CECA team concludes.

"The Arctic is subject to wholesale change, as we can now confirm by satellite monitoring," notes Professor Johannessen (see figure). "We are seeing a 3% decrease in the area of total ice cover per decade, and a 7% decrease per decade in the area of multi-year ice. With CO_2 emissions set to double by the end of the century, our climate model forecasts indicate that the summer ice could disappear completely at that time.

"Curiously enough," he adds, "the Greenland ice sheet is actually thickening by 5 cm/year. This underlines the complexity of the system. "This is primarily (75%) caused by a 'natural' weather phenomenon, called the North Atlantic Oscillation (NAO), which results in more winter snow and – to a lesser degree (25%) – by global warming, which causes more evaporation from the ocean and, again, increased snowfall."

The CECA team also investigated how the increased greenhouse gases will interact and influence the natural variability of the weather system in the North Atlantic and Arctic regions. Under the doubling of atmospheric CO_2 scenario, at the end of this century, the low pressure systems

Professor Ola M. Johannessen and the CECA team



between Iceland and the Azores (describing the NAO), will intensify – causing warmer, wetter and wilder weather in Northern Europe, particularly during winter time, with drier weather in the Mediterranean region.

Socio-economic impacts

While much more remains to be done in order to obtain unambiguous answers to the outstanding questions, the CECA consortium has identified a number of potential human and socio-economic consequences of the undoubted shrinkage of Arctic sea-ice cover – not all of which are negative:

1. Reductions in solar reflection from the ice, and increased areas of open water, would have significant effects on energy balances and atmospheric and oceanic circulation in the high latitudes;
2. Exposure of vast areas of the cold open water of the Arctic Ocean, which has a high capacity for CO_2 absorption, would provide a new and important sink for this greenhouse gas;
3. Changes in the pathways and spreading of melt water – and in the stratification in the Nordic Seas, as well as the effects of reduced deepwater formation in the Greenland Sea on global oceanic circulation, including a reduction of the Gulf Stream – could greatly alter the climate of the Arctic and adjacent regions, including Europe;
4. Broad changes in the marine ecosystem – e.g. migration of plankton in the North Atlantic due to less ice and a greater inflow of melt water – could have a negative impact on Arctic and sub-Arctic marine biodiversity. Stocks may move or change in the Nordic and Barents Seas, which are among the most important fisheries in the world. On the positive side, however, there would be a larger area for the establishment of new fishing grounds;
5. Milder conditions in the high latitudes would offer Europe increased opportunities for exploitation and production of offshore oil and gas, mineral and other resources;
6. An extended open-water season would permit increased use of the Northern Sea Route, particularly if the sea-ice conditions lessen to the extent predicted by the models. This would greatly reduce the length of voyages between Europe, the Far East and the west coast of North America, bringing both economic and environmental advantages.

Vigilance must continue

But Professor Johannessen and deputy project leader Lasse H. Pettersson caution that the Arctic Ocean in the 21st century is also likely to be increasingly vulnerable to pollution. "We must further improve our capabilities to understand, quantify and predict the spatial distribution, temporal evolution and biogeochemical consequences of human-generated contamination, including nuclear residues, in this threatened environment. It will require continuing use and refinement of the integrated methodology of observation and numerical modelling we have pioneered in CECA."

PANEL INFO

CECA *Climate and environmental change in the Arctic*

PANEL: Earth Science

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Immune system studies promise cures for common diseases

Primary immunodeficiencies (PIDs) are a group of over 130 rare genetically determined diseases leaving sufferers – mostly children – prone to infection, lymph cell proliferation and autoimmune disorders. With the collaboration of seven prominent European research teams, the EURO-PID project has amassed new information about these often life-threatening disorders. By assembling a group of patients for clinical trials, it has also made valuable progress towards the identification of effective gene therapy solutions.

> Immunodeficiencies arise from defects in the white cells, or leukocytes, present mainly in the blood, spleen and bone marrow. They can make it difficult for those affected to cope with a variety of infections, or trigger autoimmune responses, such as anaemia or vasculitis, in which the body's immune system attacks its own tissues and organs.

"The immune system is extremely complex," explains Professor Alain Fischer of INSERM, France's national institute for health and medical research, who is the coordinator of the EURO-PID project. "You can compare the processes involved to the actions of an army equipped with a range of different weapons, individually designed to combat bacteria, viruses, parasites, fungi and other potential attackers. Some forms of defence are 'innate' – in other words they are shared with even the simplest of organisms – others are 'adaptive', having been acquired much later along the evolutionary path."

Innate immunity is the first line of defence against infection, and also provides the body with a signal of 'danger'. It derives from the action of phagocyte cells, a form of leukocyte with surface or internal receptors of broad specificity, able to bind to molecules present in a variety of micro-organisms, which they then engulf and destroy.

Adaptive immunity, on the other hand, is a slower process mediated by lymphocyte cells, of which there are many different types present in the body. Each reacts to specific pathogen-associated molecules, such as proteins and sugars – which, when detected, trigger the generation of a small number of lymphocytes capable of recognising them. These rapidly multiply in order to produce a sufficient immune response, typically over a period of several days. Adaptive immunity usually increases with repeated exposure to a given infection and is retained as a memory.

Simple, but complex

Genetic mutations or deficiencies that give rise to breakdowns in the processes of leukocyte production and control are at the root of immunological disorders

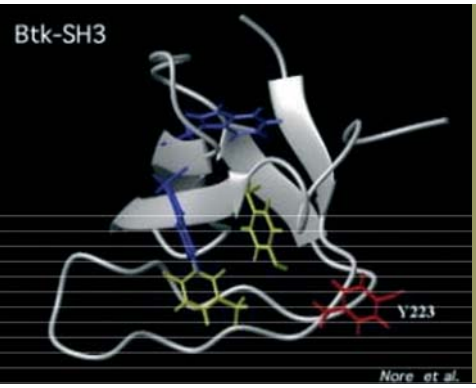
In one sense, PIDs are ideal subjects for research in this field, as they are frequently monogenic in nature – i.e. each is related to a particular mutation in a single gene. However, their study is rendered more difficult by their rarity. This makes it harder to gather adequate data, or to reach enough of the widely scattered sufferers to constitute a meaningful sample for analysis and testing. In EURO-PID, these problems were overcome by pooling the resources of seven of the most active European research teams, drawn from France, Italy, Sweden and the United Kingdom.

Through a combination of clinical immunology and basic scientific studies, the consortium made great strides in several key areas. Understanding the molecular mechanisms accounting for given conditions has provided valuable information on how cells in the immune system differentiate and accomplish their specific functions, as well as regulate immune responses.

"In all, we estimate that there are at least 130 distinct diseases leading to impaired response or system malfunction," Professor Fischer observes. "Over the past five years, our collaboration has produced a wealth of information on the responsible mechanisms, including the characterisation of defects in 20 important defensive genes."

The work focused on six principal areas:

1. Understanding the formation processes and development of defects in T lymphocytes, which are the master cells active in fighting severe infections, particularly those caused by viruses;



(Left) Model of the tridimensional structure of one domain of the btk protein (which is deficient in X-L agammaglobulinemia)

2. Analysis of the development of defects that impair the ability of B lymphocytes to fulfil their role as producers of antibodies;
3. Identifying molecular defects in phagocyte cells, which provide innate immunity against, for instance, streptococci and mycobacteria and remove dead cells;
4. Investigating how and why T and NK (natural killer) lymphocytes act in destroying infected and tumour cells;
5. Determining the nature of inherited and acquired defects in the apoptosis process, whereby excess or inappropriately targeted lymphocytes are triggered to die (failure of this mechanism is the cause of autoimmune diseases); and
6. Exploring gene therapy as a basis of new treatments for life-threatening immune disorders.

Effort rewarded

After several years of effort, the partners succeeded in developing a promising form of gene therapy for one type of severe combined immunodeficiency (SCID), and were able to organise a clinical trial on a 'cohort' of 17 patients sharing this common condition.

"Once the disease mechanism was unravelled, we could introduce a 'normal' copy of the identified gene, known as 'gamma-c', into lymphocyte progenitors in the patients' bone marrow, which is the body's blood cell factory," says Professor Fischer. Six years later, the survivors provide clear proof of principle. In some cases, however, the treatment resulted in a complication. Three of the 17 subjects experienced uncontrolled leukaemia-like cell proliferation – and, regrettably, one of them died.

Looking ahead

"Today, our immediate objective is to make the technology safer – and we are seeking an answer by modifying the way in which we introduce genes into the cells.

"Every time a genetic effect is identified, or a correlation made between the severity of a condition and a particular mutation, new diagnostic, prognostic and therapeutic tools become available to improve patient care. A second goal is, therefore, to build on our experience by developing safe vectors for gene transfer treatment of other similar conditions in the near future. We already envisage tackling at least three more PIDs within the next few years. In the longer term, I also believe our discoveries will form the foundation for strategies to alleviate and cure many more common diseases, despite the greater complexity of their genetic origins."

PANEL INFO

EURO-PID *European initiative on primary immunodeficiencies*

PANEL: Life Sciences

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Setting new standards for measuring social change

Governments, decision makers and opinion shapers have access to large volumes of economic indicators as a basis for their judgements and actions. However, they are less well served in terms of social indicators, since national and cross-national social surveys tend to be conducted with varying degrees of statistical rigour. The ESS project has now developed a consistent scientific approach that will permit accurate Europe-wide mapping of the changes occurring in citizens' attitudes and aspirations.

> The study of changing social attitudes and values across Europe, which are central to understanding modern societies, has historically fallen short of what might be expected in a generally well documented age. While deficiencies existed at a national level in many countries, they were even larger, more persistent and more serious at the European level. Volumes of important comparative data were either missing altogether or were available in such different forms in different countries that the basis for comparison was often tenuous.

Resolution of this problem was hampered by seemingly insuperable cultural, contextual and methodological obstacles. In 1995, the European Science Federation set up an expert group to help overcome these hurdles. Its conclusions formed the basis of the ESS (European Social Survey) initiative which, in 2001, first received EU funding under the Fifth Framework Programme.

World first

The vision for ESS was to pioneer and validate a standard of methodology for cross-national surveys that had not hitherto been attempted anywhere in the world. Its threefold objective was:

- to chart and explain long-term changes in attitude and behaviour within and between European nations
- to achieve and spread new standards of rigour in cross-national social measurement
- to develop robust social indictors of national performance, capable of standing alongside existing economic indicators

"Six institutions from five Member States submitted the proposal to the Commission to create a continuing central database to be fed by biennial surveys conducted simultaneously in all participating countries," observes Professor Roger Jowell of the coordinating City University London.

"The project garnered widespread support from the outset, also attracting funding from 22 national science foundations for implementation of the blueprint. There was immediate recognition that this would provide an invaluable source of data for academics from a very broad range of social science disciplines, as well as for politicians and civil servants, think tanks, journalists and the public at large."

After the successful completion of the key preparatory stages (questionnaire design, translation and piloting), the first round of data gathering took place in the autumn of 2002, with the release in September 2003 of easily available web-based findings covering 22 nations.

Since then, fieldwork for the second round has taken place with participation now increased to 26 countries. As well as 21 EU Member States, these include Norway, Switzerland, Ukraine, Iceland and Turkey. Israel, too, took part in the first round.

Strictly controlled

The project is closely coordinated by a central team from the six institutions. Within each participating country a national coordinator and a survey institute are selected to organise face-to-face at-home interviews of a statistically representative sample of at least 1 500 randomly selected citizens aged 15 and above. The rigid framework of the survey is such that no substitutions are permissible, nor any deviations from the centrally determined specification.

The questionnaire comprises two complementary elements. A top-down core element addresses change and persistence in a range of social and demographic characteristics, attitudes and behaviour patterns – including such aspects as trust in institutions, socio-political values, moral and social

Professor Roger Jowell

values, religious identity, welfare and security, and perceived quality of life. A second, bottom-up element provides for rotating topic-specific modules selected competitively in each round in response to applications from multinational groups of EU social scientists. This provides opportunities for in-depth examinations of certain topics in certain years, such as attitudes to immigration and citizenship or the work-family balance.

In addition, contextual variations between nations and influential events such as elections or natural disasters are recorded to assist data analysts in accounting for observed differences.

Growing impact

"The intention is not just to provide a snapshot, but, as survey builds upon survey, to develop a unique long-term account of change and development in the social fabric of modern Europe," Professor Jowell points out. "We also aim to improve the consistency and quality of our methods round-by-round. So far, the methodological and organisational innovations introduced in our first round suggest that our initial ambitious goals can be achieved."

"The impact of ESS on European governance could be profound," he suggests. "While other statistical agencies, such as Eurostat, collect rigorous data about the social and economic circumstances of EU Member States, they tend to avoid comparable statistics about cultural and political circumstances – how people think and feel about themselves and their world. The role of the ESS is to fill that gap."

Within 18 months of the public release of the first round data, nearly 6 000 registered users had already begun analysing the content and producing journal articles, dissertations and books (seven books in as many languages had either been published or were imminent).

Nor has interest been confined to Europe. The US National Science Foundation funded Georgetown University to set up a national replica of ESS, and is arranging for visits by leading American academics to study its methods.

Further EC funding has now been awarded to establish the ESS as a continuing Community infrastructure. Meanwhile, preparation for round three is in hand, and work is proceeding on the development of new national social indicators.

The initiative has already demonstrated that, despite the formidable difficulties, public attitudes can accurately be measured across countries: to the extent that such attitudes are critical to the formation of public policy. In an era of falling electoral participation and political engagement, the ESS will continue to serve as an important tool for reducing the democratic deficit and monitoring the health of democracy in Europe.

PANEL INFO

ESS *European social survey – innovations in comparative measurement*

PANEL: Socio-Economics Sciences

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Left-handed materials bend the rules of physics

Around 40 years ago, the Russian scientist Victor Veselago came up with the idea of 'left-handed' and 'right-handed' materials. Right-handed materials are found all around us, but left-handed materials (LHMs) are not found in nature. Veselago pointed out that LHMs could show interesting optical properties when interacting with light. To investigate this, researchers from Europe and the USA collaborated to produce left-handed synthetic materials. Now, the EXEL project has shown how the properties of these new LHMs could lead to exciting new devices in fields such as telecommunications and medical imaging.

> Much of human progress is based on our ability to bend and shape light, so new ways of doing this cause much excitement because of the possibilities for new and innovative applications in many fields. The refractive index, n, that explains how rainbows form, is a measure of a material's combined response to both the electric and the magnetic components in radiation: the former is characterised by the so-called 'electrical permittivity', ε, and the latter by the 'magnetic permeability', μ.

For all natural materials, n has a positive value. However, approximately 40 years ago, the Russian scientist Veselago envisaged so-called left-handed or negative index materials (LHMs or NIMs), which have negative indices, as a result of negative values for both ε and μ. But these negative index materials' existence was not proven for many years.

Some 30 years after Veselago's original hypothesis, United Kingdom theoretical physicist Sir John Pendry (Imperial College of Science, Technology and Medicine) put forward designs for two artificial 'metamaterials', respectively composed of non-magnetic metallic wire arrays and split ring resonators (SRRs), which would meet the NIM criteria.

At La Jolla University, in the United States, Dr R. A. Shelby, Professor David Smith, now at Duke University (US), and Professor S. Schultz combined SRRs and wires to produce the first structure that could confirm, in experiments, the existence of a negative index of refraction. This formed the basis for further pioneering work by the EXEL consortium, partly funded by DALHM, a project in the Future and Emerging Technologies scheme of EU's Information Society Technologies programme. The research was coordinated by the Foundation for Research and Technology, Hellas (FORTH) and includes additional teams from Turkey and Germany.

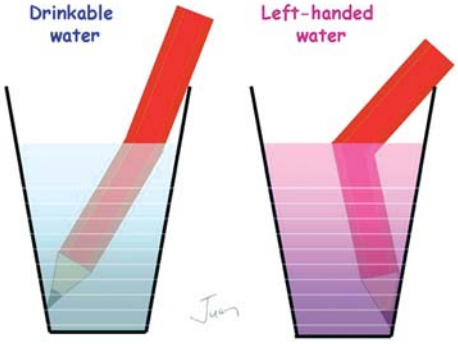
At first, the NIM concept was met with doubt and disbelief from the scientific community at large, which argued the impossibility of reversing established principles, such as Snell's law, Fermat's principle and the Doppler effect. However, the partners succeeded in refuting all of the objections – and a rich new field of interdisciplinary research was born.

"Having explored and explained the fundamental physics, we moved towards developing modified designs that are easier to fabricate, more compact and amenable to a wealth of applications," says EXEL (DAHLM) coordinator Professor Costas Soukoulis, who is also a Distinguished Professor at Iowa State University. "As well as tuneable wire-and-ring structures with nanoscale features, we were able to demonstrate that photonic crystals, developed in the EXEL consortium, can also act as NIMs."

Image-perfect superlenses

One exciting aspect of NIM behaviour is the ability of a block of such material to function as a flat 'superlens'. Conventional curved lenses, which recombine divergent incident electromagnetic rays at a fixed focal point, suffer from one significant limitation. They are unable to resolve detail that is finer than the wavelength of the radiation itself (known as the 'diffraction limit'). This is due to the fact that they focus only the so-called far-field components, whereas near-field radiation – which decays within about one wavelength distance from its propagation – is lost. In principle, NIM lenses eliminate this shortcoming because they are flat and thus their surface can be brought into close contact with another material, unlike a curved lens that only contacts at one point. This feature of NIM lenses allows them to produce perfectly detailed images of objects placed within one wavelength of their surface.

Given the present state of technology, NIM lenses cannot yet be exploited for optical wavelengths (around 10-6 m). But with further development, it could be feasible to achieve focal point sizes of only a few nanometres, almost two orders of magnitude smaller than is possible with conventional lenses.



Prof. Ekmel Ozbay, Bilkent University, Turkey

If so, the amount of information that can be stored on DVDs would be vastly increased, and transistors with features as small as 10 nm might also be made using optical lithography.

Milestone

Already, the United Kingdom team has shown how NIMs' ability to focus radio waves could lead to smaller, better performing magnetic resonance imaging (MRI) machines. Here, the wavelengths employed are in the region of a few metres, so the whole imaging process takes place in the near field.

With the support of industrial company Marconi Caswell, Professor Pendry and his colleagues fabricated a NIM comprising a roll of metallised film wound around an inert plastic mandrel (dubbed a 'Swiss roll', because of its structural resemblance to a popular jam-filled cake).

In a milestone experiment, they placed an array of Swiss rolls between an object they were trying to image – in this case, a researcher's thumb – and a small receiver coil in a standard MRI device. Without the Swiss rolls, no image could be detected by the coil. But when in place, they functioned like a bundle of wires in directing the magnetic flux towards the receiver, producing a clear picture of the thumb's internal structure.

A crucial feature of this material is that it consists of a periodic array of structures, each of which is much smaller than the wavelength of the radio-frequency fields it focuses on. Work continues to further reduce the size of the individual elements and thus optimise resolution.

Just the start

"There are many more potential uses," adds Professor Soukoulis. "Miniaturised NIMs could be manufactured into antennas and waveguides that are 100 times smaller and much lighter than those of today, transforming design in mobile communications, aeronautical systems and other strategic sectors. We can also produce materials that are totally non-reflecting over certain frequency ranges, regardless of the angle of incident radiation. They represent the ultimate in 'stealth' technology for the defence community."

"The EXEL team has been instrumental in establishing and developing a revolutionary field, which extends the realm of electromagnetism and opens up exciting technological applications from the MHz range to optical frequencies," he concludes. "And this is just the start. More inventions will come from hundreds of research groups working in the new field of metamaterials, which owes its existence in large part to the creativity of European researchers.

PANEL INFO

EXEL *Extending electromagnetism through novel artificial materials*

PANEL: Basic Sciences

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SUPPORTED BY:
- IST-FET project DAHLM (IST-2001-35511)

Finding the astrophysical Holy Grail: J0737-3039

Pulsars are rapidly spinning neutron stars, often described as 'cosmic clocks', whose observation offers unparalleled opportunities to study some of the most extreme physical conditions in the universe. By pooling resources and sharing their results, European scientists propelled themselves to the forefront of this stellar field of research. In 2003, they made a discovery that has been hailed as one of the greatest advances in astrophysics.

> A pulsar is a small, rapidly spinning and highly magnetised neutron star resulting from the violent collapse of a massive star in a supernova explosion that can light up the sky, even though it may occur at the other side of our galaxy. The Crab Nebula, the remnants of a supernova explosion recorded by Chinese astronomers in 1054 AD, shone four times brighter than Venus and could be seen in daylight. At the heart of the Crab Nebula is a pulsar. A sizable fraction of the pre-existing giant star condensed into a body typically measuring only 20 km across. As a result, pulsars are incredibly dense; a piece of pulsar matter the size of a pinhead would weigh more than the largest ocean-going supertanker!

In addition, as they rotate, they emit powerful directional beams of electromagnetic waves from their magnetic poles. When the Earth lies in the direction of these emissions, they can be observed by radio telescopes as pulses. These repeat with the regularity of a super-accurate clock whose ticking is set by the neutron star spin-period, ranging from a few milliseconds to seconds.

The rewards for finding and observing pulsars can be huge. Monitoring apparent variations in pulse-rates makes it possible to test theories of relativity, follow their precise motion in space, explore the solid-state physics of super-dense matter, study the properties of superfluid and superconducting materials, investigate extreme plasma physics, and more.

"Rarely does a single class of objects lend itself to high-precision experiments in so many domains of modern and fundamental physics," enthuses PULSE project coordinator Professor Andrew Lyne, from the Jodrell Bank Observatory of Manchester University in the United Kingdom. "The problem is that pulsars are weak radio sources, subject to dispersion effects during their passage through the interstellar medium. To study them, we need large and sensitive radio telescopes equipped with sophisticated data acquisition systems for fast sampling – and these are costly to build and run."

Unity is strength

In the early 1990s, Europe was home to four of the world's seven telescopes with major pulsar programmes. Yet, despite a degree of co-operation, the responsible groups had each developed individual hardware and software facilities tailored to their own particular requirements.

"We eventually concluded that a closer partnership would allow us to benefit from collaborative instrumentation and software efforts, sharing of expertise and training opportunities, and coordination of observing programmes," Professor Lyne recalls. "We therefore founded the European Pulsar Network (EPN), which was approved in 1994 and funded under the EU Human Capital and Mobility programme."

By 1997, the EPN members had finalised development of a common data format and set up a database to accommodate all observational feedback in a single web-based archive, accessible to all. A year later, they had begun routine, simultaneous multi-frequency, single-pulse observations with the aid of the 100-m class instruments in Germany, Italy, Netherlands and the United Kingdom.

Probing the galaxy

However, while the European instruments were ideal for developing and testing new techniques, the best prospects of finding new examples lay in searching the centre of our disc-like galaxy – which required a viewpoint in the southern hemisphere. For this, EPN sought the collaboration of the Australian Telescope National Facility (ATNF), which operates a 64-m telescope in Parkes, New South Wales.

With this added facility onboard, new sightings came thick and fast. Low-frequency surveys logged large numbers of previously unknown millisecond pulsars, which are proving to be particularly valuable in detecting the cosmological gravitational wave background – originating from a time when the universe expanded rapidly after the 'big bang'.

The birth of the partnership. European pulsar astronomers gather in 1995 under the 76-m Lovell Telescope at Jodrell Bank, United Kingdom

Professor Andrew Lyne

In a bid to reveal previously undetectable pulsars, the team also embarked on a sensitive high-frequency survey. They equipped Parkes with a 13-beam receiver system which was developed jointly by Jodrell Bank and the Italian INAF Osservatorio Astronomico di Cagliari in collaboration with the ATNF. In a massive experimental undertaking over five years, this co-operation enabled them to locate over 850 pulsars, more than the total number found in all surveys spanning 30 years prior. Furthermore, a deep search of globular clusters (gravitationally bound concentrations of approximately 100 000 very old stars, of which our galaxy has around 200) produced more significant findings, which have triggered on-going investigations by many groups around the world.

Crowning achievement

PULSE's crowning achievement to date, however, was the discovery, in 2003, of the first-known double pulsar. The existence of such a system is remarkable, since its two components needed to have survived twin supernova explosions. Its detection was fortuitous, given an astronomically brief lifespan of a few tens of millions of years.

"The original Parkes multibeam survey concentrated on the Galactic plane," notes Professor Nicolò D'Amico of INAF. "To probe the distribution of pulsars which are nearby or have millisecond periods, we also searched higher Galactic latitudes and longitudes. It was in this new survey that we discovered the 23-ms pulsar J0737-3039A, which proved to be in a very short-period (2.4-hour) orbit with a companion. The neutron star nature of this companion was confirmed with our discovery of 2.7-s pulsations from the same system.

"The large orbital velocity, small orbital separation, high orbital inclination and visibility of pulsations from both the stars ensures the occurrence of significant 'relativistic effects'," Professor D'Amico explains. Within only 18 months of timing measurements taking place, the team was able to make the most accurate confirmation yet of Albert Einstein's general theory of relativity. Moreover, visibility of both pulsars at the same time allowed direct measurement of their mass ratio, which has never before been done for double neutron star binaries."

The future is even more intriguing. Among other exciting implications, the discovery revitalises the possibility of detecting gravitational waves, which are faint ripples in space-time predicted by Einstein. What is more, the fact that the orbital plane is almost edge-on has made the double pulsar a unique laboratory for studying electrodynamics and plasma physics under the most extreme conditions.

"Our work increases mankind's knowledge of some of the fundamental physical laws that govern the Universe," Professor Lyne concludes. "These results are not only of relevance to today's scientific professionals. They also help stimulate young peoples' interest in astronomy, physics and basic research, forming an important foundation for a society increasingly based on science and technology."

PANEL INFO

PULSE *Pulsar science in Europe: the impact of European pulsar science on modern physics*

PANEL: Basic Sciences

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Research tracks health secrets of cell nuclei

Thousands of different chemicals – including steroids, hormones and others – enter the human body through the food chain and other routes. So far, less than 20% of the potentially harmful compounds targeted by EU legislation have been screened as possible initiators of diseases and genetic abnormalities. In PATHFINDER, six research teams jointly pursued novel methods to determine how these chemicals, acting through receptors found in the nuclei of bodily cells, may intervene in cellular processes. The findings could point the way to effective drugs combating cancers and other life-threatening conditions.

> By burning fossil fuels, manufacturing a wide variety of chemicals and spreading pesticides across the countryside, our industrialised society releases many potentially harmful compounds into the environment. Some of the most toxic of these are long-lived and fat-soluble. As a result, they accumulate through the food chain and are eventually consumed by human populations. In fact, because humans are at the top of the food chain, we are particularly vulnerable to these foreign substances, which can interfere with our hormonal balance and trigger a variety of diseases.

The objective of the PATHFINDER consortium was to understand the role of the nuclear receptors (NRs) present in cells, which are often the target proteins for chemical contaminants found in dietary products or the environment. Together with associated ligands (binders), NRs acquire the ability to attach to specific DNA elements located in the vicinity of target genes, where they modulate gene expression by increasing or decreasing the cellular concentration of specific proteins. Contaminants also trigger similar transcriptional processes, but in an inappropriate context – which can provoke disease conditions, such as cancers, obesity and abnormal sexual differentiation.

PATHFINDER is part of an on-going research effort spanning several decades. Major factors behind its success were the complementarity and synergy between the different groups in the consortium and the use of novel techniques to uncover new knowledge.

Complex issues

Cellular responses to NR activators are very complex and present on many different levels. It was, therefore, crucial to draw on a range of disciplines and infrastructures, develop appropriate animal models and employ state-of-the-art methods to gain the necessary insight. These issues were addressed by establishing a joint collaboration concentrated on understanding the biology of three important NR systems:

- the estrogen receptors ERα and ERβ, which are linked to sexual development, brain development and the immune system;
- the thyroid hormone receptors TRα and TRβ, affecting metabolism and early development; and
- the liver X receptors LXRα and LXRβ, influencing intermediary metabolism and leading to neuro-degenerative and immune diseases.

All of the above belong to an NR family comprising 48 members, many of which have been shown to be critical to developmental processes and disease.

Success factors

"PATHFINDER evolved from co-operation between my own group and those of Professor Vincent Laudet (Ecole Normale Supérieure de Lyon, France) and Dr Sari Mäkelä (University of Turku, Finland)," explains coordinator Professor Jan-Åke Gustafsson, of the Swedish Karolinska Institute. "Following my identification and characterisation of the estrogen receptor Erβ, in 1995, and the identification of its homologue ERRβ, in 1997, we went on to investigate the potential interplay between ERα and ERβ, the mechanisms of phytoestrogen action, and estrogen effects

Prof. Jan-Åke Gustafsson

in the male reproductive system. These studies marked the start of a long line of collaborations, many of which are still ongoing. The subsequent introduction of our other partners in this project produced a coherent and focused group that has made a strong impact on research, with major advances in the understanding of NR biology and function."

A significant contributor to the overall achievement was the selection and sharing of a number of unusual animal models for *in vivo* testing. As well as several specially bred mouse strains, these included two transgenic frogs, zebra fish and the amphioxus, which shares many gene types with the vertebrates. One important discovery, among several to have been patented, was the fact that frogs produce fluorescent tadpoles ideal for monitoring and assessing the effects of pharmaceuticals and chemicals on NR signalling. This new discovery is now being exploited via the spin-off company Watch Frog.

Another notable asset was the link with the Genome Institute of Singapore (GIS). Gene expression profiling, a key method for PATHFINDER, was prohibitively expensive to the European partners, given the facilities available to them. This obstacle was overcome with the help of the GIS, which had put huge efforts into establishing its own microarray spotting system and analysis centre, while also having access to experienced bioinformatic groups for data processing.

Breakthroughs benefit society

Together, the partners achieved a number of notable breakthroughs, including confirmation of the crosstalk between the estrogen receptors and ERR binding receptors. They then went on to characterise the part played by ERβ in prostate tumour formation and the role of the liver X receptors in fatty acid metabolism and fat genesis.

These results provide critical information that could help protect the general population from the negative affects of contaminants. In addition, it could enhance EU competitiveness by helping to demonstrate that European foodstuffs are safe to consume. Furthermore, the findings identify routes to the development of new pharmaceutical compounds that will benefit humanity and, through eventual commercialisation, bring added value to the European economy.

The PATHFINDER methodology, combining the latest molecular biology techniques and genomic approaches with innovative and powerful bioinformatics methods, will undoubtedly continue to provide new and exciting scientific results with real potential for future discoveries and patents.

PANEL INFO

PATHFINDER *Portraying the Effects of Nuclear Receptors in Health and Disease*

PANEL: Life Sciences

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Bark-based adhesives make homes healthier

While natural tannins extracted from tree bark were once in great demand as chemicals for the conditioning of leather, their market was decimated by the arrival of synthetic alternative materials to leather. New chemical processes and improved manufacturing techniques developed in the TANNIN project herald a new era of environment-friendly adhesives for high-performance wood panelling. However, European industry has hesitated, allowing a Japanese manufacturer to take the first step in committing to full-scale implementation.

> The profitability of tannin extraction from tree bark declined rapidly as plastics progressively eroded its market as a conditioner for natural leather hides. Limited use of formaldehyde-cured adhesives for bonded and pressed wood fibre panels, widely employed in construction and furniture manufacture, failed to reverse this trend. Using spent bark makes the extraction of tannins more economically viable. The spent bark chips have a ready market as mulch (which helps conserve moisture in soil) for tree nurseries because they are free of tannin that would otherwise inhibit sapling growth.

Natural alternative

Western Europe currently consumes around 3.2 million tonnes/year of adhesives for panel production, but has largely opted for more 'modern' synthetic materials – urea-formaldehyde, melamine-formaldehyde, phenol-formaldehyde, etc. As well as containing synthetic oil-based components, these face the problem that formaldehyde is toxic and carcinogenic. They thus present health hazards both during manufacture and through long-term leaching of residues into the interiors of buildings. The dilemma for industry was that alternatives, such as isocyanates, lignins and protein adhesives, also suffer from a variety of drawbacks: toxic risk, performance shortfalls, or a requirement for high levels of synthetic additives

Tannins cured with formaldehyde have the potential to serve as very effective adhesives. Although they consume only one-tenth of the quantity of formaldehyde needed for synthetics, and their emission of formaldehyde is much lower, they share the problem of unreacted residues in the finished panels. Moreover, even though they outperformed those bonded with melamine-formaldehyde and phenol-formaldehyde exterior adhesives in 20-year tests involving external exposure to high UV levels, their commercial appeal remained limited.

Now, the consortium of TANNIN has demonstrated novel chemical processes that not only eliminate the use of formaldehyde as a primary reagent, but also avoid its generation as a secondary by-product. Collaboration between three core partners began early in 1993. Three years later, the initiative won EC support as a 24-month FAIR project, led by the Ecole Superieure des Technologies des Industries du Bois (ENSTIB) at the University Henri Poincaré – Nancy 1, France.

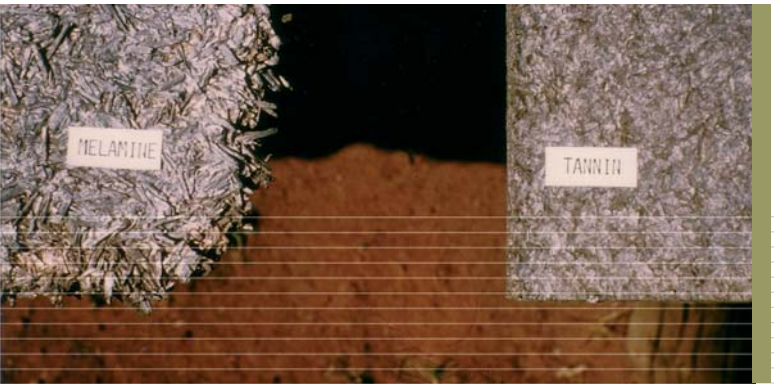
Choice of processes

The first breakthrough for the three-member partnership was to show that tannin would polymerise in the presence of catalytic amounts of dissolved silica or of silicates, without the addition of formaldehyde or any other aldehyde. Furthermore, the reaction was rapid, offering scope for higher productivity in industrial exploitation.

Tannin reaction varies according to the type of tree from which it is extracted. With the most active forms, the catalysed process made it possible to produce boards outperforming the relevant standards for interior panels (90% of the European market). In the case of other tannins, the catalytic effect of the cellulose of wood fibre was itself sufficient to trigger tannin polymerisation, yielding sufficient bond strength for internal-grade boards.

A third mechanism demonstrated by the consortium was to employ hexamethylenetetramine (hexamine) as the hardener. Although it can, in some circumstances, produce formaldehyde as a reaction intermediate, the partners established that this did not occur with the fast-curing tannins. The cross-links obtained can even withstand temperatures beyond 120˚C for six hours or more without any toxic emission whatsoever.

Further chemical development identified several more reaction strategies – and a number of aspects of the work



have subsequently been patented. Four doctoral theses also emerged from two European universities.

Advantages ignored

"Our options all utilise 95-100% natural ingredients and produce no noxious emissions," points out TANNIN coordinator Professor Antonio Pizzi. "Tannin can be extracted from managed plantations, or even from scrap material, such as pecan nut waste. And, while the original sources were mainly in the southern hemisphere, studies by our Italian colleagues at Silvachimica established that various European conifer species are equally suitable.

"We proved that the processes were both environment-friendly and economically viable for Europe," declares Professor Pizzi. "Frustratingly, even after carrying out a number of convincing in-plant trials, we were unable to persuade a single board manufacturer to abandon its established practices."

New impetus

Then a new partner appeared on the scene. A Japanese company, facing tough national legislation that would virtually outlaw the use of formaldehyde, joined forces with the European trio. With its participation, they added yet another dimension to the technology: the incorporation of steam injection into the pressing cycle. A similar technology for other applications had also already been developed by Erlenback Maschinen Company – a German equipment manufacturer – for light panels using hemp waste. ENSTIB supplied the tannin-hexamine adhesives technology to this company and the machine developed is on sale.

The Swiss HSB School collaborated with the Japanese in developing this technique to an industry ready stage. A particular strongpoint, determined already in the initial project, was that the pressure required to consolidate some type of boards (OSB) is halved, allowing smaller, lighter presses to be employed. In addition, steam-assisted pressing is able to deliver marine-grade boards withstanding Japan's extreme four-hour boiling water immersion test.

Sekisui, which owns the largest Japanese construction company, is already building 10 000 houses/year using board based on tannin imported from Italy. It has just completed a new factory dedicated to the hexamine process, where it is making structural components, such as roof beams, measuring up to 12 cm in thickness. When the plant reaches full capacity in 2006, its annual output will exceed the current 1 500 tonnes.

"At last, Europe is beginning to follow this lead," says Pizzi. "A major Swedish furniture manufacturer and pulp and paper company are now setting up a facility, although without steam injection, for which tannin will be extracted from the bark of locally grown spruce trees. It took the very tough legal pressure in Japan to overcome the conservatism of industry. No doubt more countries will soon move in the same direction. This could spur further take-up of what is, in any case, an inherently attractive opportunity for Europe.

"The added value of tannin production would provide an incentive for the start-up of small businesses in rural areas, where the spent bark can still be sold as mulch or burned to produce energy. The green nature of the resultant products will help encourage greater use of renewable materials in the construction sector – and families can be assured of a healthier living environment."

PANEL INFO

TANNIN *Natural tannin-based adhesives for wood composite products of low or no formaldehyde emission*

PANEL: Engineering

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Patterning packs more data onto super-dense disk drives

The storage capacity of computer hard disk drives has more than doubled annually over the past few years. However, today's technology is reaching the physical limits of its ability to pack more and more digital information into ever-smaller spaces. Eight European partners in the EU's HIDEMAR project ('Growth' programme) were at the forefront in demonstrating economical, environment-friendly production techniques for a new generation of materials. Their concepts, already being taken up by industry, could bring a remarkable tenfold density increase by the end of the decade.

> In recent years, the global volume of stored digital data has been more than doubling annually, passing the 2.2 million Tbytes (2.2 x 1015 bytes) mark by 2004. Today, despite recent advances in solid-state memory, disk-based magnetic recording remains the dominant storage mode. Manufacturers' ability to provide progressive increases in capacity, reasonable read/write speeds and competitive pricing has so far secured its position as the medium of choice. However, industry and the public continue to show a voracious appetite for more.

The soaring demand for storage arises from data-intensive computer applications, including graphics, animation, multimedia and desktop publishing, to which can be added a growing market for non-PC consumer devices such as set-top boxes, cameras, laser printers and satellite navigation systems.

Reaching the end

Current conventional disks are so-called 'longitudinal' media, in which data is recorded as individual bits in a continuous film of switchable magnetic domains of ferromagnetic material deposited on a metal, ceramic or glass substrate. Each bit consists of a collection of a large number of grains to statistically reduce the noise. This technology has proved remarkably durable: capacities grew by 25-30% per year throughout the 1980s, jumped to a spectacular 60% average annual increase over the past decade and exceeded 100% in the last few years.

The sudden acceleration resulted principally from the successive introduction of magneto-resistive and giant magneto-resistive read heads, which made it possible to retrieve bits from smaller and smaller domains. However, when these become so small that their magnetic energy is on par with ambient thermal energy at the operating temperature, they can become unstable and lose their information content. This phenomenon is known as the superparamagnetic limit – and, notwithstanding the ingenious efforts of the best scientists, longitudinal media are fast approaching the end of the road. The latest disks achieve densities of 100 Gb/in2; significant progress beyond this point will require a radically different solution.

New direction

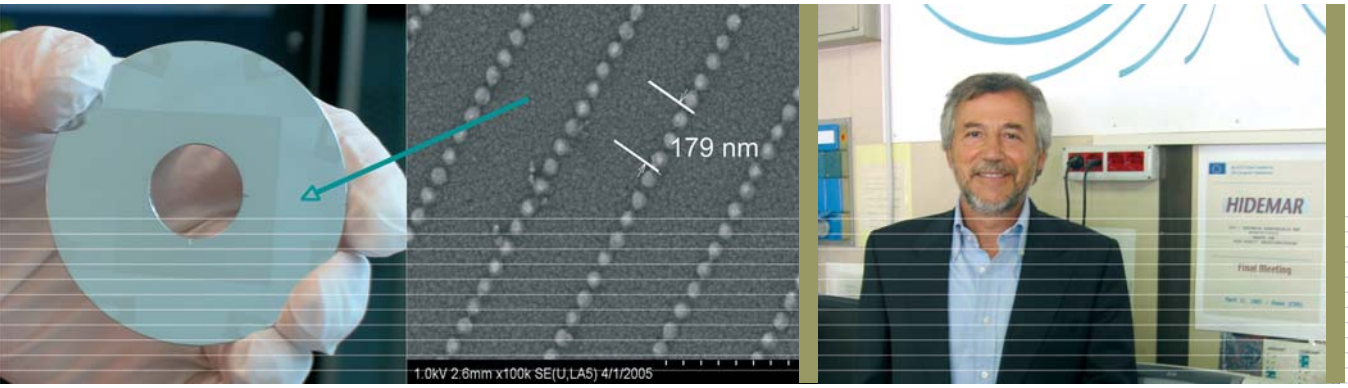
The next generation is likely to depend upon 'perpendicular' technology, whereby numbers of bits are stacked in multilayers with magnetic moments oriented vertical to the surface of the disk. Patterned media, consisting of regular arrays of single-domain nanomagnets separated by a non-magnetic matrix, are widely seen to be the most promising way ahead – perhaps culminating in ultra-high-density disks holding up to Tbits/in2.

To address these issues, the HIDEMAR project brought together a multidisciplinary consortium comprising four national research institutes, two universities and two industrial companies, together representing six different EU Member States. Heading the three-year initiative was the Italian Consiglio Nazionale delle Ricerche (CNR).

The collaboration focused on CoPt, FePt films and CoPd multilayers with high uniaxial anisotropy (the tendency of magnetisation to align along specific low-energy spatial directions). One of the specific goals of the team was to reach a density of 200 Gbits/in2 by patterning disks via two different routes: nanolithographic techniques and environment-friendly chemical self-assembly of nanoparticles.

Apart from making it possible to overcome the superparamagnetic limit, patterned materials would offer several additional advantages:

- improved signal-to-noise ratio, as interactions between the individual nanomagnets are minimised;
- simpler writing with binary switching of the single domain moment (uniaxial anisotropy); and



Dr Dino Fiorani

• full compatibility with existing rotating disk technology.

The challenges were to optimise the materials themselves, and to develop manufacturing processes that will be cost-effective on an industrial scale.

Partnership pays off

"Our work drew on the complementary expertise of partners in materials science, recording media fabrication and disk drive systems," observes CNR's Dr Dino Fiorani, HIDEMAR's coordinator. "By combining experience in thin film growth by sputtering and pulsed laser deposition, advanced nanolithography and nanopatterning, and a variety of chemical self-assembly routes, we were able to complete a wide-ranging exploration of the available materials preparation options. These were validated using a number of techniques – while modelling and numerical micromagnetic simulations, plus fundamental studies of the underlying magnetisation processes were also undertaken."

By the close of the project in April 2005, the partners had succeeded in depositing a large area of Co/Pd multilayers with high perpendicular anisotropy onto disks by sputtering under industrial conditions. These were patterned using electron beam lithography (EBL) and focused ion beam (FIB) lithography – ultimately to form by EBL regions with circular tracks of magnetic dots measuring just 27 nm in diameter, with a periodicity of 60 nm. Matched with a target-beating data density of 208 Gb/in^2, the lab demonstrator was a world premier.

Substantial progress was also made in the development of magnetic anisotropy nanopatterning (MAN), a new technique for patterning by ion implantation, which is being patented by CSIC, Spain, and Unaxis Balzers, Lichtenstein. This promises to become a faster and cheaper alternative to EBL for mass production at the deep sub-micron level.

The chemical self-assembly studies produced microns-square regular patterns of perpendicularly anisotropic Fe/Pt nanoparticles as small as 2-3 nm, at much lower temperatures than had previously been achieved. Although not aligned in the circular tracks required for conventional disk reading, self-assembled nanoparticles could eventually permit storage at much higher data densities than those in the immediate horizon.

In conjunction with heat-assisted magnetic recording devices, the world could be seeing mini-media holding tens of terabits per square inch in a few years, Dr Fiorani predicts. "The industrial take-up of our results to date will give Europe a lead in what will surely be a massive market."

PANEL INFO

HIDEMAR *Self-assembled nanoparticles and nanopatterned arrays for high-density magnetorecording*

PANEL: Engineering

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Euro-African partners finally probe 100-yr cosmic ray riddle

Since the discovery of cosmic radiation by Austrian physicist Viktor Hess in 1912, identifying the origins of these high-energy particles emerging from the interior of the Milky Way has been a challenge for generations of physicists. Using highly sensitive telescopes based on a combination of European technologies, the H.E.S.S. consortium has added vastly to the global sum of knowledge. Its observations have already more than tripled the number of known sources.

> Cosmic rays are high-energy charged particles originating in outer space. They travel at nearly the speed of light and strike the Earth from all directions. Most emanate from within the Milky Way Galaxy, but beyond our solar system.

Produced as a result of non-thermal mechanisms, studied in detail at the theoretical level, the particles are accelerated to almost the speed of light by processes, such as passage through huge electric fields generated by rotating neutron stars, or progressive energy build-up in shock waves created by supernova explosions, or the termination of large-scale flows. High-energy gamma rays are secondary products of these cosmic particle accelerations. Furthermore, while the charged particles are deflected by interstellar magnetic fields, gamma rays propagate in straight lines through the universe – and thus act as signposts pointing back at their sources.

Until recently, a lack of suitable instrumentation meant that only a few accelerator sites had been identified, and even less were studied in any detail. Yet, interplay between cosmic rays and magnetic fields influences the evolution of galaxies. Any new knowledge that could be gained about them would thus contribute greatly to our understanding of the Universe, its origins and its evolution.

Collaboration delivers the tools

The H.E.S.S. (High Energy Stereoscopic System) project, bringing together a large consortium of partners from European and African countries, was launched in 1998 with the objective of filling this gap by becoming the world leader in the domain of high-energy gamma-ray astrophysics. Central to the collaboration was the design of a powerful new multi-telescope system based on proven technology and technical approaches developed by the participating countries, which would make it possible to explore the most extreme objects in the Universe.

"Supernova remnants, active galactic nuclei powered by black holes, the centre of our own galaxy, and possible emission from dark-matter annihilation, can only be fully understood if they are viewed at the highest energies," points out Heinrich Völk, Director Emeritus at the Max-Planck-Institut für Kernphysik, and one of the scientific initiators of the collaboration. "We not only produced an instrument of unparalleled sensitivity for this purpose, but also profited from use of the stereoscopic imaging technique pioneered in the German/Spanish/Armenian precursor project HEGRA (High Energy Gamma Ray Astronomy)."

The H.E.S.S. installation currently comprises four Imaging Atmospheric Cherenkov Telescopes (IACTs) set up on a plateau in Namibia, Africa, at 1 800 m above sea level. A major advantage of this location is its clear skies and absence of rainfall or light pollution, providing an ideal environment for celestial observation. In addition, its position in the southern hemisphere allows the researchers to look at the centre of the Galaxy

Sensitivity and speed

In Cherenkov telescopy, the atmosphere itself functions as the detector for gamma rays. The high-energy photons themselves are halted as they impinge on the outer atmosphere, shedding their energy to form a shower of secondary particles reaching maximum density at around 10 km above ground level. Because these move at a velocity greater than the speed of light in the atmosphere, they emit short bursts of bluish light, known as Cherenkov radiation, lasting for a few billionths (10^{-9}) of a second (comparable to the sonic boom produced by an aircraft breaking the sound barrier).

Cherenkov radiation diverges to form a cone, resulting in a 'light pool' with a diameter of around 250 m at ground level. The large light pool provides the technique with a potential collection area of some 50 000 m^2. This is its principal advantage over satellite-based methods, for which

H.E.S.S. mirror facets, reflecting the blue sky during daylight. The 382 mirror facets are made of glass and have a diameter of 60 cm. They can be individually aligned under remote control

the maximum possible detector area is only about 1 m^2.

Recording the short-lived Cherenkov phenomena requires both high sensitivity and extreme speed of data capture. Each H.E.S.S. telescope features a tiled spherical mirror with a total area of 107 m^2. Collected signals are focused onto a fine-pixel camera developed from those used in the earlier French CAT project. Together with their integrated electronics, the IACTs are capable of capturing sample readings in times as short as one billionth of a second!

New levels of performance

Construction of the Namibia telescopes began in 2001 and was completed in January 2004. The four systems are positioned in a square formation, around the circumference of a 120-m circle. Their simultaneous observation of a given event is the basis of the stereoscopic measurement – which, together with the large mirror area, makes it possible to reach an energy threshold of 100 GeV. The locations of each gamma-ray event can thus be pinpointed to within less than one-tenth of a degree.

In addition, the cameras offer a 5° field of view, which is again the largest for any such instrument. It has enabled the consortium to score several 'firsts', including the mapping of extended sources and the scan of a large region of the central Galactic plane. Moreover, scanning an area, such as the Crab Nebula, which 12 years ago required 50 hours, can now be completed in 30 seconds. This makes it feasible to carry out blind searches for new sources.

EU ahead

By mid-2005, the H.E.S.S. collaboration had detected 24 very-high-energy gamma-ray sources beyond doubt – in a field where, little more than a year earlier, no more than about six such objects were known. Of the positively identified sources, 20 are new 'discoveries' and several possibly represent a new class of cosmic-ray accelerator. Several distant Active Galactic Nuclei have been confirmed as gamma-ray sources, and new insights have been gained into the effects of intergalactic background light on their spectra.

"The ground-breaking nature of our work is already providing a new generation of young scientists with invaluable experience in multidisciplinary teamwork," says Professor Völk. "Plans are in hand to add a fifth telescope to the Namibia cluster, further enhancing the quality and scope of its measurements. Given the rate of achievement to date, a rich harvest of physics can be expected in the future, and the H.E.S.S. collaboration puts EU astronomers in a world-leading position to reap the benefits."

PANEL INFO

H.E.S.S *The H.E.S.S. experiment: revolutionising the understanding of the extreme universe*

PANEL: Basic Science

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Blockers of inflammatory cells reverse disease

Chronic inflammation and autoimmune disease cause great pain, and sometimes even death. Consequently, their investigation and treatment are prime concerns for society. PITCID, a consortium of six European research teams, has identified a potential therapeutic approach based on the targeting and deactivation of a family of enzymes, the phosphoinositide 3-kinases (PI3Ks), which are known to be involved in the development of inflammatory conditions. The same molecules also mediate a wide variety of other cellular processes, suggesting current research could lead to novel medicines for still more debilitating diseases.

> "The great impact of chronic inflammatory diseases, in terms of both human suffering and economic cost, makes their alleviation a high priority for the medical fraternity, observes PITCID project leader Matthias Wymann, professor at the University of Basel, Switzerland. "As with many diseases of this kind, the problem is how to produce drugs that are robust and efficient in curing the ailments, without causing undesirable side-effects for the patients."

Self-destructive process

When inflammatory conditions reach an acute state, the white blood cells (leukocytes), normally responsible for destroying bacteria in the body, become over-activated and attack the host's own tissue.

As long ago as 1952, the fungal antibiotic wortmannin was discovered and, within the next decades, was shown to be capable of combating this effect. Heavy doses were found to block inflammation in rats and mice, although causing other eventually fatal problems. At the time, how it worked was unknown.

It was not until 1993 that Professor Wymann and a team in Japan made the breakthrough of linking the anti-inflammatory effect to PI3Ks, a family of proteins that controls the signalling cascade within cells.

In view of its toxic nature, wortmannin itself could not be considered as a basis for drug development. At the same time, however, it was apparent that PI3Ks contributed greatly in disease progression. As a result, interest in PI3K inhibition increased dramatically, and many important discoveries have since been made, both by the PITCID partners and by other researchers around the world.

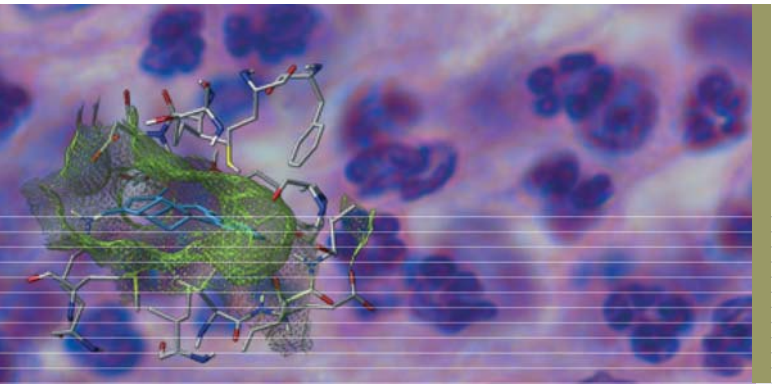
It is now known that PI3Ks are enzymes involved in a large number of cellular processes, including apoptosis (programmed cell death), proliferation, migration and adhesion. As well as triggering inflammatory and allergic disease, they also play a part in cardiac function. In fact, there are eight PI3K family members, divided into three classes. Given the multiple roles of this family, the bid to develop therapies based on their suppression needs to be pursued with considerable caution. The catalytic subunits designated p110α, β, γ and δ are currently regarded as the most interesting for therapeutic intervention.

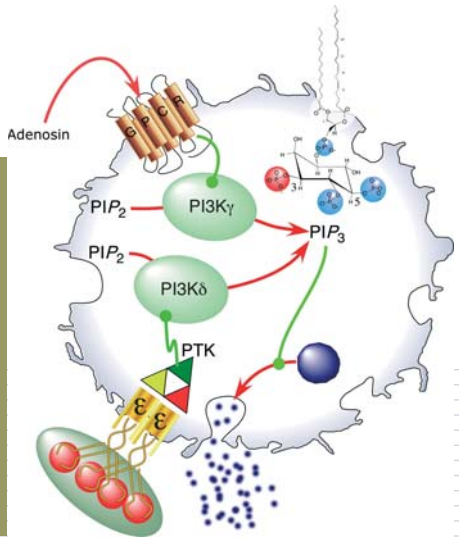
Mechanism identified

Early *in vivo* animal trials, in which the gene for PI3Kγ was deleted, showed clearly reduced leukocyte-mediated inflammatory responses – and, equally importantly, the subjects remained alive and healthy. A spokesman for leading pharmaceutical company Novartis described the experiments as "mimicking what the most specific therapeutic compound might do".

"We reasoned that if we could block cell migration to the target tissue by deactivating PI3K, this would be sufficient to prevent inflammation," Professor Wymann recalls. "If so, we would have a potential answer to chronic inflammatory and autoimmune diseases like asthma, rheumatoid arthritis, chronic obstructive pulmonary disease, atherosclerosis, inflammatory bowel disease, multiple sclerosis, and more."

The underlying process is that neutrophils and macrophages, which are particular types of leukocyte manufactured by the body in large quantities on a daily basis, become activated by peptide molecules known as chemokines. They then move to sites of inflammation where they perform their normal (or in acute diseased states, abnormal) function. PI3Kγ relays signals from surface receptors on the leukocytes. Here, it produces a lipid named PIP3, which builds up on the leading edge of the cells





(left) A portion of the molecule (enzyme) in front of neutrophils that have invaded a tissue

through a cascade reaction and acts as part of the signalling pathway that steers them towards their destination. This process is reversed by the lipid phosphatase PTEN. Individuals deficient in the latter are subject to uncontrolled cell proliferation and migration, leading to fatal inflammation and cancer.

Even in a model simulating heart failure due to chronic rise in blood pressure, inhibition of PI3Kγ provided adequate protection – confirming the cardiac implication of the enzyme.

Anti-allergy bonus

In 2000, Serono Pharmaceutical Research Institute joined forces with the academic partners, adding valuable industrial experience to the consortium.

"As an added bonus, our research showed that we could not only prevent leukocyte cells from migrating, but also control guardian cells, such as tissue-resident mast cells, which monitor for inflammation and trauma," Professor Wymann adds. "Mast cells are triggered when antigen binds to what is known as the IgE receptor. In a person with elevated IgE levels, contact with an allergen, such as pollen or bee venom, initiates an allergic chain reaction releasing secondary mediators such as adenosine. Once again, PI3K deactivation blocks the reaction and suppresses symptoms of allergy."

Boosting EU competitiveness

With the build-up of all this evidence, the consortium sought to apply its new knowledge to the development of compounds suitable for PI3K isoform-specific inhibitory drugs.

"The results of two distinct pre-clinical *in vivo* models in rheumatoid arthritis demonstrated that we could suppress the progression of joint inflammation and damage by inhibiting PI3K≥ with a selective, orally-administered small molecule," says Serono's Dr Christian Rommel. We not only succeeded in slowing the progression of the condition by treatment at the point of its onset, but were also able to revert the symptoms when arthritis was already established – and that is a truly remarkable discovery."

Dissemination of the published biological data from the project has also attracted interest from a number of other major pharmaceutical manufacturers. As a result, several hundred researchers around Europe are engaged in the race to translate the PITCID results into marketable products, thus increasing competitiveness, bringing added value across EU industry and promising enhanced quality of life for patients.

PANEL INFO

PITCID *Phosphoinositide 3-kinase as target for treatment of chronic inflammatory disease*

PANEL: Life Sciences

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Gene detectives track cancer causes

Some people are predisposed to cancers by inherited gene variation; in others, genes become mutated or silenced when tumours form. The identification of both types is usually a first step in discovering how they function, and how the diseases develop. British and Finnish partners in CANCERGENES have collaborated in mapping the genetic pathways of several cancers as an essential prelude to the search for cures.

> Up to 50% of cancer forms are the result of inherited genetic defects, which can be traced to particular families. In other cases, genes undergo change as tumours grow. Professors Ian Tomlinson (London Research Institute) and Lauri Aaltonen (University of Helsinki) have co-operated for around eight years in the investigation of both types, mainly in relation to bowel cancers.

Their continuing multidisciplinary collaboration involves the identification and clinical examination of at-risk families and individual patients, together with tissue studies, mathematical modelling and in-mouse disease models. Among other achievements, their work has contributed to the identification of five or six from the known total of around 80 predisposition genes.

New knowledge

An initial success was the mapping and cloning of the genes for two conditions – Peutz-Jeghers syndrome and juvenile polyposis (benign polyps) – which give rise to colorectal and other cancers. The genes involved, known respectively as LKB1 and SMAD4, play important roles in multiple tumour types, and the discovery of LKB1 spawned subsequent efforts by many groups to elucidate its function.

PANEL INFO

CANCERGENES *Identification of cancer predisposition genes and pathways of tumorigenesis*

PANEL: Life Sciences

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More recently, the partners mapped and identified the gene for the inherited syndrome leiomyomatosis and renal (kidney) cell cancer (HLRCC). Their investigations highlighted a previously unknown link between deficient energy production and tumour formation.

In addition, they have characterised the clinical and molecular features of bowel tumours and worked extensively on identifying the genetic pathways of sporadic colorectal cancers. For this purpose, they have contributed to the development of new analytical technologies, such as array-genomic hybridisation and genomic mismatch scanning.

Risk assessment and cancer prevention improved

One of the many immediate benefits from CANCERGENES is the ability to test patients and families with inherited cancers, to classify their diseases and to estimate their risk. "By relating a family's disease to mutations in a specific gene, such estimates can be based on molecular data that are inherently more reliable than clinical findings alone," says Professor Tomlinson.

"Screening programmes can be tailored to an individual's mutation. Those who have not inherited the mutation can be reassured – while remedial treatment, if available, as well as clinical screening, can be proposed to the vulnerable." Professor Aaltonen adds: "In Finland, a systematic hereditary colon cancer prevention programme has been ongoing for several years and this nation-wide effort has provided firm scientific evidence that cancers and cancer-related deaths can be prevented through this approach."

"Genetic analyses can also provide considerable general insight into tumour growth mechanisms, which can be followed by studies to determine the functional effects of mutations. We have, ourselves, undertaken such studies, but there is ample scope for others to follow up our findings. This is essential if we are to gain a wider understanding of tumorigenesis and to develop therapeutic strategies against the genetic targets we have identified."

Chemical theory reveals patterns of the living world

Could there be a fundamental chemical explanation for the different shapes of living things, such as fish, snail shells or plants? British mathematician and computer pioneer Alan Turing thought so. In the aptly named TURING project, teams from France and Belgium were the first to provide experimental support for his theory and unearthed new knowledge about chemically driven patterning mechanisms.

In 1952, Alan Turing published his paper 'The chemical basis of morphogenesis'. He suggested that a system of chemical substances reacting together and diffusing through a tissue is adequate to account for the formation of shapes and patterns observed in the living world; from the development of embryos to patterns on the skins of mammals and fishes – the phenomena known as morphogenesis.

Turing proposed that the synergy between reaction and diffusion could produce spontaneously sustained spatial patterns of concentration in initially uniform mixtures of chemicals. But, with his untimely death, this brilliant theory remained largely unexplored for more than a decade.

Subsequently, Nobel Prize-winning chemist Ilya Prigogine of the Université Libre de Bruxelles (ULB) put the theory to the test and demonstrated that the phenomenon can only occur in reactions evolving far enough from thermodynamic equilibrium and with substances fulfilling specific kinetic and diffusion properties.

However, it was not until 37 years after the original prediction that collaboration between theoreticians in ULB and a French experimental group at the Centre de Recherche Paul Pascal in Bordeaux (CNRS) finally succeeded in observing the stationary symmetry-breaking patterns envisioned by Turing. These had, by then, acquired mythical status.

The experimental breakthrough

In the late 1980s, the TURING group devised an apparatus making it possible to fulfil the theoretical requirements and eliminate spurious effects that had marred previous approaches. "We used constantly fed and stirred tank reactors," explains project coordinator Dr Patrick De Kepper (CNRS). "By fitting a thin slab of hydrogel in contact with the contents of the tank, we created systems in which the reaction-diffusion process could be isolated and maintained at a controlled distance from equilibrium."

With the aid of these 'open spatial reactors' and an appropriate choice of reaction, the long-sought stationary pattern of spots emerged during an historic meeting of the partners in Bordeaux, France, in December 1989. Continuation of the work brought further confirmation, as varying experimental conditions gave rise to both static and dynamic patterns, involving further theoretical developments.

Introducing self-shaping and motion

Then came a new stage. "Rather than employing mechanically idle gels, we began to test chemo-responsive types, such as those made of polyelectrolyte polymers," says Dr De Kepper. "When we dip thin soft spaghetti-like rods of these materials into solutions, they swell or contract according to the acidity. With simple acid auto-catalytic reaction, we can generate quite complex cyclical motions, even though the chemical bath is uniform and stationary.

"Here, the motion stems from a cross-talk between the size changes of the system and the chemical processes inside the gel. You could say that, whereas we began by 'painting', now we are 'sculpting'. With materials changing size or properties, such as porosity or surface tension, we could mimic the kinds of motion and shape responses that occur in many living systems."

Turing's once-neglected theory now has an immense impact in many fields – from biology to astronomy. The present work, besides shedding fresh light on the mechanisms of biological development, could lead towards new classes of 'intelligent' soft materials and soft micro-robots capable of working in liquid environments.

PANEL INFO

TURING *Chemical morphogenesis: Turing patterns and beyond*

PANEL: Basic Science

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Visually impaired people get to grips with 3D graphics

Tools such as Braille keyboards and speech synthesis software are already helping the visually impaired to join the information society. Now the four-nation GRAB consortium has developed an innovative system that could give visually impaired people interactive, tactile access to the fascinating world of 3D graphics.

> Two research institutes and a specialist SME joined forces with three leading European organisations for the blind in a bid to enable sightless people to gain meaningful experience handling shapes and objects displayed in the virtual world of 3D computer graphics.

Since 'seeing' in the conventional sense is not an option, the group adopted an approach combining haptic (touch) interaction with voice and sound feedback. At the centre of the GRAB system (Computer graphics access for blind people though a haptic virtual environment) is a desk-top apparatus equipped with two robotic arms, designed and produced by PERCRO, each terminating in a force-feedback thimble linked to a central PC with purpose-developed software.

Basic interaction concept - feeling not seeing

The GRAB set-up gives users the sensation of exploring 3D virtual objects by 'feeling' them, either with the thumb and index fingertip of one hand, or with the index fingers of two hands. "In fact, contrary to initial expectations, we found that the volunteer testers generally favoured the two-handed method," observes coordinator Teresa Gutierrez, of Spain's Fundacion Labein. "It enables them to fix a reference point with one hand, while moving the other around the object to determine its geometric shape and characteristics, such as size, weight, texture and spatial separation from other elements."

During haptic exploration, the user also receives voice prompts and audio signals, and issues commands by voice, by tapping on the target object or through keyboard entries. An auxiliary video screen enables observers to monitor progress and evaluate how easy it is to use the GRAB system. Another important aspect of the research was to determine which haptic and audio signals provided the most helpful guidance, and to eliminate those that simply caused unnecessary distraction or confusion.

Pilots show the way

"We developed three simulators," Gutierrez continues. "The most popular was an adventure game, in which users had to find their way around a multi-room house. We even implanted a virtual bomb, which players had to deactivate within a short period of time in order to stay in contention."

"Secondly, we produced a chart data explorer for finger-tip reading of Excel-based line graphs, bar and pie-charts – e.g. for financial or statistical analysis – with 'magnetic' attraction to the contours and vocal announcement of key values."

"The third application was a city map explorer, allowing the visually impaired to familiarise themselves with an area and to locate important facilities and destinations ahead of a planned visit."

Wider potential?

At present, the GRAB system is too expensive to commercialise in what will always be a limited market. However, PERCRO estimates that an annual distribution of around 100 units, based on standard industrial components, could reduce the cost to around €3 000.

Nonetheless, the system demonstrates real potential as an integrated platform for the design and development of audio-haptic applications in fields as diverse as architecture, art, aeronautics and medicine.

PANEL **INFO**

GRAB - *Computer graphics access for blind people though a haptic virtual environment*

PANEL: Information Society

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What makes a European European?

Is there a common perception of European identity? If so, how is it affected by the evolution of the European Union? A network of social and political historians, represented principally by French and German partners in the IDEE project, has deliberated on these questions. Its observations highlight the sometimes confusing influences that create a dilemma for citizens in reconciling the notion of 'nationality' with that of 'europeanity'.

Understanding the subtle nature of European identity, as perceived by its citizens at various stages of history, will be an essential part of chronicling the development of democracy in the region. A special study group, created for this purpose in 2002 by France's Centre National de la Recherche Scientifique (CNRS), coordinates the work of an established network of more than 130 prominent European research professors in social sciences and humanities.

The group, called IRICE (Identities, International Relations and Civilisations of Europe), comprises teams from three Parisian universities, researchers from CNRS itself and has a special partnership with a group attached to Humboldt University, Berlin. Its research associates represent 14 European countries (Austria, Belgium, Britain, Czech Republic, Finland, France, Germany, Hungary, Italy, Luxemburg, Poland, Spain, Sweden and Switzerland).

Identity and democratisation

The aim of their research is to study the links between national identity, European identity and the democratisation process in Europe. A central question is whether a new form of equilibrium is emerging in the framework of European integration.

In its earlier work, the network had established that there was an old 'European identity' – i.e. the feeling of belonging to a common culture – but that it did not lead automatically to political unity. 'European consciousness' was seen as more important and much more recent, arising from the concerns generated by two World Wars. This feeling played a major role in the subsequent process of European integration. 'European sentiment' or 'European patriotism' based on emotions remained weak, and did not create as many emotions as national sentiment.

The latest study reveals a paradox: that compared with earlier times when the unification process was a dream, European feelings actually weakened as the Community was being built.

A further conclusion is that, during the European integration period, a multiple-identity perception has emerged. A new equilibrium has replaced the former conflict between national and European identities.

Changing balance

As the project of European integration progressed in the 1980s and 1990s, a new political identity was born. However, like every newborn, this identity comes with its own practical problems regarding decision-making processes. The classical 'balance of power' between states *(équilibre des puissances)* has been supplanted by an intra-community 'balance of power' between institutions *(équilibre des pouvoirs)*. Unlike the identity equilibrium which can be seen as largely harmonious, this latter equilibrium is fragile since it gives rise to tension between different levels of citizenship.

More specifically, individual citizens have great power over mostly smaller matters at the national level, but have little influence at the European level where big decisions are made. This situation, the research points out, may create a crisis in the European democratic system. But the silver lining from all this is that it could also promote a new European consciousness, a desire for more robust European-level institution building – and, hence, more democracy.

Since 2000, the IDEE participants have produced 14 collective books. Their findings represent an important source of authoritative information on key issues relating to the understanding of European integration.

PANEL INFO

IDEE *Identités, démocratie et équilibres de l'Europe*

PANEL: Socio-economics Sciences

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A look at past **Descartes winners**

> Descartes Prize 2000

Chemistry close to absolute zero

Coordinated by Professor Ian Smith of Birmingham University (United Kingdom) together with Dr Bertrand Rowe of Rennes University, France, this project broke new ground by developing methods for studying the kinetics of gas-phase chemical reactions at temperatures just a few degrees above absolute zero (-273°C).

At these temperatures, many reactions between simple molecules and ions proceed with unexpected speed, the scientists found. The collaboration leading to the Descartes Prize in 2000 has since been consolidated into a full-blown EU network involving researchers in six other research groups in Germany, France, Italy and the United Kingdom.

Smith continues to make good progress in his research, and the Descartes winnings have helped meet his team's equipment needs. For example, key equipment was moved from Birmingham to Rennes, establishing the latter as a leading centre for the study of molecular processes at ultra-low temperatures.

He also recently received funding from the UK Engineering and Physical Sciences Research Council to study the effect of reagent rotational energy on the rates of fast, low-temperature reactions – which stems from his Descartes work and should greatly improve our understanding of this complex field. Much has been achieved in this collaboration but much work in low-temperature chemistry lies ahead!

The project was coordinated by Prof. Ian Smith from the School of Chemistry at the University of Birmingham (United Kingdom) in co-operation with Dr Bertrand Rowe of Rennes University (France).
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over the years

The XPD gene – one gene, two functions, three diseases

Over the past decade, a team coordinated by Professor Alan Lehmann of Sussex University has studied diseases in which a faulty gene can mean the body is unable to repair damage to its DNA, or genetic material.

Focusing on just one gene – called XPD – the Descartes Prize-winning consortium demonstrated its unusual characteristics, discovering that not one, but three conditions can result from a faulty XPD gene. These are xeroderma pigmentosum (XP), which radically increases the chance of developing skin cancer; trichothiodystrophy (TTD) resulting in brittle hair; and Cockayne Syndrome leading to severe physical and mental retardation.

With these findings, Lehmann's team now helps doctors around the world to obtain early diagnoses for these diseases. For cases of XP, this means parents will know they must protect young children from sun exposure. The Dutch partners in the project have since come up with new forms of TTD and the research has led to developments in other areas of medical research. But the three diseases can only be cured if scientists can work out how to replace the defective XPD gene, and Professor Lehmann estimates this is at least another five to ten years away.

Winning the Prize has increased the team's scientific standing not only in Europe but throughout the medical world, and the award has been put to good use. Members of the team have also gained from grants under various schemes within the EU's Sixth Framework Programme for research.

The project was coordinated by Prof. Alan Lehmann of Sussex University in Brighton (United Kingdom) in co-operation with researchers from the Erasmus University in Rotterdam (Netherlands), CNR in Pavia (Italy), and CNRS in Strasbourg (France). E-mail: A.R.Lehmann@sussex.ac.uk

Plastic transistors operating at 50 kHz for low-end high-volume electronic circuits

Dr Dago de Leeuw of Philips Research Laboratories (NL) and teams of researchers are leading the race in developing and manufacturing polymer transistors on flexible surfaces. The goal is to create an electronic display on a material that has the look and flexibility of paper, and perhaps one day will replace regular paper with 'e-paper'.

Members of the team have also taken part in a follow-up EU-backed project called Plastronics which ran from 2000 to 2001. This two-year project resulted in seven patent applications. The speed at which the technology is developing is astonishing. In January 2004, the Philips Research team demonstrated to the world's media a flexible and active matrix display with paper-like appearance which overcomes previous limitations by being made almost entirely of plastic. Although there is still some work to do, these results are an important step towards the development of low-cost electronic paper.

So far, the investigators have developed a disposable identification tag that can be incorporated in the wrapping of a package. The device also leads the way in linking large numbers of all-plastic transistors into circuits. This 326-transistor device can be bent in half and still work properly.

With the help of the Prize, the team has made great strides in optimising this technology for use in more sophisticated devices, such as small memories and active matrix displays, which are more efficient and economical. To date, the research has resulted in several patent applications, and a number of companies have expressed interest in their research findings.

This project was coordinated by Dr Dago de Leeuw of Philips Research Laboratories in Netherlands in co-operation with researchers from the Eindhoven University of Technology, the Universität of Ulm (Germany), the University of Cambridge (United Kingdom) and the Risø National Laboratory (Denmark). E-mail: leeuw@natlab.research.philips.com.

Descartes Prize 2001

Development of novel drugs against human immunodeficiency virus (HIV)

Some 20 years ago, scientists announced they had identified the cause of AIDS as a lentivirus, an aggressive human immunodeficiency virus now commonly known as HIV. Professor Jan Balzarini who was at the vanguard of scientists at the Rega Institute for Medical Research in Louvain, Belgium, is striving to learn more about HIV and to search for new treatments. Commission funding in the 1980s led to the creation of a centralised drug-screening facility which drew on expertise from across Europe.

In 2001, this collaborative approach bore fruit when a prize-winning group, led by Professor Balzarini alongside Spain's Instituto de Química Médica, the Academy of Sciences of the Czech Republic, Sweden's Karolinska Institute, the University of Wales, and the University of Rome, Italy, focused on identifying novel drugs and antiviral targets. It has also designed new treatments against HIV and other diseases which lower the rate of viral drug resistance.

The consortium developed the drug Tenofovir – a phosphonate nucleoside – which prevents HIV replication and suppresses the replication of many HIV strains that became resistant to other established anti-HIV drugs. Basically, this drug is able to reduce the amount of HIV in the blood and, when used in combination with other antiviral drugs, it can help prevent or reverse damage to the immune system and reduce the risk of AIDS-related illnesses. A closely related drug (adefovir) is used for the treatment for hepatitis B.

Tenofovir was approved for use in the USA, in October 2001, and in the EU five months later. Since winning the Prize, partners in the group have looked into sub-classes of phosphonate nucleoside drugs and investigated a new 'pro-drug' approach to make (anti-HIV) drugs more soluble and easier to take orally, to name two developments. Thanks to the Descartes Prize, the group gained deeper insight into the action of some novel drug leads, studied their pharmacology, and designed and synthesised these drugs, Professor Balzarini notes. He adds that patents have been filed on several new antiviral compounds and the pro-drug technologies.

The project was coordinated by Prof. Jan Balzarini of the Rega Institute for Medical Research in Louvain (Belgium) in collaboration with researchers from the Instituto de Química Médica in Madrid (Spain), the Academy of Sciences of the Czech Republic in Prague (Czech Republic), the Karolinska Institute in Stockholm (Sweden), the University of Wales in Cardiff (United Kingdom) and the University of Rome 'Tor Vergata' (Italy). E-mail: jan.balzarini@rega.kuleuven.ac.be

Development of new asymmetric catalysts for chemical manufacturing

Headed by Professor Michael North of King's College in London (United Kingdom), together with colleagues from Germany, the United Kingdom, France, Russia and Armenia, this prize-winning project resolved one of the biggest challenges facing chemists: how to produce only the desired 'hand' of a chemical compound resulting in less chemical waste and minimum cost. Many chemicals have two hands. One can have a desirable property, the other – its mirror image – can be harmful. Traditional methods for dealing with 'undesirable hands' are wasteful and costly, so the scientists are developing catalysts which are capable of producing the desired hands – so-called asymmetric catalysts – in much greater quantities than their unwanted sisters.

This has resulted in the development of over 50 new catalysts for chemical reactions, potentially replacing inferior manufacturing methods with more cost-effective and environmentally friendly commercial processes. This will have a knock-on effect for consumers in terms of the cost and quality of these products. The process can be applied to many different potential pharmaceuticals and is currently being refined and commercialised by a leading fine-chemicals manufacturer.

Since winning the Prize, the research teams have progressed in the field of asymmetric cyanohydrin synthesis. Manufacturer Avecia formally launched one of the catalysts (CACHyTM), in February 2002, and a second patent, based on vanadium catalysts, has been filed. In 2004, the technology was sub-licensed to the Japanese firm NARD, thus enhancing the global impact of the catalyst.

Further progress has been made in the chemistry of cyanide sources, and partners from the project are investigating the subsequent transformations of the cyanohydrin acetates. The use of the catalysts in other processes is also being investigated and the chemists have achieved promising preliminary results in the field of asymmetric-phase transfer catalysis, with patents to follow. The Prize money has been used to fund PhD students, buying chemicals, consumables and equipment to continue the research, and funding exchange visits of staff and students between the collaborating laboratories. Winning Descartes gave the team valuable international recognition of the quality and importance of the work, according to Professor North.

The project was coordinated by Prof. Michael North of King's College in London (United Kingdom) in co-operation with researchers from Germany, the United Kingdom, France, Russia and Armenia.
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Descartes Prize 2002

Autoreactivity in multiple sclerosis: structural, functional and pathological studies

Multiple sclerosis (MS) is a chronic autoimmune disease – where the body's immune system attacks its own central nervous system – affecting around 350 000 people in Europe. A team of six European research centres in Denmark, Sweden and the United Kingdom, led by Professor Lars Fugger of the Aarhus University Hospital, succeeded in describing how the disease starts. The prize-winning project showed how a virus can mimic a compound found naturally in the nervous system and trigger the disease.

Through their experiments, the team successfully defined the principal players in the autoimmune attack and envisaged how the virus may start a disease. Their ultimate objective is to develop new drugs and immunomodulatory therapies, which are urgently needed for the treatment of MS patients.

The team helped identify compounds in the brains of MS patients, which explain how their immune systems' overreactions lead them to attack their own cells. Using mice engineered to mimic the same genetic defects as human MS patients, they discovered that certain genetic variations may make some people more prone to developing MS than others. They then defined the principal causes of autoimmune attacks and envisaged how the virus may lead to diseases, with the aim of developing new drugs and therapies.

Recently, partners in the team identified how MS genes that express high disease risk can interact, and managed to crystallise protein from the immune system of MS patients. The resulting crystal structure provides a high-resolution picture of how this protein can contribute to the disease process, and might represent a target for new drugs. All of the original partners have recently started collaborating on other immunology projects, and they have set up liaison offices in each centre to facilitate co-operation. They are also working with European pharmaceutical partners on developing new MS medicines, some of which are already being tested. The Descartes award was put to good use by extending the consortium, while the attention it attracted helped put MS on the European medical map, notes Fugger.

The project was coordinated by Prof. Lars Fugger formerly of the University of Oxford – John Radcliffe Hospital (United Kingdom) in co-operation with research teams from Aarhus University Hospital and the Danish School of Pharmacy (Denmark), Lund University (Sweden), Dundee University (United Kingdom), Oxford University (United Kingdom) and Albert Einstein College of Medicine (USA). E-mail: fugger@inet.uni2.dk

Solving the gamma-ray burst riddle: the universe's biggest explosions

Twenty astrophysicists, led by Professor Edward van den Heuvel of the University of Amsterdam, won a Descartes Prize for their research into the origins of gamma-ray bursts – fleeting but powerful flashes of photon energy detected in space.

Discovered almost by accident in the 1960s, gamma-ray bursts have become astronomers' Holy Grail. Professor van den Heuvel and his team solved this 30-year riddle, concluding that these bursts come from the star-forming regions at the edge of the Universe, not from our own galaxy, as first thought. This discovery greatly narrowed the number of viable explanations into what causes gamma-ray bursts. The new clues support what were once just speculations, that the bursts represented the explosive death of massive stars.

Most astronomers now believe that gamma rays are produced when young, massive black holes shoot jets of gas into space at close to the speed of light. Bursts occur, they think, as a gas jet breaks up and its parts collide with each other.

Gamma-ray bursts are detected by satellites orbiting the Earth and travelling through the solar system.

The winning research was carried out with the BeppoSAX satellite, operated by the Italian Space Agency and the Dutch Agency for Space Research. BeppoSAX also discovered afterglows – the emission following a gamma-ray burst in other parts of the spectrum, ranging from radio waves to X-rays, and lasting from a few days to several years. This discovery has revolutionised the field of gamma-ray burst astronomy.

The Prize has helped the team develop new instruments for pinning down the genesis of these gamma rays. Since winning it, several new members have joined the consortium, including partners from Israel, France, Sweden and the USA, and Professor Van den Heuvel has joined the Descartes Grand Jury. Moreover, the team discovered that the burst on 29 March 2003 was associated with an extremely powerful stellar explosion, a so-called 'hypernova'.

The project was coordinated by Prof. Dr Edward van den Heuvel from the Astrophysical Institute 'Anton Pannekoek' and the Centre for High-Energy Astrophysics at the University of Amsterdam (Netherlands) in co-operation with research teams from the University of Amsterdam, SRON and NASA/MSFC (Netherlands), CNR/IASF in Roma, INAF Trieste and the University of Ferrara (Italy), the University of Copenhagen (Denmark), LAEFF-INTA (Spain), Cambridge University (United Kingdom) and AIP (Germany). E-mail: edvdh@astro.uva.nl

Descartes Prize 2003

Polymer light-emitting diodes for displays

This winning project, led by Professor Richard Friend of the University of Cambridge (United Kingdom), in association with researchers from Cambridge Display Technology Plastics and centres in Belgium, Sweden and Germany, developed polymer-based light-emitting diodes which open the door to significant innovations in electronic display technologies. The glass or silicon in screens of all kinds could, for example, be replaced with much cheaper, lighter and more efficient plastic.

Plastics are normally thought of as insulators, but it was discovered in the late 1970s that if an organic polymer was doped chemically, it could act as a conductor or semi-conductor, behaving like metal but with better conductivity. This led to a new technology which is challenging liquid crystals as the future medium for displays. Unlike liquid crystals, polymer-based light-emitting diodes displays (PLEDDs) are electro-luminescent, which means their molecules emit light on their own. Displays are made by applying a thin film of polymer to a glass or plastic base coated with transparent electrodes. Light is emitted from the polymer when an electric field is applied across the electrodes. The result is virtually instant lightup and a lighter, more energy-efficient display than with liquid crystals. As PLEDDs are robust, large area displays can be produced. An additional advantage is that they are cheap to make and can be dissolved and printed on a variety of surfaces using an ink-jet system.

The scope of these technologies will be widened when organic thin-film transistors are available. Dutch electronics giant Philips was first to use the technology in manufacturing its prototype 'Spectra' electric shaver, which featured in the 2002 James Bond film Die Another Day. Real commercial success will come when full-colour displays are introduced. The technology has proved itself in small-scale screens but more research is needed to develop it for larger screens and to generate polymers that can produce the three primary colours. The predictions are that PLEDDs for televisions and computers could be available by the end of the decade.

The Prize money was distributed to all the consortium partners, leaving them free to choose how to use it. Several members seemed keen to spend some of the winnings on improving networking between partners, particularly for exploring new ideas.

Prof. Richard Friend of the University of Cambridge (United Kingdom) in association with researchers from Cambridge Display Technology (United Kingdom), Materia Nova in Mons (Belgium), Linköping University (Sweden) and Covion Organic Semiconductors in Frankfurt am Main (Germany). E-mail: rhf10@cam.ac.uk

Nutation: Non-rigid Earth nutation model

This winning team, led by Véronique Dehant of the Royal Observatory of Belgium, together with groups from eight European countries, used detailed computation of variations in the Earth's rotation and orientation in space to improve measurements of the planet's position. The causes of nutation – Earth wobbling on its axis as it orbits the Sun – are similar to those of the precession of the equinoxes, involving the varying attraction of the Moon on the Earth's equatorial bulge.

This poses a problem when trying to work out accurately where in the world we are with respect to space or to a satellite orbiting around the Earth. Nowadays, the demand for precise positioning and navigation systems is huge – in shipping, aircraft and, increasingly, private global positioning systems. However, the motion of the Earth is complex. The combined effects of the Earth's spherical shape, axis and interaction with the Moon and Sun and atmosphere cause our planet to shake, making global positioning something of a hit-and-miss affair at times.

In today's society, efficiency is key to the way that we are trying to move technology forward. If geographical measurements were improved, we could be more efficient travellers or have greater personal security. The team set about tackling the problem by developing a new model guaranteeing more accurate measurements to within centimetres instead of metres, as in the past. This could prove invaluable for space missions and satellite applications.

Since winning the Prize, the working group has grown with the welcome addition of young scientists interested in the research. Future directions include improvements to the model and studies on how the discovery will affect Global Positioning Systems (GPS). Further down the line, Véronique Dehant plans to apply the same methodology to study Mars. The work will help determine whether the Red Planet has a liquid core similar to that of the Earth. The consortium is using their winnings to sponsor PhD and postdoc exchanges, as well as paying for working group meetings.

Led by Prof. Véronique Dehant of the Royal Observatory of Belgium in association with researchers from her institution and from the Bureau International des Poids et Mesures in Sèvres, Institut de Mécanique Céleste et de Calcul des Ephémérides in Paris and the Observatory of Paris (France), the Space Research Centre of the Polish Academy of Sciences in Warsaw (Poland), Complutense University of Madrid, the Universities of Alicante and Valladolid (Spain), the Technical Universities of Dresden and Munich and GeoForschungsZentrum Potsdam (Germany), the Technical University of Vienna (Austria), Astronomical Institute of the Academy of Sciences of Czech Republic in Prague (Czech Republic), the Main Astronomical Observatory of the National Academy of Sciences of Ukraine in Kiev (Ukraine) and the Sternberg State Astronomical Institute of Moscow State University (Russia). Furthermore, non-European researchers from the US, China, Japan, and India participated in the project. E-mail: astro@oma.be

Descartes Prize 2004

'Power station' genes for healthy, long lives?

Coordinated by Professor Howard Trevor Jacobs of the University of Tampere in Finland, five institutes pioneered the field of mitochondrial DNA (mtDNA) and are now gathering new knowledge that will guide the development of curative therapies with the potential to prolong human life.

Mitochondria are key components of the body's cells: they produce enzymes which burn sugars and fats to deliver the energy needed for all vital functions. Uniquely, mitochondria contain small quantities of DNA that are separate from the 'main' DNA contained in the cellular nuclei.

In 1988, Dr Ian Holt, who now heads a team at the United Kingdom's Medical Research Council (MRC), opened up the field by making the breakthrough discovery of genetic mutations in the mtDNA of people exhibiting muscular abnormalities. Since then, scores of different mtDNA mutations, plus a similar number of nuclear disease genes, have been identified as the causes of numerous disorders. These most commonly manifest themselves in tissues which are highly dependent on biological energy: the brain, heart, muscles, and secretory and sensory organs.

Throughout the 1990s, the group made major progress in mapping, identifying and determining the functions of key nuclear genes involved in the maintenance and replication of mtDNA. Through the development of a special genetically modified strain of mice, they were also able to demonstrate a link with the aging process.

In the months since they received their award, the members were busy conducting both fundamental and applied research. The Descartes Prize greatly boosted recognition of this field of work, even among the general public. Professor Jacobs maintains that wider understanding of the term 'mitochondria' and appreciation of its importance in human health and disease will be a very important gain for this area of studies.

The project was coordinated by Prof. Howard Trevor Jacobs of the University of Tampere, Finland, working with the collaboration of Karolinska Institutet's Department of Medical Nutrition (Sweden), the Medical Research Council (United Kingdom), the Istituto Nazionale Neurologico 'Carlo Besta' (Italy), and the Institut National de la Santé et de la Recherche Médicale (France). E-mail: Howard.T.Jacobs@uta.fi

Quantum teleportation, a key to secure communications

Under the leadership of Professor Anders Karlsson of the Kungliga Tekniska Högskolan, Stockholm, Sweden, European and American researchers joined forces to develop and demonstrate intriguing applications of quantum physics: from quantum teleportation to the perfectly secure transmission of encrypted information over cable links and through free space – eventually aiming towards a global network for secure communications.

Quantum physicists have shown that teleportation, the science-fiction dream of making an object disappear while a replica appears somewhere else, is indeed a reality – at least for photons (light particles) or atoms. In this initiative, the partners sought to extend the transmission limits of such quantum teleportation, and to show its use in message encoding that is totally random and literally unbreakable.

To perform this, they employed an effect called quantum entanglement, whereby simultaneously produced photons – even when separated by distances that exclude normal physical influences – effectively perform as if they were single objects. Modification of one automatically causes its remote counterpart to behave in the same way.

The security of such systems resides in the fact that if someone eavesdrops on the transmission, it breaks the entanglement. The twin properties thus disappear and the legitimate communicators are alerted.

Much new knowledge was gained about the fundamental mechanisms of entanglement, and how to generate and detect entangled photons. New laser-based photon generator sources were produced, with higher brightness, smaller size and greater ease of use than ever before. Specially customised detectors and counting electronics were also developed, enabling more complex transmission experiments to be performed.

The results were spectacularly demonstrated with the world's first ever quantum cryptographic bank transfer, sent on 21 April 2004 over a 6 km optical fibre link passing beneath the River Danube in Vienna.

The project partners are aiming to set up a global network for secure communications. Professor Karlsson notes that the technology could also find applications in life science areas, such as for rapid DNA sequencing.

The project was coordinated by Professor Anders Karlsson of the Kungliga Tekniska Högskolan, Stockholm (Sweden), with partners from the Ludwig-Maximilians-Universität München (Germany), the Institut für Experimentalphysik Universität Wien (Austria), the Centre for Quantum Computation, Oxford University (United Kingdom), the Group of Applied Physics, Geneva University (Switzerland), the Physics Division in the Quantum Institute, Los Alamos National Laboratory (US), the Research and Technology Division, Thales (France), and the E&EE Department, and Bristol University and QinetiQ in the United Kingdom. E-mail: andkar@imit.kth.se

Descartes Prizes

How to take part?

The Science and Society programme of the European Commission's Directorate-General for Research is responsible for organising the annual Descartes Prizes: one for **collaborative scientific research** and one for **science communication.**

The Commission welcomes the widest possible pool of entrants for these prestigious prizes.

Research prize

Proposals may be submitted by teams of scientists themselves or by public or private organisations, such as research centres, foundations or universities, which can nominate candidates for the prize in the following categories:

> Socio-economic sciences
> Life sciences
> Basic sciences (physics, chemistry, mathematics)
> Earth sciences
> Information sciences
> Engineering

Communication prize

Candidatures will be accepted from organisations or individuals that have achieved outstanding results in science communication. Organisers of other science communication prizes may send their winners as candidates for the EU prize in one of the following categories:

> Professional scientists engaged in science communication towards the public
> Popularising science through the written word
> Popularising science through audio-visual and electronic media
> Innovative action for science communication
> Editorial policy for the promotion of science whatever the media

Participation guidelines for the Descartes Prizes:

http://europa.eu.int/comm/research/descartes/index_en.htm

General information about the Descartes Prizes:

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European Commission
EUR 21933 - Descartes Research Prize - Excellence in scientific collaborative research
2005 – 43 pp. – 21 x 29.7 cm
ISBN 92-79-00185-X

KI-NA-21933-EN

RENE DESCARTES

Understanding the power of knowledge

Today, scientific excellence is paramount for Europe to succeed in the competitive environment of international research and scientific development. But is this such a new concept?

René Descartes (1596-1650) understood the power of knowledge over 350 years ago. As a philosopher, mathematician and scientist, he pioneered analytical geometry and developed a detailed account of the physical universe in terms of matter and motion. His famous work *Meditations on First Philosophy* is now perhaps best remembered by the statement it contained *cogito, ergo sum* (I think, therefore I am). Despite his penchant for philosophy – a very solitary practice – he was not necessarily one to work in isolation.

Born in France, Descartes travelled widely around Europe. Between 1620 and 1628, he spent time in Hungary, Germany, Italy and France. His most productive years were spent in Netherlands – where he wrote *Discourse on the Method*, published in 1637, and other major works. He relocated to Stockholm in 1649 to become Queen Christina of Sweden's teacher but died of pneumonia a year later. Like the Enlightenment scholars who followed in his footsteps, Descartes corresponded widely – most notably with the Cambridge Platonist Henry More (1614-1683) – and was one of the first people to suggest a universal language through which people of different nationalities could exchange ideas.

The prize that bears his name acknowledges that science is rarely the preserve of a single brilliant mind in a single country. The sharing of ideas and means yields a whole that is greater than the sum of its parts. His willingness to share his thoughts and explore relationships with his peers is a poignant metaphor for what the European Commission is trying to achieve with the prestigious yearly event, the Descartes Prize. Winning a Descartes Prize is not meant to compensate scientists financially for their hard work, but is a token of how the European Union appreciates cross-border scientific excellence and communication.

Publications Office
Publications.eu.int

ISBN 92-79-00185-X