40 European Science Foundation YEARS 1974–2014

A CELEBRATION OF 40 YEARS OF EUROPEAN SCIENCE

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“If the ESF did not exist, it is clear that it would have to be invented – urgently.”

Hubert Curien,
ESF president, 1981

FOREWORD

Martin Hynes,
ESF chief executive

The essential dynamic of scientific endeavour has remained recognisable since the development of moveable type and the printing press, one of those advances that according to Francis Bacon more than 400 years ago "changed the whole face and state of the world." The city of Strasbourg has an honourable place in the history of printing, and 500 years later, Strasbourg became the seat of a great collaboration by a host of institutions that encouraged both the advance and the application of science for the continued good of Europe and its people. But this book is more than a celebration: it is an invitation to learn from the past and reflect on science in Europe now, and on the ways science could change, along with the information technology that both marshals and disseminates learning and will soon affect forever the way science is done.

In the year European Science Foundation began, the computer mouse existed – but hardly anybody knew that – and the Apple Macintosh computer that was to make the mouse a tool of science and scholarship lay 10 years in the future. But the mouse and the digital interface democratised computing in a way that in 1974 could never have been imagined: Douglas Engelbart, one of the pioneers, campaigned projects "augmenting human intelligence" and another, Steve Jobs, called them "bicycles for the mind."

At the time of ESF's inception, science was largely a national or a corporate endeavour devoted to achieving priority. The concepts of "open access" and "open innovation" had yet to be articulated. In the four decades that followed, science accelerated, new disciplines emerged, the idea of international partnerships took hold, and a European research era was born. Scholarship became not just international, but interdisciplinary.

It is not too fanciful to suggest we are now on the cusp of yet another revolution in collaboration and the use of new media, new publication dynamics and new analytical frameworks. Just as the computer mouse, the screen, the tablet and the internet have delivered new ways in which business can reach the consumer, so too these new tools have opened new ways in which to do science, prosecute learning and share scholarship. New publication structures will empower a new generation of dedicated scientists, new approaches and new kinds of collaboration. Advances in data assembly and data-mining will deliver unexpected discovery, and change the understanding of the great challenges such as energy security, and climate change. To those of us in an organisation that is more than ever devoted to an effective evidence base for decision-making, it remains vital that all these things should continue to develop for the benefit of society, and for its people.

1. THE WAY WE WERE

The European Science Foundation came into existence on 18 November 1974, in a distracted and divided world. Spain was still ruled by a Falangist dictator (Francisco Franco was to die the following year). Portugal had only just ended 48 years of dictatorship, with a military coup, in what became known as the Carnation Revolution. In that year, Portugal still claimed Mozambique and Angola in Africa as its colonies. Greece had been ruled from 1967 to 1974 by a military junta: the first democratic elections in Athens took place that November. The Arab members of the Organisation of Oil Exporting Countries had only just ended their embargo on petroleum exports, during which oil prices had risen fourfold: as a consequence, oil importing countries were plunged into economic crisis. In Britain, the industrial action by the miners had limited coal stocks so severely that the then government imposed a three day working week for the first three months of the year. The Cold War divided Europe, the state of Germany and the city of Berlin: the so-called Iron Curtain extended from the Baltic to the Adriatic. France's President Pompidou had died in office, and in the United States of America, President Nixon resigned in the wake of a scandal known as Watergate. In Argentina President Juan Peron died, to be replaced by his wife Evita. Britain, Ireland and Denmark had only just joined the original six members of the European Economic Community the previous year.

EUROVISION, BUT THAT'S NOT THE SAME AS A EUROPEAN VISION

The idea of a wider united Europe with a common currency still seemed improbable. The idea of a European science community must have seemed of low political priority, although when France, Germany, Italy, the Netherlands, Belgium and Luxembourg signed the Treaty of Rome that established the European Economic Community in 1957, they also signed a second treaty that linked their atomic energy agencies, in a partnership called Euratom. But even this was not the first of a network of co-operation that linked European physicists and engineers. CERN, the European organisation for nuclear research, had been formed in 1954. Other treaties and conventions followed Euratom. Astronomers in five European countries had in 1962 launched a formal co-operation called ESO, the European Southern Observatory. By 1974, it had six members. In 1964, space scientists took CERN as a model and, less successfully, founded ESRO, the European Space Research Organisation. In 1961, rocket scientists in Britain, Australia and Europe had launched ELDO, the European Launcher Development Organisation. Altogether the organisation attempted 10 launches from a base in Australia. Four were described as successful, but no functioning satellite was successfully put into orbit. In 1974, ELDO and ESRO were united as the European Space Agency. In the same year,

nine nations launched the European Molecular Biology Laboratory. But the only European organisation in 1974 with any popular profile was Eurovision: in that year, the acronymic Swedish quartet ABBA won the European Broadcasting Union's annual Eurovision song contest with a number called "Waterloo." Scientists at the time had just established a series of remarkable paradigm shifts, and changed human understanding of the universe, the planets and the microcosm. They had, in just a decade, confirmed the hypothesis of a "Big Bang" in which matter, space and time all had one singular beginning; they had established the mechanism and confirmed the theory of plate tectonics, and had begun to see the Earth's surface features in a new light; and they were learning how to "read" and manipulate DNA code.

A SET OF REVOLUTIONS THAT SHAPED THE MODERN WORLD

But all of these advances had yet to be settled conclusively and in any case the wider world had yet to become aware of them at all. The computer revolution was about to begin, with the first floppy disk drive in 1974, and the first 8080 Intel microprocessor chip, but neither Apple nor Microsoft yet existed and IBM had yet to make a portable computer. World Health Organisation scientists had in the 1960s launched a global programme to eradicate smallpox, one of the world's great killers, but *Variola major* was still a plague and in 1974 the virus infected 60,000 and killed 15,000 in India. Britain, Europe and the United States were all experiencing alarming economic inflation. For many, however, life was getting better, and so was the expectation of life. In 1974, the average life expectancy of a French or German woman was 74 years (now it is 84 years). The global population, too, was growing: it reached 4 billion that year. There were terrorist outrages in Japan, Italy, Israel, the US, Ireland and the United Kingdom. The world's attention was not on science, and certainly not at the time very closely focused on European science. The newly-born European Science Foundation began by addressing the Big Science of space research, particle accelerators and astronomy – projects so expensive and complex that international partnership was the only approach – but also began to think about mathematics, archaeology, social sciences and the challenge of genetic manipulation.

THE PROBLEM: WHAT DOES A WORD LIKE EUROPEAN ACTUALLY MEAN?

"*We have sought the 'European dimension' and although I cannot yet claim we know what that fine phrase means, there have been good reasons for considering all these matters in a European context*," said ESF's first president,


Brian Flowers, in his first annual report in 1975. But he had a complaint: even European science agencies didn't seem to be very focused on the possibilities of European science. And he gently upbraided the Member Organisations for their apparent neglect.

"*I must voice my concern, for I believe that you, our Members, are not yet serious about us. I would not wish to be misunderstood; it was you who agreed to create us; you have smiled upon us, you have answered our letters, you have received us with courtesy, you have even granted us more money than we have so far been able to spend. But you have not used us. You have not yet come to us with a problem needing a solution, you have not yet sought our advice, nor have you tried to reach agreement with each other using us as the appropriate channel for discussion*," Sir Brian said. His member organisations listened, and his colleagues in Strasbourg started to make things happen anyway, and at gathering pace. What follows is a story of astounding change, at astounding speed: of European missions to the frozen hydrocarbon seas and beaches of Saturn's moon Titan, of explorations of matter at the measure of a nanometre, and measures of atomic change at the speed of a femtosecond, of advances in economic status and health that will add another three billion souls to the sum of humanity; of changes in communication technology that would not have been imaginable in 1974; of the spectre of alarming and possibly permanent climate change; and of the creation of not just an acceptance of "European science" but the creation of a European research council to fund and support it. And the newly-born ESF was to play a significant role in all of these changes.

"The infant Foundation which was born in Strasbourg last year, having been conceived – I know not where nor when – some say in Brussels, some Aarhus, some say it was before these towns were even heard of – is taking its first tottering steps. We must hope it will not fall flat on its little face."

Brian Flowers,
ESF president, 1975

From left to right

- Carnation Revolution in Portugal, spring 1974. © Gérald Bloncourt
- Juan Carlos Borbón and Francisco Franco – Spain, 1974.
- The Arabian delegation at the 1974 Opec conference in Vienna. © AFP
- The Berlin Wall © Corbis
- Richard Nixon announcing his resignation on television, 8th August 1974. © Hulton Archive
- ABBA won the European Broadcasting Union's annual Eurovision song contest.

2. THE GROUND TRUTH ABOUT EUROPE

Pick your political metaphor: a united Europe; a deeply-divided Europe; a Europe going up in the world; a Europe worn down and washed out; a Europe in a state of constant change. Every one of these is literally true, and in a series of ESF partnerships, projects and programmes, European scientists have explored their own continent in unprecedented depth and detail. The first of these projects was the European Geotraverse.

The idea was born in 1980, during an encounter between the distinguished seismologist Stephan Mueller (the European Geosciences Union every year now awards a Stephan Mueller medal) and Eugen Seibold, president of the Deutsche Forschungsgemeinschaft, Peter Fricker of the Swiss National Science Foundation and others. The idea was bold, and quite literally profound: an exploration of one transect of the continent, from North Cape in Norway to Tunisia in North Africa, a distance of 4,600 kilometres, across a narrow band – about 60 kilometres – but to a depth of up to 450 kilometres. That meant exploring not just the continental crust of Europe and its seabed, but the hot, viscous mantle below both as well. This daring idea was endorsed and sponsored by the European Science Foundation in 1982, to be divided into 13 separate projects involving up to 200 scientists from 14 nations and 11 European institutions.

THE SHOCKING REVELATIONS FROM THE CONTINENTAL DEEP

The only instrument that could penetrate to such depths was a seismic wave, so scientists detonated a series of carefully planned and controlled explosions and (at sea) blasts from an airgun array and then analysed the tremor signals that returned from the depths. The seismic data was matched by studies of the Earth's magnetism and heat flow along the way. The project meant that researchers from very different traditions and cultures had to harmonise their methods of collecting and recording and sharing data, and had to work together across national boundaries to build up a picture of the deep structure that united a continent.

The Geotraverse project came to an end in 1990. Like all great scientific endeavours, it delivered some ground truths about the foundations of Europe and it confirmed a picture of Europe as a mosaic of ancient fragments of vanished landforms assembled, with some violence, by tectonic forces long ago, forces that were still at work. As one researcher observed, hardly any of this bore the label "Made in Europe". But even more, it revealed huge gaps in contemporary geophysical understanding of the world at our feet. *"First of all, you have to know the structure of things. Then you can begin to understand the function,"* says Enric Banda, involved first of all as a scientist and later as ESF's secretary general.

"It was a benefit for science, for geoscience, it was even a benefit for economic science because we did discover a number of things important for natural resources." So long before the project came to an end, partner nations had begun to discuss EUROPROBE, another ground-breaking ESF programme. This looked at the puzzling mix of geological structures that seemed to unite, and sometimes divide, the separate nation states.

"The European scientist today has also to face the multiplicity of institutions, all working for the same cause, but often with overlapping areas of competence. Some streamlining here would be very useful! It is in the interest of the scientists to remain informed about institutional and political developments at the European level, as at the national level, and to participate, when possible, in the decision making process."

John Goormaghtigh,
ESF secretary general, 1991

THE SUTURE ZONE THAT BROUGHT TWO BLOCS TOGETHER

By this time, researchers could call on another help from on high and from unexpected partners. Global positioning satellites could provide precision measurements from space, and scientists within what had until 1990 been the Soviet bloc could share the methodology and address the wider question of Europe's structure all the way to the Ural mountains in Russia; the complexity of the Pannonian Basin, the Dinaric Alps and Carpathians, a region that is home to 12 nations; and the more narrow question of the Trans-European Suture Zone (TESZ), evidence of an old division that extends 2,000 kilometres from Denmark to the Black Sea, and stitches together two very different geological provinces. EUROPROBE revealed something of the 3.5 billion years of dynamism and change locked away in the strata far below the streets of Gothenburg or Genoa, Strasbourg or Sofia, but it too raised more questions than it answered. Just as the partners in Geotraverse had done, the EUROPROBE scientists pleaded for more time, and more resources. EUROPROBE confirmed the European continent as both the outcome of ancient forces and as a work still in progress, a continent still under construction in some places and in process of demolition in others.

So another initiative was TOPO-EUROPE, a concerted effort by teams of scientists across the entire region to measure, monitor and understand more about the processes at work. Isostatic forces are still lifting the mountains of Scandinavia in response to the end of the Ice Age and the retreat of the glaciers. Mountains are still being thrown up and then distorted by the impact of the African tectonic plate with the European crustal mass. Earthquakes and volcanic blasts have shaken cities and obliterated populations during southern Europe's recorded history, and could do so again at almost any time. And the existing patterns of erosion and the redistribution of silt along the river basins, flood plains and estuaries of the continent could soon be accelerated, or made more hazardous by climate change. With each new programme, the array of technologies available to scientists multiplied, but so did the questions.

Photo page 8

Mountaineers climbing a granite rock ridge in the Chamonix Aiguilles (Arête des Cosmiques, southwest ridge of Aiguille du Midi), melting glaciers of Mont Blanc and the Aiguille du Goûter behind. Photographed in August in the French Alps.
© Duncan Shaw/Science Photo Library

A LANDMASS IN A PERMANENT STATE OF CHANGE

One of these was: what are Europeans doing to the continent that they share, as they pump water from aquifers, clear forests, quarry stone from mountains and gravel from rivers, and dig clay, to extend cities, create urban heat islands and stoke global average temperatures in ways that have already begun to raise coastal sea levels? So even TOPO-EUROPE, with its panoramic picture of a dynamic landmass, adjusting to the forces concealed at depth and to the people and their domestic animals and plants that have subtly altered weather patterns on the surface, is not the end of the story. EUROMARGINS had already explored the impact of deep tectonic processes on the life and movement along the shallow coastal margins of the continent, and the once-unimaginable mix of circumstances that nourishes cold water coral reefs off the coast of Norway, and drives brine seeps and mud volcanoes off the Gulf of Cadiz, and the forces that expose the Iberian peninsula with earthquake and tsunami hazard.

In the literature of European geophysics, the phrase "natural laboratory" occurs again and again. That is because a mountain, or a valley, can answer questions about the process that made it. A programme called EUCOR-URGENT focused on the puzzles of the Upper Rhine graben, an ancient rift that separated the Vosges and the Black Forest mountains, created by some bygone process that seems to have ceased – but still has the potential to shock the cities of the region with powerful earthquakes.

Such projects have a natural life. Scientists move on, form new alliances and explore new questions. Governments switch their science budgets. But a set of questions put within the first few years of the European Science Foundation remain, and the networks of co-operation that began with that first decision to take a slice through Europe from north to south are still at work. And so, of course, are the deep forces that are slowly reshaping the continent beneath our feet.

"I have said that knowledge should be our currency in Europe. If that is so, then ESF is its European mint."

Enric Banda,
ESF secretary general, 2001

3. THE HEART OF THE MATTER

European volcanologists now know how a volcanic super-eruption takes place. No human has ever seen a super-eruption. Nobody would wish to. One happened in Wyoming 600,000 years ago, blew 1,000 cubic kilometres of ash and lava into the atmosphere and left Yellowstone National Park as its legacy. An event of such violence is unimaginable, but thanks to a simulation in a Grenoble laboratory, researchers know more or less what must have happened, deep in the earth's crust, to trigger such a world-altering upheaval. Scientists jammed a speck of rock between two tungsten carbide anvils and crushed it and heated it to temperatures you might find deep in a volcanic magma chamber – and then used a powerful x-ray synchrotron to measure the change in density when solid rock turned into an expanse of explosive magma with enough force to tear its way through 10 kilometres of continental crust, explode into the upper air, darken the skies worldwide and make planetary average temperatures drop by 10 °C for perhaps 10 years.

In the same laboratory, an international team used the x-ray beam to peer inside the 380 million-year-old remains of an armoured fish unearthed in Australia, and managed to reconstruct the all-but-vanished muscles of the creature's neck and abdomen, without damaging the precious fossil. As a consequence, evolutionary biologists now have a better idea of how musculature evolved in the transition from jawless to jawed vertebrates – that is, how a fish evolved a face.

MASTICATION MYSTERIES OF 16 MILLION YEAR-OLD MOUSE

In the same year, the same technology delivered another revelation, an insight into the evolution of the unique chewing apparatus of the mouse family *Murinae*. The information gained was enough to explain why these fragile but agile little mammals managed to mount a world takeover bid. There are now 584 species in the family and they make up one mammal in ten, because 16 million years ago they evolved teeth that could crush insect exoskeletons, and then four million years later, mandibles that meant they could go back to being herbivores: all this from close examination of several hundred fossil specimens. Chinese, US and French scientists used the same facility to make an intricate scan of a little fossil skeleton of the world's oldest known primate, something weighing only a few grams, preserved in a lake bed in China 55 million years ago. The detailed information was precise enough for them to reconstruct the entire skeleton in digital form, and even make it digitally "stand up" to reveal the strangeness of the feet, and eyes, and limbs of the ancestor of all primates: all this without breaking the tiny fragments of the fossil and the rock around it. Spanish, French and US researchers used the facility to look deep into some pieces of amber and see not just the bodies of trapped insects but the pollen grains on those bodies: evidence of pollination more than 100 million years ago.

Every one of these advances in understanding the world around us, all within the last year or so, is the outcome of a set of decisions taken, and a set of plans proposed, almost 40 years ago by assemblies of scientists in Strasbourg.

Almost the first big project the newly-formed European Science Foundation set itself was to discuss, agree and then begin to provide the argument for a new and powerful research tool that could match any in the world and be available to all European scientists. They had the name almost immediately: the European Synchrotron Radiation Facility or ESRF. Helwig Schmied, once a physicist at CERN with an interest in science policy, was at the time an ESF scientific officer, and took up the challenge with enthusiasm.

"*I was convinced that there was much more money around at the time than there were good projects*," he recalls. "*So I thought we should prepare to deliver the world's best machine.*"

BLUEPRINTS FOR A FUTURE THAT NOBODY COULD FORESEE

By the spring of 1979, the ESRF working party had prepared an elaborate scientific case for a machine the size of a football stadium and outlined what they expected it to do, and how it might advance physics, chemistry and molecular biology. They had specified much of the instrumentation, the accelerator machinery, and its operational methods. They had even calculated the scientific and engineering manpower required for the permanent staff, how time might be allotted for competing experiments and even the accommodation that might need to be set aside for visiting scientists who would need to conduct their own experiments in the synchrotron beam. They had done all this with a declared awareness that even if European national governments accepted the case and started work immediately, that the science would change, and the technology would advance, and the instrumentation and computing systems proposed in 1979 would most certainly not be what was finally in place by the time the facility had been completed.

That wasn't the end of things: the scientists who had compiled the initial study, which supposed a green field site, but also allowed for construction at an existing laboratory, still had to think about a future home for ESRF. CERN in Geneva was one considered site, but there were also proposals for location at Risø in Denmark, Daresbury in England, Strasbourg itself, Trieste in Italy, Dortmund in Germany and (a late entry) the Institute Laue-Langevin at Grenoble. Ambitious and costly international projects always take time to gather any momentum, and although the case had been made in detail in 1979, and then repeatedly made by physicists who saw a profound opportunity for all science, the ESRF did not start running until 1994. When it did open for business, and became available to scientists from all over Europe and beyond, it began to make history.

The intense, shining light from one of the world's most precise and powerful instruments was used by protein crystallographers to study the complex structure of the ribosome, that tiny molecular structure vital to all life on earth. The research won a two-thirds share in the 2009 Nobel Prize for Chemistry for Ada Yonath of the Weizmann Institute in Israel and Venkatraman Ramakrishnan of the Molecular Biology Laboratory in Cambridge, both of whom worked at Grenoble. But the instruments were used to explore a huge variety of matter at ever more sophisticated levels. In 1999, for example, life scientists used a beamline to explore the remarkable properties of that natural polymer, spider's silk, as it emerged from a spider. In the same year, physicists

Photo page 12

View of a night eruption of the volcano Mount Etna in Sicily with the full Moon in the sky (upper left). The glowing hot ejected matter leaves orange trails as it is thrown from the crater. Etna is a very active volcano which has erupted and released lava several times in recent history. Eruptions are caused by magma (molten rock) being forced up a vent by pressure from deep within the Earth.

Prehistoric cockroach, coloured 3-D computed tomography (CT) image. This model of a prehistoric cockroach (order *Blattaria*) is based on a specimen that was found trapped in 100 million-year-old opaque amber (fossilised conifer plant resin) from the Charente-Maritime region in France. The amber was X-rayed at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. The X-rays produced here are one thousand billion times brighter than hospital X-rays. The sample was scanned at multiple angles to create virtual 'slices' which were reconstructed into 3-D computer models. The cockroach measures 7millimetres in length.

explored the magnetic properties of metals at the tiniest scales; chemists worked out how sulphur compounds became incorporated in the calcareous structure of the shell of a little Mediterranean mollusc; and geoscientists used the instruments to model the properties of iron at the intense pressures and temperatures of the Earth's core. Twenty countries now support ESRF, 600 people work there, 3,500 visiting scientists use the facility each year and more than 20,000 scientific papers have been published from the research. By March 2014, more than 1,200 proposals were competing for beam time between August 2014 and April 2015. This is more than twice the number the facility can cope with in the time available.

> "Why should we be concerned to create a better European identity in science? No other field, including politics, religion, economics has been more successfully international than science has been. Modern science was born in Western Europe. Therefore as Europeans we have a special responsibility for the further development of this child."
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> **Eugen Seibold,**
> *ESF president, 1990*

4. JOURNEY INTO THE UNKNOWN

Under orange coloured skies, on an enormous plateau of very hard ice called Xanadu, on the surface of Saturn's moon Titan, sits a low, wide cylinder packed with sensitive scientific instruments, none of which now transmit data. Huygens is a European Space Agency lander, and it has been there for more than nine years, in temperatures of around minus 180 °C, occasionally splashed by a chilly drizzle of semi-frozen methane, in an atmosphere of hydrocarbons, overlooking a landscape of frozen hydrocarbons. Huygens had just 180 minutes of global glory as it parachuted through Titan's atmosphere, touched down, looked around, took some photographs and sent a message home. It was the most distant contact with a celestial body; Europe's first landing on an alien surface and palpably the European Science Foundation's most far-reaching endorsement. In 1984, ESF's space science committee is on record, with the space science board of the US National Academy of Sciences, as recommending that ESA and the US space agency NASA proceed with what was then called the Titan Probe and Saturn Orbiter, a mission that later became Cassini-Huygens, a mission more than 20 years in the making, a mission that involved a seven year flight to a destination more than a billion kilometres from Earth, a mission that continues today. Cassini is still in orbit around Saturn and its moons, and still delivering discovery. Huygens was a once-chance-only shot in the dark. Happily, it was a direct hit, and it delivered what researchers like to call "the ground truth" that confirmed observations from orbit.

RENDEZVOUS WITH A COMET AND A RIDE TO THE SUN

Less directly, a second and perhaps even more daring forthcoming space spectacular can be traced back to debates in Strasbourg. Later in 2014, an ESA spacecraft called Rosetta is to rendezvous with a comet called 67P/Churyumov-Gerasimenko, place a lander on its surface, and then ride with it on its journey to the Sun. It will be a celestial firework display to illuminate the 40th anniversaries of both organisations. In 1980, a workshop in Strasbourg sponsored by the ESF forged a European strategy for planetary science and explicitly proposed a comet rendezvous and an asteroid fly-by. Eberhard Grün, then a young physicist with an interest in the primitive solar system, and now a professor at the Max Planck Institute in Heidelberg, and at the University of Colorado, was a member of the study group that identified the Titan probe as a candidate for an ESA "cornerstone" mission. *"The idea of sample return comet studies was already a major topic,"* he recalls. He was to become involved with both missions. In fact, by then ESA was already hard at work preparing for Giotto's 1986 encounter with Comet Halley, but a case for continuing planetary exploration of all aspects of the solar system at the most detailed level had been made.

All adventures in outer space have complex beginnings: they depend on ministerial support, guaranteed finance, technical capacity, scientific enthusiasm, fierce argument and perceived need. ESF's near contemporary ESA was the new agency that arose from a merger of ELDO, the European Launcher Development Organisation and ESRO, the European Space Research Organisation, and it represented a new seriousness of purpose in European endeavour. ESA had a difficult beginning: a programme of launches proposed by ESRO but never delivered by ELDO; wavering support from the science ministers of the founder governments, and a difficult relationship with the United States, which offered partnership but not necessarily on terms helpful to ESA. When President Reagan made Europe a partner in the newly-proposed, but much-delayed international space station, to which he gave the name Freedom, the French science minister Hubert Curien, who was also a former president of ESF, remarked *"I cannot help smiling at the label 'international' – I would be so much happier to meet this word in an American document."* The ESF's Space Science Committee grew from the advice network developed for ESRO and ELDO: this ever-changing body at various times included Roy Gibson and Reimar Lüst, two men who became directors-general of ESA, Sir Hermann Bondi, a former Director-General of ESRO, and Edoardo Amaldi, a physicist who played a role in the establishment both of ESRO and of CERN. (ESA's third automated transfer vehicle ATV-3, which delivered fuel, food and water to the International Space Station in 2012, was called Edoardo Amaldi).

Illustration page 16

Artist's impression of Rosetta's lander Philae on the surface of comet 67P/Churyumov-Gerasimenko. Philae will be deployed to the comet in November 2014 where it will make in situ observations of the comet surface, including drilling 23cm into the subsurface to extract material for analysis in its on board laboratory. © ESA/ATG medialab

A STRATEGY IN THE MAKING AND MISSION TO MARS

The new agency inherited an existing programme of satellites from ESRO (the first to be launched in 1975 was a celestial gamma-ray detector called Cos-B) but it also began with severe constraints on its budget, an uncertain decision-making progress, and no over-arching scientific strategy for the decades ahead. The ESF Space Science Committee got off to a quick start by confronting all the problems inherent in Europe's share in a NASA proposal for a large aperture 2.4 metre telescope in orbit. One of these problems would be the exact nature of Europe's connection with a Space Telescope Science Institute, another would be with Europe's on-board instrumentation. The timetable for this ambitious project repeatedly slipped; when it was launched, a hairline error in the telescope mirror necessitated a repair mission: however, what became known as the Hubble Space Telescope swiftly became a triumph, delivering remarkable imagery that became hugely popular with an appreciative public, and it offered an extraordinary new tool for space research. But the Space Science Committee was also given the somewhat more thankless job of setting out Europe's obligations and requirements concerned with Spacelab, an automated laboratory that would fly with the Space Transport System first announced by President Nixon in 1969, to be launched in 1981 as the NASA space shuttle. ESA's own historians say that Spacelab connection offered ESA a way into manned flight, a new foundation for transatlantic partnership, and a new level of project management experience. It was hardly a bargain: a German space chief later called it "Europe's most expensive gift to the people of the United States since the Statue of Liberty."

In the mid-1970s none of this could have been foreseen: the challenge for the Space Science Committee, beyond these immediate questions, was to identify what science did not know; what it could find out; and what in particular Europe could deliver in the exploration of the planets, moons, comets, asteroids and the swirling clouds of interplanetary dust of the solar system. In a

ESA's Huygens probe bounced, slid and wobbled its way to rest in the 10 seconds after touching down on Saturn's moon, Titan, in January 2005, a new analysis reveals. The findings provide novel insight into the nature of the moon's surface.
© ESA

landmark document from 1980, the planetary scientists who met in Strasbourg summed up all Europe's contribution to research up to that point, listed the theoretical studies necessary to make sense of observational data, proposed a set of targets for laboratory study, took a measure of proposals already in hand, and then tried to identify the challenges for the future.

SUDDENLY, A EUROPE POISED FOR A JOURNEY INTO DARKNESS

At that point, Europe had only just acquired a launcher: the Arianne rocket, even without an upper stage, would be able to lift more than a ton of payload, and put a 500 kg orbiter around Mars, they noted. Then the committee listed the capabilities Europe had already demonstrated – the capacity to build structures that would withstand the hostile environment of space, communications over epic distances, retro propulsion motors that could brake a spacecraft for a rendezvous, solar power technology and a wide spectrum of scientific instruments and then finished, "We conclude therefore that the capability of putting scientific instrumentation into deep space and operating it efficiently exists in Europe."

ESA's Horizon 2000 programme took off. The first ESA astronaut flight was in 1982, with Spacelab. Human voyages continued, with the Shuttle, Mir and the ISS. The Space Science Committee continued. A steady stream of workshops, studies, policy documents, green papers and other publications followed, many aimed not so much at ESA as at the space ministers and governments that finance such projects, others addressing the wider technical challenges of ambitious projects such as a Mars sample return mission. Among them, in 2012, was a five volume roadmap called Theseus: Towards Human Exploration of Space – a EUropean Strategy. As pulp press serial thrillers and adventure comic strips used to say: watch this space. The adventure on the high frontier continues, and the challenges are more ambitious than ever.

> "Either ESF is an organisation which does science, enables science, catalyses science, or it is nothing. I have not given seven years of my life, and much previous effort, to the pursuit of contemplative wisdom."
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> **Michael Posner,**
> *ESF secretary general, 1992*


tur: dies annorum nostrorum in ipsis
septuaginta annis.
Si autem in potentatibus octaginta
anni ⁊ amplius eorum labor et dolor.
Quoniam superuenit mansuetudo: ⁊
corripiemur.
Quis nouit potestatem ire tue: ⁊ pre
timore tuo dinumerare.
Dexteram tuam sic notam fac: ⁊ eru
ditos corde in sapiencia.
Conuertere domine usquequo: et de
precabilis esto super seruos tuos.
Repleti sumus mane misericordia tu
a: et exultauimus et delectati sumus in

5. LET THE PEOPLE SPEAK

Nobody could accuse the European Science Foundation of neglecting the Europeans. In the course of 40 years, ad hoc committees, networks and partnerships of historians, social scientists, economists, linguists, archaeologists and palaeontologists have studied the citizens of the continent in extraordinary detail: from the first hominid colonisation in the Old Stone Age through to the post-war migrations that created modern multi-cultural society. The variety of subjects is astonishing, but there are themes common to all. One is that these separate collectives of researchers were all concerned with a European landscape with permeable borders, or with no borders at all. Another is that all such studies involved moments of change, advance or occupation. Explorations of the making of the idea of a European community included the arrival of the first settlements of *Homo erectus* in the middle Pleistocene 700,000 years ago, the Neanderthals in the middle Palaeolithic, and the relatively recent takeover by anatomically modern humans, *Homo sapiens sapiens* about 30,000 years ago.

CROSSROADS AT THE END OF THE ANCIENT WORLD

Themes of migration, intrusion, adjustment and development continue across the centuries: the very first extended scholarly co-operation in the 1970s considered Byzantium, the civilisation that grew from both the Greek and the Roman worlds, and that endured for more than 1,000 years, from the founding of Constantinople in 330 AD to the city's capture by the Ottoman Turks in 1453. This set a pattern for subsequent projects: it united a number of disciplines; it demanded field work and even archaeological excavation (the steering committee proudly reports that there were 74 field trips by 52 scholars from 11 countries) and it involved setting new standards for co-operation in historical geography. A new and detailed understanding of the Roman Empire, Greek culture and Christianity in the Mediterranean world in the Middle Ages was not just interesting in its own right, the scholars concluded: it was of vital importance for the understanding of the Renaissance and of modern European states and society. All of which, over the subsequent decades, other humanities scholars and social scientists proceeded to examine, in a series of seemingly eclectic sorties and excursions into history that ranged from the medieval liturgical Latin tropes that became part of the Catholic Mass throughout western Christianity to development of chemistry as a European science between 1789 and 1939.

Having established the enduring geography of Byzantium, another co-operation turned westward and considered the Transformation of the Roman World. This was quite different from the Byzantium project. This was a study in which both the written sources and the archaeological evidence were scarce. It spanned the barbarian takeover bid for the Roman Empire mostly by peoples of Germanic origin, who either changed the culture of Rome or were partly assimilated into it, a shift in the power structure that culminated in the enthronement of Charlemagne in 800 AD. "*The story of how Rome fell has always been regarded as being of crucial importance*," Evangelos Chrysos, chairman of the programme committee wrote in 1993. "*If you are interested in the origins of Europe and the emergence of the European nations, you need always to go back to the cross-roads at the end of the ancient world*." Consciously, or unconsciously, bygone scholars had worked within the cultural or ideological boundaries of their own countries, and sought answers that served their own national or local interests. This time, researchers would try to break down the differences between separate intellectual traditions and seek a new way of telling an old and uncertain story. This shared approach to the examination of the things that Europeans have in common led in a number of directions, among them the creation of modern science.

Photo page 20

Constantinople, Luttrell Psalter folio
Whole folio (page) and border illustrations from the 14th-century Luttrell Psalter showing the city of Constantinople (bottom) and text from Psalm 89. This city was the capital of the Byzantine Empire, but here is represented as an English walled city (with banners of the Luttrell and Sutton arms). It had been sacked and captured in 1204 by European Crusaders, who established the Latin Empire (1204-1261). The Luttrell Psalter is an illuminated manuscript that was produced in East Anglia, England, and dates from around the period 1325-1335. The text is in Latin, while the marginal illustrations show saints, Bible stories and everyday rural life.

ALL THE ELEMENTS OF OBJECTIVITY AND TRUTH

So the theme of transformation continued with a research programme called From Natural Philosophy to Science. In the course of 500 years, from 1200 to 1700, Europeans came to the conclusion that there was more to matter than the four elements of earth, air, fire and water, and that the universe might not revolve around the Earth. But the programme was not concerned with retelling the story of a journey from the medieval world to Copernicus and Newton: it sought a pan-European approach to the more difficult questions of how notions of truth, certainty, objectivity and authority evolved during those years. The common approach not only united historians from different nations: it also linked separate disciplines. Alchemists, of course occurred in the story, but an earlier programme had already tackled the story of the science that fuelled the Industrial Revolution: the evolution of chemistry in Europe from the French Revolution to the Second World War, a long period of invention that drove economic change. This too suited a united approach, according to Christoph Meinel, chairman of the committee: "*It is one of the remarkable features of the emergence of chemistry that the field acquired a truly European identity early. Communication has been at the heart of the process*." But long before the textbook, the scientific journal and the newspaper, Europeans had been exchanging ideas. A programme called Cultural Exchange in Europe 1400-1700 united scholars from 21 organisations. It started from the proposition that during these centuries Europeans became increasingly aware of the ways in which they differed from Asians, Africans and – later – the Americans and how much the obvious cultural differences within Europe masked hidden convergences. This too was another multi-disciplinary approach that assembled an extraordinary range of observations – Greenland Eskimo drinking cups, translations into French of the 17th century English woman dramatist Aphra Benn, of the problems faced by translators in the Portuguese Empire – as texts for studies of the way ideas permeated the European identity.

IMPERIAL AMBITIONS THAT LED TO AN IDENTITY CRISIS

Portugal at the height of its sway had colonies in China, India, Africa and South America, and plenty of challenges for any translator, but Portugal was hardly alone in its territorial annexation. Another network had already studied the History of European Expansion: a process wider than the slave trade and imperial domination, a process which spread western ideologies such as democracy and socialism, according to its chairman, Henk Wesseling of the University of Leiden. "*Colonialism destroyed existing states and empires and introduced a new form of political organisation, the nation-state, in most parts of the world*." It also created economic hierarchies, divided the world into developed and undeveloped regions, divided labour on a global scale and created the "modern world system." One partnership focused on the emergence of the modern state in Europe between the 13th and 18th centuries, and another on the idea of a republic, and republicanism, along with the notion of a community free to govern itself. The republican tradition can be dated back to Machiavelli and the Italian Renaissance but its study set agendas that in 1995 were bristling with relevance for both the Europe of the Union, and the newly-emancipated Europe, according to the research partners.

COLLECTIVE MEMORY OF DICTATORSHIP AND RESISTANCE

The relevance of history continues. In 1994 a network of German, Dutch, French, British, Hungarian and Russian researchers confronted the much more recent past to take yet another look at a dark period of change and movement in the collective history – the National Socialist Occupation Policy. "*If there is such a thing as a common European identity, it is (and perhaps rightly) imbued with the collective memory of dictatorship, occupation, economic plunder and human exploitation, persecution and extermination of so-called racially inferior ethnic groups*," said Wolfgang Benz, chairman, of the Technical University of Berlin. The sudden access to archives in the former Soviet states and once-secret material elsewhere had made it possible to look once again – and this time from what the network called a "post-national" perspective – at questions of collaboration, reaction, resistance and persecution. As the network began, occupation and persecution disfigured political life in former Yugoslavia. As this chapter is written, old divisions exposed by the Nazi occupation of what is now Ukraine are once again dangerously alive. As Professor Benz said in 1994, the collective memory serves as a warning to future generations. Hindsight has lessons for us all.

> **"The European Science Foundation… not only represents the best of science from across Europe but also encompasses all scientific disciplines, from the life and physical sciences to the humanities. It is an independent, non-governmental organisation, a free voice that can act as a clearing house and a forum for open exchange of opinion… It is the broker, matchmaker and at times marriage counselor of European science."**
>
> **Hubert Markl,**
> *president of the Max Planck Society, 1997*


GROWTH
ADVICE
ASSISTANCE
STRATEGY
MOTIVA
HELP
INSPIRE
INNOVATION
PARTNERSHIP
PLANNING
IDEA

6. EUROPE, SCIENCE AND A NEW ERA

If the future has changed for the European Science Foundation, it could be because the ESF helped the process. In 1975, the idea of "European science" was uncertain, ill-defined and in any case improbable. There were huge and increasingly successful European co-operations such as CERN and ESO but these were driven by the needs to share the burden of expense. They were "big" science, fuelled by long-term commitment, and as successive directorates became acutely aware over successive decades, national commitment to such programmes could waver. The partnerships that coincided with the founding of ESF – among them the European Space Agency and the European Molecular Biology Laboratory – were driven by the same challenge: the costs were huge, and no single country could expect to sustain them all. And although each of these great European co-operations embraced a suite of scientific disciplines and engineering skills from across the continent, and delivered increasingly impressive results, the idea of "European research" remained an abstraction. *"When the ESF was founded it was very difficult to get people to work across international and disciplinary boundaries, largely due to lack of funding,"* Lord Flowers, the Foundation's first president, recalled on the ESF's 25th anniversary. "*The ESF was, to be frank, an experiment, yet it has proved its usefulness through the number of programmes it runs, all peer-reviewed*." His successor, Hubert Curien added "*There isn't really such a thing as a European at the moment. This diversity has its strengths but it also has its weakness: it makes it much more difficult to reach a consensus*." He identified another enduring problem: lack of political will. *"We have to put science at the heart of government,"* he said. "*We are surrounded by science and technology but too often it's not properly represented round the policy-making table*."

HOW TO PUT SCIENCE NEAR THE HEART OF GOVERNMENT

But by then, CERN had become the world centre for particle physics, an international partnership was racing to sequence the human genome, and the World Wide Web had begun to make the notion of the "global village" a reality. Attitudes had already begun to change, in the universities, in the national academies, in industry. Research partnerships flourished across the Atlantic, and increasingly across European borders. There is a case for arguing that an assembly of ever-changing scientists and managers based in a modest headquarters down a narrow street in a historic city in Alsace, and backed by far-seeing Member Organisations, gradually created the idea of a European research area that was quite distinct from any national science programmes, but that could supplement and complement them all, and that within half a lifetime would make the idea of a European Research Council, with its own budget, its own staff, and its own mission statement, seem not just plausible but compelling. ESF's strength, argued Sir William Mitchell, a former British research council chief and by 1992, an ESF vice president, was that it could serve scholars from all academic fields and across Europe "*with a relatively small staff and without any bureaucratically-generated stance in any particular field*." It catalysed a huge number of scientific networks and programmes and increasingly it became regarded by governments as a Europe-wide source of independent and objective advice, Mitchell said.

The relative modesty of the ESF's budget inadvertently worked to the advantage of European science, according to Hubert Markl, president in 1997 of Germany's Max-Planck-Gesellschaft. "*As a small and mobile organisation, the Foundation has gained the freedom and flexibility to concentrate on new ideas and unconventional procedures, something that more unwieldy larger institutions cannot have*." Sir Dai Rees, president of ESF at that time, and like Mitchell, a former head of a British research council, says *"To achieve any serious results, one clearly has to build up a reputation which is solid enough for people to look to ESF automatically for enlightenment on such questions. I was therefore delighted to find such a large and comprehensive body of really good stuff produced after I left. ESF certainly picked up the ball and ran with it."*

"ESF has played an important role in the evolution of European research. In establishing Science Europe, Member Organisations are building on this legacy and taking strategic collaboration to the next level by developing new policies and activities to strengthen the ERA."

Paul Boyle,
president, Science Europe, 2014

CRITICAL LEADERSHIP ROLE FOR THE 21ST CENTURY

Out of this continuous search for the pan-European element in scholarship, there gradually emerged the idea of a European intellectual area, which soon enough became the European Research Area. By the turn of the millennium, scientists had begun to believe that European science – after more than a decade of constraint even in those countries with a long and powerful tradition of science – could compete on the world stage. The US policy expert Tom Ratchford of the George Mason University in Virginia told the ESF general assembly in 2000: "*As a unique European institution that spans not only the continent but the range of issues from basic research to technology policy, the ESF can play a critical leadership role in defining Europe of the 21st century*." By then, too, both the EU leadership in Brussels and the national governments had begun to take both the idea of the "knowledge society" and science as the basis of economic growth seriously. Change was in the air anyway. And it gradually created a culture in which it became normal to seek cross-border partnerships within one continent. The Lisbon presidency of the European Council in 2000 had declared a European Research

Photo page 22

Conceptual computer artwork.

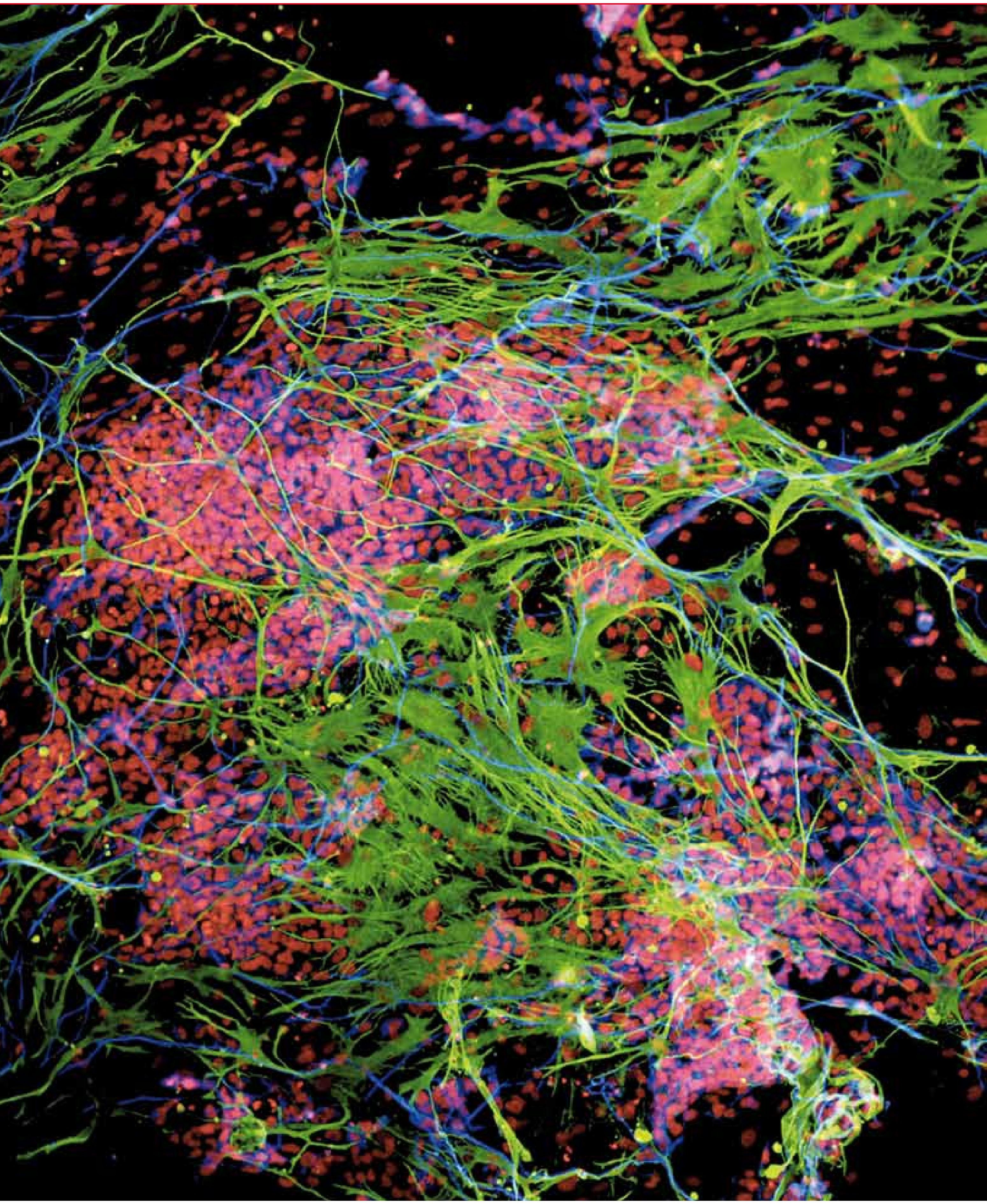
Area and stressed the importance of science, and science partnership. EU fellowships and collaborative network programmes had been an effective stimulus, says Sir Martin Rees, Britain's Astronomer Royal and a former President of the Royal Society. "*As a young researcher 35 years ago I met my counterparts from mainland Europe in the USA – that's where we all went to gain postdoctoral experience. It was probably the same for others here. Now things are different. Young scientists are more likely to migrate within Europe.*"

The ESF's position papers were part of the mechanism that drove change, according to Enric Banda, the geophysicist who took over as secretary general in 1998. "*I still remember one called New Structures for the Support of High Quality Research in Europe. It was taken up politically by the Danes and then it took off,*" he recalled. "*It was a fantastic contribution to European policy.*"

SCIENCE THAT OUTGREW THE IDEA OF SOVEREIGNTY

This was the 2003 position paper that formally proposed the European Research Council, and Banda was already behind the idea. He had argued in 2002 that science was by its nature, international, yet seen as a national responsibility by the government agencies that funded it, and wished to guard their sovereignty. The case for an ERC, Hans Wigzell of the Karolinska Institute in Sweden had argued in 2002, was that it could be run by scientists, for world-class science. The Framework Programmes of the EU had been important in starting to move scientists together but, he said these were "*loathed by many scientists, who describe them as Loch Ness monsters of bureaucracy.*" The ESF's position paper summed it up: it argued for "*an ERC, which should encompass all disciplines (including the humanities and social sciences), could act as a spearhead for institutional reform; a catalyst for new inter- and transdisciplinary research activities; a creator of new trans-national funding opportunities for young researchers; and last but not least, the provider of a more research-friendly administrative and organisational environment urgently needed to attract more foreign researchers.*" In a sense, by making the case for the ERC, the ESF had argued itself out of a job, and Helga Nowotny, chair of the European Research Advisory Board, all but said so at the time. Quite what happened to ESF would depend on how the ERC took shape but "*in any case, ESF will face major structural changes – which it has already begun to acknowledge and tackle.*"

> **"I recall that ESF's founders originally envisaged it becoming a 'European Research Council'; it is not that in fact, but few research councils have achieved so much with so little."**
>
> **Lord Flowers,**
> *founder president of ESF, looking back on 15 years of achievement*



7. READY FOR ANYTHING

To an outsider, one thing emerges clearly from a study of four decades of reports, documents and announcements prepared by the scientific committees, staff and officers in Strasbourg: the European Science Foundation could be quick off the mark. It saw a need, acted, and advised; sometimes the response even seemed to anticipate the stimulus. The organisation was born in 1974, and the 1975 annual report identified concern about the risks of genetic manipulation, a study of which *"should be based on scientific expertise much wider than that of molecular biology alone, and should have regard to legal, philosophical and religious aspects as well as the direct applications for agriculture and health."* All of which showed a sympathetic awareness of an undercurrent of public alarm at the time. In 1974, politicians and members of the public alike knew almost nothing about DNA, and if they did, were not explicitly aware that almost every cell of every living thing shared and replicated the molecule on a daily basis, and when they heard about recombinant DNA technology, were inclined to imagine science fiction nightmares in the laboratories. Sinister new plagues might bubble up from test tubes; ominous new life forms might escape and change the course of evolution. In the US, biologists were to stage the historic 1975 Asilomar Conference in California to address exactly the same concerns, and to end their voluntary moratorium on the infant technology of gene splicing and genetic manipulation. In some countries the unease remains – at least in relation to human genetics and to food crops – but by 1977, Sir John Kendrew, the head of the European Molecular Biology Laboratory was able to state, in an annual lecture to the European Science Foundation, that the hazards were hypothetical. "*They might exist, but there is no evidence that they do.*"

THE QUICK-RESPONSE, PROBLEM-SOLVING STUDY GROUP

If the study of the challenges of genetic manipulation was a response to a perceived need, others were anticipations of problems still in the making. The ESF helped set up a European Mathematical Federation and – appropriately for a science foundation based in one of the great cathedral cities – organised a partnership on the preservation of stained glass. It then began making an inventory of existing and anticipated ground-based telescopes within member states, on the grounds that it would be a "useful tool for individual astronomers and a help in promoting their collaboration." It also launched an ad hoc committee on biological recording, systematics and taxonomy: throughout the decades, there would be attempts to make tallies of the flora and fauna of Europe and its surrounding seas. Humanities scholars and sinologists announced in 1977 that they wanted to create a "canon" of Taoist scriptures and begin an examination of past and present Chinese statecraft. This was one year after the death of Mao Zedong, and the arrest of the notorious Gang of Four, that finally brought an end to more than a decade of convulsion in China known as the Cultural Revolution, an episode marked by the widespread loss of China's heritage. The three volume Handbook of the Taoist Canon was finally published in 2004, to be described as a "milestone" in Chinese studies. In 1978, the year that Louise Brown, the world's first "test-tube" baby was born through in vitro fertilisation, the ESF set up a study of the legal and ethical aspects of medical research into human reproduction. In 1980, the ESF drew up a statement called The Protection of Privacy and the Use of Personal Data for Research, another anticipation of what would become an enduring problem in a world of widely-digitised data. The 1982 annual report introduced a toxicology group that was already examining the consequences of a tragic criminal operation in Spain, involving the sale of adulterated olive oil, in which 600 people died. Many projects seem to have either been well-timed, or launched in response to unexpected events. The European Science Foundation's forest ecosystem research network was more or less co-incident with widespread anxiety about the impact upon European forests of acid rain: aerosol discharges from power station chimneys fell as a dilute solution of sulphuric acid, and – for a few short years in the 1980s – there was widespread alarm about *Waldsterben* or forest dieback. European scientists in 1984 gathered to talk about atmospheric chemistry even before the discovery of the devastating hole in the ozone layer in the Antarctic that led to the banning of CFCs. By 1985, ESF had become a partner in the JOIDES ocean drilling programme and by 1987 had begun to explore the value of "natural archives" such as tree rings, peat-bogs, lake and ocean sediments, polar ice sheets and mid-latitude glaciers as evidence of climate change. Global warming at this stage had yet to make news headlines: these would not occur until the devastating heat extremes and drought in North America in 1988. So once again, it looks as though ESF is ahead of events.

HOW TO SPOT A HAZARD BEFORE IT HAPPENS

In fact, this is more probably evidence that many alert and inventive scientists had begun to understand what ESF could offer. By the mid-1980s, scientific networks had arrived: a new, cost-conscious way of establishing partnerships. Peter Colyer, scientific officer with responsibility for networks, remembers that many such began with ideas from individual scientists: "*Bottom-up – it's a bit of a cliché but it does describe the origins of most of the networks. Some of the best proposals arrived unexpectedly and unsolicited. The network scheme was deliberately open to ideas coming directly from active scientists,*" he says. "*Of course some nudging and encouragement was also required. Although ESF was, in theory, connected to all European scientists through the Member Organisations, most scientists were not informed about ESF and what it could offer them.*"

Some ESF responses began with formal requests: ESF and its committees formed "think-tanks" to gather opinion and deliver advice. As the years passed, the ESF's networks multiplied and the demands for advice and common viewpoint grew in number. The 1980s saw a series of spectacular volcanic disasters, including the murderous lahar of Nevado del Ruiz in Colombia in 1985 to the toxic eruption

Photo page 22

Stem cell-derived nerve cells. Fluorescence light micrograph of neural (nerve) stem cells that have been derived from human embryonic stem cells (HESC). Tuj1 protein is blue, glial fibrillary acidic protein (GFAP) is green, and cell nuclei are red. HESC are pluripotent – they are able to differentiate into any of the 200 cell types in the human body. The type of cell they mature into depends upon the biochemical signals received by the immature cells. This ability makes them a potential source of cells to repair damaged tissue in diseases such as Parkinson's and insulin-dependent diabetes.
© Silvia Riccardi/Science Photo Library

of Lake Nyos in Cameroon in 1986 so the volcanologists formed their own network. There were huge public alarms over genetically modified foods and in 1997 ESF was called upon for advice. Dolly the Sheep became the first cloned mammal, so there had to be a protocol on attitudes to the cloning of humans.

These were exercises with lessons for everybody. "*Some of the smaller countries in Europe were especially aware of limited capacities to make authoritative and well-grounded recommendations*," Sir Dai Rees, president from 1994 to 1999, remembers. "*They felt the need to find others with whom to join forces. We needed to do some work on characterising the various bigger pictures. Those of us in larger countries were not always so modest, but once we started talking we were surprised (to our shame) to find how stimulating and helpful were the perspectives from elsewhere*."

The issues and the anxieties continued to emerge, and ESF continued to respond: the spread of antibiotic resistance, the hazard of direct asteroid strike and the possibility of very large scale industrial accidents – in 1999 toxic sludge flowed into a river in southern Spain and launched the Coto de Doñana ecological disaster – all provoked a need for collective preparedness. ESF was, says Enric Banda, former secretary general in the first years of this century, in the business of giving advice. "*We were always on the edge of research. The big money was with the different nation states. We had the ideas, we had the enthusiasm to get people together, but the money was not in our hands, it was in the hands of the countries, and the Commission.*" But ESF did play an important advisory role. "*We were asked for advice. Countries would say: can you look at it?*"

Ian Wilmut and Dolly. In 1996, British embryologist Professor Ian Wilmut created "Dolly", the world's first sheep cloned from an adult sheep cell. The research was conducted at the Roslin Institute in Edinburgh, Scotland. The cell nucleus was removed from an egg cell taken from a Scottish Blackface ewe. Next, an adult cell from the udder of a 6-year-old Finn Dorset ewe was cultured and injected into the enucleated egg cell. A spark of electricity then fused the udder cell with the egg cytoplasm and stimulated the egg to grow into an embryo in the womb of a surrogate sheep. Photographed at Edinburgh's Royal Museum, where Dolly has been displayed since her death in 2003.

"ESF's advice is rooted in the knowledge and expertise of 62 scientific institutions spanning 21 European countries and all the scientific disciplines, including the social sciences and humanities. This has enabled the Foundation to provide science with a voice at the European level."

Peter Fricker,
ESF secretary general, 1998

8. PLACES TO GO, PEOPLE TO SEE

It was on a scale far greater than any wartime invasion or occupation, and it signalled a change more far-reaching than any revolution. After 1918, and even more so after 1945, Europe become a zone of migration. The sum of migrant workers involved "*a larger population than that of many European countries*," wrote the French philosopher and social scientist Jean-Jacques Salomon. "*Not only did the migrant workers initially form a seventh state within the six Common Market countries, and later a tenth within the nine EEC countries, in terms of numbers, but they also populated a new territory with psychologically, sociologically, linguistically and culturally fluctuating borders, moulded by the characteristics and traditions of the sending as well as the receiving countries.*"

Salomon chaired the ESF standing committee that produced the ground-breaking Report on Studies of the Human and Cultural Aspects of Migrations in Western Europe. In 1977, as the ESF launched a series of programmes and partnerships to revisit the history of the continent, and even before the first decisions to explore the geological and tectonic structure of Europe's home territory, social scientists identified migration as a profoundly important and enduring field for study. This migration was both internal and from abroad: migrant workers flooded into the industrialised cities of northern Europe, while sun-seeking tourists from the north began to change the nature of the increasingly deserted villages of the southern Mediterranean. Nations which had once been imperial powers found themselves increasingly at home to workers from what had once been colonies: the clash of different cultures, Salomon said *"drafted the outline of new traditions and cultures."* The experience played into contemporary culture in all sorts of ways: the German coinage *Gastarbeiter* or guest-worker became a familiar term in other languages; British television screened a hugely popular series called Auf Wiedersehen, Pet about British guest-workers on a construction site in Düsseldorf. Demographers and economists could measure and monitor change, but what did migration mean in human and cultural terms?

THE NEW ARRIVALS WHO CHANGED THE CITIES OF EUROPE

Having put those questions, successive committees, networks and programmes went on to examine similar and inter-connected questions for the next three decades: the changes in demography in Europe that made immigration an imperative; the questions of identity that confronted settled migrants and their children in the new homelands; the residues of suspicion and hostility among settled and incoming populations; the embrace of aspects of migrant culture; the problem of those communities always on the margins of society; issues of language choice and local loyalties; and – since migration raised questions of political choice – the problems of belief in government itself. Separate from, but intimately connected with this dramatic change in the makeup of Europe's population, was the launch of the European Social Survey, a project so ambitious that ESF officers grouped it under the heading of Big Science, to keep company with shared neutron beam sources and synchrotrons.

The first examination of mass migration in peacetime Europe began in the first years of ESF, during a kind of pause in the movement into the western countries, chiefly because, in the economic downturn that followed the OPEC crisis of 1973, there were fewer jobs to migrate towards. Experts in linguistics could however, find something to do: a huge population of new workers all had to learn, however imperfectly, to buy food, rent accommodation and negotiate transport in their new home, and thus presented an opportunity for an ESF "additional activity" called Second Language Acquisition by Adult Immigrants. Other demographic changes – lower fertility rates, consensual unions, more frequent divorce and an ageing population – created both migrant opportunities and occasions of concern, and in 1989 inspired an ESF network on Demography and Social Change. By 1993, the migration issue had acquired even greater urgency and yet another ESF programme had returned to the theme.

"*Within Europe and beyond, millions are on the move, their journeys reshaping the human mosaic whose study lies at the heart of geography*," wrote the geographer Russell King, who had just edited yet another ESF study called Mass Migration in Europe: the Legacy and the Future. "*Albanian boat people on the Adriatic Sea, Bangladeshis occupying a disused spaghetti factory in Rome, Filipinos running away from an erupting volcano, refugees fleeing out of former Yugoslavia – these are just some of the images recalled from the last couple of years.*" The oppressed of the East were lured by the promise of the West, the impoverished of the South sought a slice of the riches of the North, and political rhetoric had taken a military tone, with references to "Fortress Europe." Migrants had been temporarily recruited because of a shortage of labour in the post-war boom years. These guest-workers, however, tended to stay, settle and create multi-ethnic populations in many European cities, doing a range of low-paid manual jobs that the local workers did not want to do. Migrant communities suffered from high rates of unemployment, their children attended overcrowded inner-city schools and emerged with few qualifications and a sense of "not belonging". Many of these were joined by people seeking political asylum, or by clandestine immigrants. But as the world's labour market became more international, Western Europe also became a major theatre of highly skilled and professional migration. The Iron Curtain that had once divided Europe "*seems to have been converted into a 'welfare curtain' protecting the West from East European immigrants*," Professor King observed. But, he warned, with the planet's population growing at 250,000 a day, an extra billion in one decade, control and exclusion would be politically infeasible. That left, of course, Europe's poorest people with nowhere to go.

HOW TO TAKE STOCK OF A SHIFTING POPULATION

Within two years, the same programme – it was called Regional and Urban Restructuring in Europe – had delivered a study called Europe at the Margins: New Mosaics of Inequality, and it addressed the stresses evident all too clearly on the streets of the big cities. More than 50 million people in Europe were classified by the European Commission as "poor" because they survived on half the average per capita income of their respective member states, and their number was increasing. Average unemployment in the under-25 group had reached 20 per cent. "*The new Europe cannot*

Photo page 32

Crowd of commuters boarding an underground train in London, England.
© Annabella Bluesky/Science Photo Library

be built on a basis that is sustainable in the long term, with so many people and places 'missing out' as they are at present," the authors warned. Within another two years, yet another consortium of social scientists had set out to find a little bit more about the new Europe, and devised a blueprint for a European Social Survey that would deliver systematic and regular data and provide analyses that could inform both national and European policy making.

The idea was not to duplicate the multiplicity of opinion polls, questionnaires and research already available to social scientists. It would benefit all member states, and help build infrastructures for social research. And it would maintain strict standards: a demand that immediately set new puzzles for those who had to compose comparative questionnaires. These puzzles of course were compounded by the now large and settled immigrant communities in Europe, puzzles predicted by Jean-Jacques Salomon 20 years earlier. "*For instance, are there functionally equivalent words or phrases for 'slightly agree', 'slightly disagree' or 'just a bit' in Polish, Bengali or Japanese*?" wondered Professor Roger Jowell, who headed the methodology committee. "*The fact is that different languages are not just equivalent means of defining and communicating the same ideas and concepts. In many respects they reflect different thought processes, institutional frameworks and underlying values. Good science demands that we don't turn a blind eye to these issues*."

"Imagine if you look back to medieval times, the time when the oldest European universities were founded. In those days the most natural thing in the world was to travel, even if it was very difficult to travel within Europe. So we had a time in the past when it was common for the intellectual elite to move across the whole range of the former Roman Empire. Since then we have split up into many nations. We have to overcome this division not by losing our cultural differences, but by combining them."

Hubert Markl,
president of the Max Planck Society, 2001

9. ADVENTURES IN THE SEA AND ICE

The first focus was – of course – on Europe, its structure and history, its people and its resources. But very swiftly the European Science Foundation began to look beyond its borders. During more than three decades of networks and programmes, ESF-sponsored scientists drilled holes in the ocean floor, took deep cores from glaciers in Greenland and Antarctica, followed the great ocean currents, modelled the interplay between global atmosphere and global ocean, explored the global climate of the last 66 million years and then began the attempt to understand the changes that have shaped the planet in the last 20 or so million years, along with the evolution of the plants and animals that now occupy the landscape. Since any research that involves snow vehicles, icebreakers, aircraft, helicopters and very long distances is expensive, international co-operation already existed: European partners embarked on joint polar research during the International Geophysical Year in 1957. But in 1985 ESF established a polar research network to identify projects in glaciology, geology and ecology. The geologists wanted to study the history of the separation of Greenland and Spitsbergen; the glaciologists wanted to explore ice sheet dynamics and the climate connection. Western and Northern European countries packed 120 scientists on the German icebreaker Polarstern for five months in 1988 and 1989 in the Atlantic sector of the Southern Ocean, to explore the life in the sea ice, in the pelagic zone and at the sea floor. Some European countries were already members of the Deep Sea Drilling Project but another 12 joined, in an ESF consortium, to drill into the ocean bottom at a range of latitudes to examine the climate history recorded in the sediments. There was even a hope that they could get through the ocean crust to the Mohorovicic discontinuity that marks the crust-mantle boundary. This ambition proved to be beyond the reach of the most advanced technology. But the project delivered hard evidence – literally rock hard evidence – that could confirm, disprove or reshape many of the hypotheses so far built on less direct study. It also offered a kind of international university in which every participant aboard the drilling vessel became a student, learning from others. In 1987 ESF's then President Eugen Seibold called the signing of a partnership between the US National Science Foundation and ESF that took European nations into this kind of Big Science "one of the highlights of my whole geological career".

CLAIMS, COUNTER-CLAIMS AND CALM QUESTIONS

At around the same time, another group of European scientists embarked on a study of the climate of Europe and what humans had done to it since the end of the last glaciation. "*Innumerable scientific and pseudo-scientific reports on ozone problems, the greenhouse effect, an anticipated global warming of the* *atmosphere and visions of world-wide rising sea levels have been startling emotions all over the word – and the need for basic research has been felt urgently*," said Burkhard Frenzel, who chaired the research group. The ocean-going research was extended through the ESF's network mechanism and by 1993, a party of marine geologists set off aboard the Russian research vessel Gelendzhik, to sail the Mediterranean and learn at first hand the story told by the sediments at the bottom of a landlocked sea.

"*The Dutch saw the network as a brilliant means of enabling a larger group of young scientists from several countries to participate in real-time survey cruises. Each summer for three years, we sponsored a research cruise in the western, central and eastern Mediterranean respectively. So everybody benefited – the Dutch extended their work, other young scientists joined them, and the Russians defrayed some of the costs of their vessel*," says Peter Colyer, who coordinated the ESF networks at the time. "*I arrived at the ship in Barcelona with a suitcase full of US dollars, part of ESF's contribution to that year's cruise. Half an hour later, most of the crew were seen going down the gangway for a few hours shore leave. They had been paid. ESF Member Organisations might not approve their funds being spent in the bars and fleshpots of Barcelona, but most expenditure on science goes in salaries and wages, and employers cannot decide what the staff do with their money*."

Photo page 36

Brunt Ice Shelf boundary (down centre) with the Antarctic Sea. An ice shelf is a sheet of ice that extends over the sea from land. The ice cliffs seen are up to 25 metres high. Icebergs (upper centre) form at ice fronts due to the weakening of the shelf caused by the action of the sea. Fast ice (sea ice) has frozen to the ice shelf (centre to bottom centre).

THE ANSWERS THAT LIE FROZEN IN THE POLAR ICE

By now European scientists had begun to think in terms of "grand challenges" and the ESF and the European Commissioners had established ECOPS, a European Committee on Ocean and Polar Sciences. This was to be followed by a Marine Board, and a European Polar Board, both under the ESF umbrella. Collectively, scientists launched EPICA, a European ice coring programme in Antarctica, which by 2004 was to bring to the surface ice cores more than 3,000 metres long that offered testimony to the history of climate for the last 800,000 years. There was also a huge initiative aimed at operational forecasting of the ocean and coastal seas, a master plan to explore the largely unexplored Arctic Ocean, and another to investigate the unexpected variety of the floor of the deep sea. This had once been seen as a relatively homogeneous environment which altered very slowly. *"Recent discoveries have changed this old picture dramatically,"* the first ECOPS memorandum observed.

By the 1990s, too, questions about global warming and climate change had a fresh urgency. How fast did ice caps melt in prehistory? How swiftly would sea levels rise? What controlled the cycles of warming and cooling before the Industrial Revolution tipped the scales and set the global thermometer in one ominous direction? ESF aimed high, and backed an Airborne Polar Experiment to study not just the ozone levels at the poles but the behaviour of the Arctic and Antarctic polar vortexes, and the behaviour of polar stratospheric clouds. Instruments were borne on a dual turbofan Russian aircraft that could carry a research payload of 1,500 kg, could reach altitudes of 22 km and could stay aloft for 5 to 6 hours. Another project focused on the Arctic Ocean and the Nordic Seas during the last 2 million years, and the global "ocean conveyor belt" that regulates the European climate. Around 140 scientists from Europe, Russia, Canada and the USA began a co-operation into understanding just how the oceans distributed heat around the globe. This research was based on measurements and laboratory experiments but above all on mathematical modelling. Ocean drilling advanced with a new ship, the JOIDES Resolution, that could operate at depths of up to 4,000 metres with a much smaller drill and could begin to answer questions not just about sea floor structure but – an increasingly important theme – the potential for oil and gas exploration.

MARVELS OF A DISAPPEARING MEDITERRANEAN SEA

This is not a story with an ending. The exploration of the planet is likely to continue as long as there are people on the planet, but by the beginning of the 21st century, European scientists had between them, and working through a series of programmes, composed a dynamic picture of the enormous geographical and environmental changes during the last 12 million years. It was called Environment and Ecosystem Dynamics of the Eurasian Neogene: EEDEN for short. It pulled together some of the separate strands of previous projects, including the Messinian salinity crisis. This was a layer of salt on the sea floor that testified that the Mediterranean and closed up, and evaporated, in the past, just one of a series of changes that altered ecosystems and helped make modern Europe what it is today. It is worth remembering that, in 1974 when ESF was formed, the theory of plate tectonics was still contested; the submarine volcanic system that drove sea floor spreading and delivered energy to an unexpected set of submarine communities had yet to be discovered; the biology of the ocean trench and abyssal plain was a mystery; the long term natural cycles of climate change were only dimly understood; and the greenhouse effect was still an entirely theoretical proposition. The last 40 years have been a voyage of discovery for everyone.

"As today's world becomes ever more complex and interdependent, ESF is unique as a European organisation in being active across a whole spectrum of advanced knowledge. Besides representing an unparalleled source of expertise, we also have the ability to co-ordinate and manage science and technology activities, rather than just contribute to the definition of related policies. This is the core strength on which we must build."

Umberto Colombo,
ESF president, 1992

10. THE TRANSIENT INVISIBLE LIBRARY

Some things become clearer with hindsight. In its 40-year history, the European Science Foundation has become the collecting point, temporary archive, and unfinished index of one of the greatest, most eclectic and largely invisible collections of information ever to be assembled on an ad hoc basis. With a membership that extended from Iceland to Istanbul, from Lapland to Lampedusa, and that united scholarship in disciplines ranging from musicology to advanced mathematics, from geophysics to gerontology, and from economics to early Hebrew semantics, this should be no surprise. Since the whole purpose of the ESF was to introduce scientists who had never before worked together, and to create a new synergy, information began to gather like moss on a moist stone. The new teams of scholarly partners began by compiling lists: ordered information is always important for people who want to avoid duplication and make the most of limited resources. Astronomers in Europe started to calculate how many telescopes they had, or expected to have, and then started to count themselves (they were pleased to find that there were 2,400: they outnumbered US astronomers, and were on average younger, too). Marine scientists began by compiling an inventory of 750 current research projects. Humanities scholars announced a plan to catalogue manuscripts in European archives (these were, the ESF annual report for 1977 confessed "very out-of-date" in many of the "most eminent libraries"). Biologists very quickly started talking about taxonomy: since plants, animals and fungi do not heed national borders, there would be obvious value in shared lists. Since the purpose of inventories is to identify what is missing, Europe's biologists immediately began to compile a survey of plant-parasitic nematodes, with a final goal of computerised maps showing the distribution of different species in each individual country. There were also to be handbooks of marine fauna of south-west Europe and the Mediterranean, and the invertebrate fauna of Scandinavia. Within a year or two, the same scientists were talking about *"a complete European Floristic, Taxonomic and Biosystematic Documentation System,"* a reminder that the business of identifying and grouping species remains a work in progress.

ASTRONOMERS COUNT, ARCHAEOLOGISTS TAKE STOCK

Europe's archaeologists – scholars once again concerned with civilisations that extended beyond national boundaries – set about compiling an inventory of existing facilities: 500 laboratories and institutes in 14 nations in 1978. By 1979, this tally had grown to 695, and embraced all member states except Portugal, Yugoslavia and Turkey. The archaeologists had also started listing their collective resources in aerial photography, geophysical and geochemical sampling, underwater archaeology, palaeobotany, archaeozoology, and the central indexing of individual archives. In a world in which computing was still novel, bewildering and of not-yet-proven value, the humanities scholars proposed a computerised documentation centre of original and modern translations of Biblical texts. They also wanted to organise the "extensive archival material collected by the Inquisition": both projects were reminders that the Judaeo-Christian tradition both united and divided the people of Europe. Brain and behaviour research in Europe had its own training programme, the administration of which was in 1979 transferred to the ESF, a move that metaphorically made Strasbourg the nerve centre of European neuroscience.

But only metaphorically: because in the course of the years research programmes were created, ran their course and then ended. Assemblies of scientists formed and then separated, with an uneven record of subsequent publication of research findings. Some projects ended with a final report commissioned by the scientific committee that embraced and weighed every aspect of the investigation: some ended up with a formal statement and an indication that individual academic publications would follow. Some just ended with workshops, informal partnerships and mutual stimulation that might lead to yet further co-operation. The ESF's committees and scientific officers who had to manage and facilitate such projects had – in theory – an opportunity to become keepers and indexers of a glorious collection of eclectic, unexpected and valuable data and reference material. But only a brief opportunity.

"*All the professional staff were on short-term secondments from national bodies, usually around for three years. This meant that no one was likely to see an activity through to completion and beyond, so there was no invisible repository*," recalls Peter Colyer, who co-ordinated the ESF network system during the 1990s. "*One or two of my colleagues had their secondments extended so they became virtually permanent members of staff, but this was risky: they broke the link with their sending organisation so there was no job to go back to.*" Secretaries-general, too, were appointed only for a term, and were always under pressure from Member Organisations to find places for new staff, so both the scientific projects and the organisation that made them possible were – like science itself – always in a state of flux and ferment. Money, too, limited the scope for achievement: in 1987 the great editor John Maddox wrote in the journal Nature that "*evidently, ESF has been embarrassed by the proposals that have come its way. Only nine of thirty or so have been accepted so far... The general opinion is that ESF's budget should be ten times bigger than it is.*"

ANCIENT INSECTS, ENDURING DIALECTS AND CHRONICLES OF KINGS

But out of this continual growth and renewal, always fertilised by enthusiasm and pruned by budgetary restraint, some powerful co-operations took root, and bore fruit. Scholarship advanced, and the new ideas were born. One scientific network united specialists in fossil insects, creatures that had been around for 400 million years, organisms that constituted four-fifths of all living things. The network embarked on its own palaeoentomological data bank, a project to trace the phylogeny of fossil insect relationships and to identify the evolution of the pupa or chrysalis stage; there was a third project to understand how such fragile tissues became preserved, and a fourth to examine what such fossils could reveal about ecosystems and climate regimes of the past. Another network pursued an even less tangible but increasingly important question: the way Europe's dialects – among them Frisian, Catalan, Galician, Bosnian, Croatian and even the German *Sprachinseln* of the former Soviet Union – converged and diverged, and the role these dialects played in regional identity and political status. Some projects were concerned not with the "what"

Illustration page 40

Infinite library, conceptual computer artwork. This could represent the increasing amount of information available online.
© Christian Darkin/Science Photo Library

of scholarship, but the "how and why". Europe's medieval historiographers got together in 1989 to compare notes, for instance, on the way the chronicles of 13^{th} and 14^{th} century Castile reflected the pretensions of contemporary royalty, while the Norwegian and Icelandic Sagas could be interpreted as reflecting the value systems of kings and nobles in a relatively egalitarian society.

Other programmes actually created the foundation for new information: new and advancing technology drove the creation of what are now vital Geographic Information Systems but it was an ESF scientific programme that formulated their objectives and made possible a network to maintain integrated systems that would deliver enduring rewards. Some of this drive to assemble and record the resources of knowledge found enduring security. One repository is now MERIL, ESF's Mapping of the European Research Infrastructure Landscape. Another became ERIH, the European Reference Index for the Humanities, a catalogue and at the same time a showcase for the variety and liveliness of Europe's scholarship. Once again, the sheer variety of the projects that flowered and occasionally faded in the 40 years of ESF is slightly dizzying: the crystallography of biological macromolecules; the interplay between music and Europe's collective cultural history in monastery, cathedral, concert hall, opera house and private salon; even the powerful and enduring relationship between scientific advance and the visual image that illuminated it. There were programmes of big, enduring concerns such as forest ecosystems and the biology of tropical canopies, and even a network on an evolutionary wild card. In 1993, European researchers announced four workshops to take the measure of impact cratering in Europe. Impact craters are the geological scars created by the arrival of asteroids at 20 kilometres a second, each of them potentially a punctuation mark in the story of life on Earth, and any one of them potentially a death sentence for human civilisation, bringing to a full stop all scholarship and all academic proceedings, including of course any invisible library as well.

"The case for spending two days travelling to and from Strasbourg cannot simply be the food. The truth is that the European Science Foundation seems to be every participant's concept of what constitutes a good idea. The budget may be small, but is it not the future of European research in microcosm?"

John Maddox,
editorial in Nature,
3 December 1987

11. THE PULSE OF A CONTINENT

Health matters, especially to those who don't have good health. Overall, Europe spends about a tenth of its gross domestic product on health and medical care: that is €2730 per person per year, but only about €40 per person per year on all health and medical research of the kind that might extend healthy lives. Spending on tobacco and alcohol per person is about 20 times higher. As the European Medical Research Councils have been saying for more than 40 years, health research is an investment for the greater good. The EMRC took shape in 1971, and by 1975 had become one of the standing committees of the infant European Science Foundation, from where it prompted, sponsored, encouraged or embraced a wide range of initiatives, all of them directed to a healthier Europe. During the 1990s the EMRC identified the environment – air quality, clean water, buildings, traffic, food, diet, trace elements, industrial toxins and so on – as a key component in any public health programme, and at around the same time both the European Commission and the World Health Organisation arrived at the same conclusion. The outcome was an intergovernmental conference of WHO and European health ministers in Helsinki in 1994, and from this the European Science Foundation, and its EMRC standing committee, identified seven key areas where actions could make a significant difference to public health.

AIR OF UNCERTAINTY, EVEN BEHIND CLOSED DOORS

At the conference request, the ESF then went on to formulate 10 fields where research could deliver benefits. It omitted smoking, because that involved individual choice. It omitted specific areas of alarm, such as the endocrine disruptors that stubbornly maintained a low but detectable presence in the water supply of almost every modern country, not because these were safe, but because they were already being studied in great detail. But that left ESF's standing committee and its member scientists plenty to think about. What followed were workshops and other examinations of some big environmental issues, and some finer details. Ambient air particulates – the levels of aerosols, fumes, exhaust discharges, soot and other fine particles in the air – became one big theme. Levels of these could be linked to variations in mortality, morbidity and pulmonary function at very low levels: even lower than Europe's proposed or existing air quality standards, and so low that it seemed there could be no levels at which researchers could confidently say that no effects could occur. Another was indoor air pollution: on average, most people spent seven tenths of the day in offices, homes or enclosed public spaces, exposed to dust, mites, moulds, radon gases, changes in humidity and temperature and a suite of chemical agents. Beyond these, the scientists looked at heat, crowding, noise, air, water and soil pollution as sources of stress, and even anxiety about environmental conditions, and its effect on stress. It also looked at fine details of the environment – trace elements levels that might be linked to neurophysiological illnesses; at microbial and chemical contamination of drinking water; at the potential of climate change and stratospheric ozone depletion to affect health; and even at the environment and child injury. The purpose was to identify the best approaches and help policy makers make policy. "*Without this knowledge*," said Sir Dai Rees, president of the ESF, "*there is a danger that legislation could misdirect resources towards problems that have little real impact on health*."

Were the European ministers grateful for this painstaking help? Sir Dai, who headed the UK Medical Research Council before his presidency of ESF, and who had plenty of experience of the confused meeting of science and society, has no very happy memories of the episode. "*By the next conference of ministers however, people, priorities and panic issues had all changed. Brussels bureaucrats, whom one might have presumed to be concerned about continuity of thought (as the UK Civil Service, whatever its other failings, certainly would) were no help. They were preoccupied, as ever, with promoting their own wheezes and gimmicks. Consequently when the product of our labours was presented to ministers, it received no serious consideration. We had to listen for example to one particularly obnoxious diatribe from the Austrian ministry castigating our presumption for having written it. Nobody pointed out that we had done so by invitation. As a non-speaking attendee, I suffered agonies in the back row, wondering whether to break protocol by blurting this out (I didn't)*."

In fact, throughout its life in Strasbourg, the EMRC kept up a steady flow of informed opinion, advice and analysis aimed at politicians, policy makers, pharmaceutical partnerships, and people caught up in wider medical research. Its activities and networks addressed issues that ranged from health indicators to animal experiments; from training in brain and behaviour research to the interaction between mental and physical illness; health inequalities; human stem cell research and even the use of synchrotrons and other beam lines for medical science.

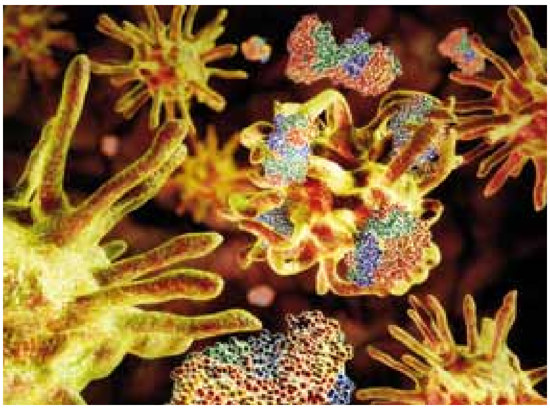
MOLECULAR BIOLOGY, METALS AND THE MORALITY OF MEDICINE

In the 40-year existence of EMRC, medical science made amazing gains, at the most basic level. Geneticists and biochemists first learned how to splice DNA and manipulate it in the mid-1970s, and then very quickly, how to sequence it. That gave scientists their first chance to investigate the molecular biology of inheritance and the links with thousands of diseases associated with changes to particular genes. With a set of instruments of increasing subtlety and sophistication, neuroscientists began first to make connections between brain chemistry and mental illness. Chemists and medical scientists co-operated in ESF programmes on the roles of metals in biological systems (for a carbon-based lifeform, humans contain surprising quantities of sodium, calcium, magnesium, potassium, chromium, manganese, iron, cobalt, nickel, copper, zinc and molybdenum). Immunologists began to take closer and more detailed looks at the genetic, cellular and molecular processes linked to allergies, and proposed a European database of the differences in exposure to grass and tree pollens, and house dust mites; along with a prevalence of the genes linked to allergy. All of these advances in understanding made the need for clinical collaboration even more urgent.

The scientific opportunities were greater than ever before, but so were some

Photo page 44

Air pollution. A trembling Sun silhouetted against the dark smoke coming out of an industrial chimney. The main forms of air pollution derive from the burning of fossil fuels such as coal, crude oil and natural gas in power stations, automobiles and for domestic purposes. Following the burning, a huge amount of harmful gases is thrown into the atmosphere, including sulphur dioxide and nitrogen oxides which are involved in the formation of acid rain and carbon dioxide which plays an important role in the global warming effect.

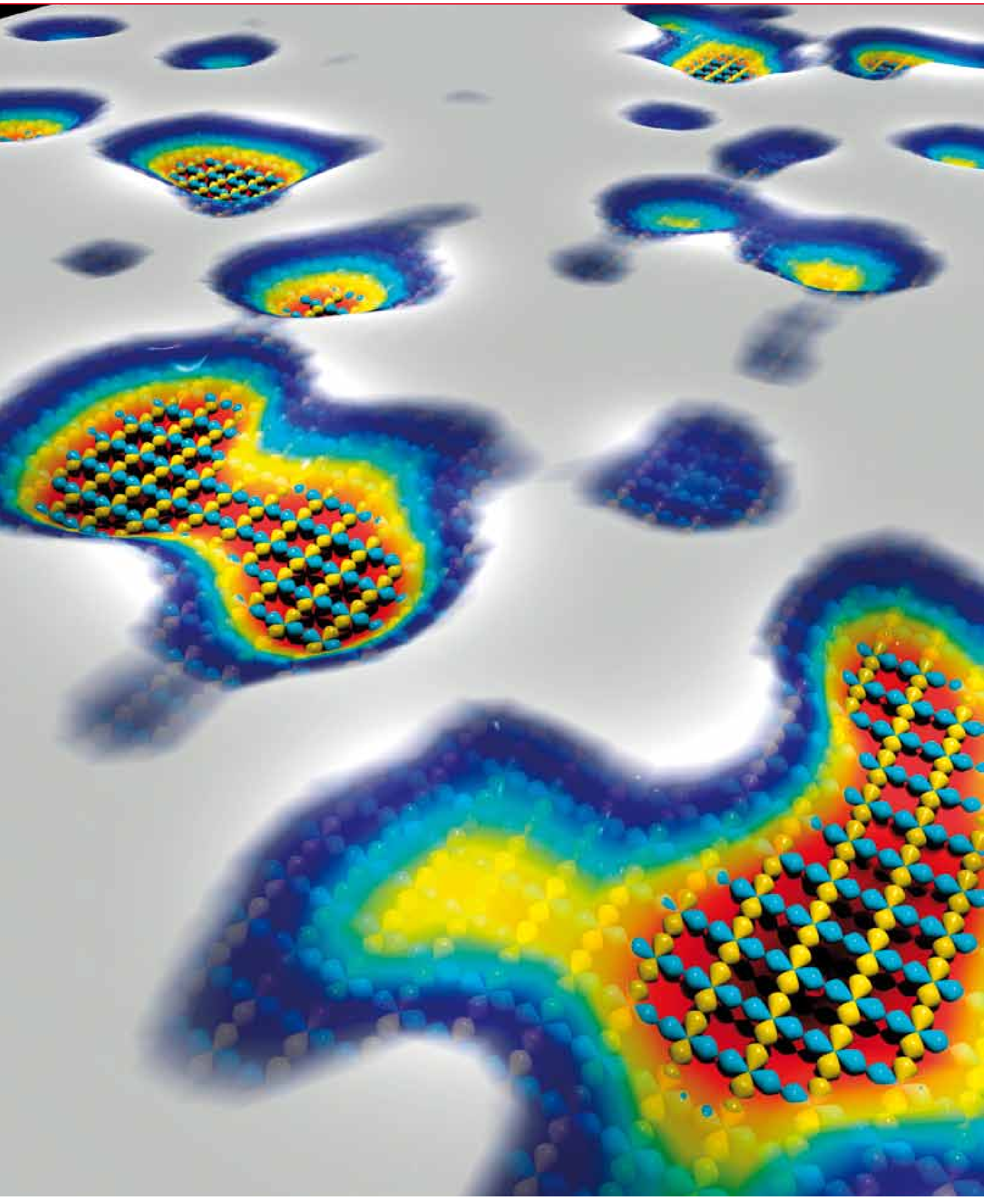


Prions destroying dendritic cells.
Artwork showing prions (multicoloured molecules) entangling in the projections of dendritic cells (yellow), stopping them from working. Dendritic cells are part of the mammalian immune system. Prions are malformed proteins that propagate their malformed nature to other proteins. BSE (bovine spongiform encephalopathy) and CJD (Creutzfeldt-Jakob disease) are examples of prion-mediated diseases.
© Medi-Mation/Science Photo Library

challenges to the health of the community. The 1980s and 1990s, one EMRC expert pointed out, had been dominated by fear of infection, by HIV and by bovine spongiform encephalopathy, or BSE, but the great agencies of illness and death had not changed: vascular and respiratory diseases, psychiatric disorders, malaria, pneumococcal infection and so on. And during the entire 40 year history of the Foundation, debate about medical science has been infused with a sense of ethical or moral anxiety. The new medical technologies grew up in company with a new scientific discipline called bioethics. The very first medical science publication from ESF in 1977 was about recombinant DNA, the discovery that opened the door to genetic engineering. It was the text of an ESF lecture by Sir John Kendrew, one of the giants of molecular biology, and it calmly confronted the concern, examined the hazards, explained the science and presented the possibilities. The rest is history: recombinant DNA technology is now in laboratories almost everywhere in the world, and the basis of a huge, new industry. In an accident of circumstance, at the time of writing, the very latest ESF medical science publication is a study of the questions raised by, and the potential value of, another technology that has provoked anxiety and divided opinion. This is Human Stem Cell Research and Regenerative Medicine: Focus on European Policy and Scientific Contributions. It wasn't the first study of human stem cell research: there have already been three this century.

And this report, too, leaves its readers in no doubt about Europe's valuable track record in such research and *"the need to continue to fund this research so that its full potential can be realised."* It is not the only investment by high science in tomorrow's health: NuPECC, ESF's Nuclear Physics European Collaboration Committee in 2013 took a long cool look at the contribution that radiation by nuclear particles can make to medical imaging and cancer therapy. Tumour bombardment by hadrons – protons, neutrons and light ions – is relatively new, but it is accurate, efficient, and delivers more damage to the tumour and less to the healthy tissue around it. It has already helped more than 100,000 patients worldwide. Hadrontherapy, the NuPECC researchers decided, is in a clinical research phase "with great potential".

> **"ESF's good standing was built on promoting science for intellectual benefits that have stood the test of time. A generation of scientists will testify that ESF gave them European horizons".**
>
> Sir Dai Rees,
> *ESF president, 1996*



12. THE DEVIL IS IN THE DETAILS

Large science, as ESF's first president Brian Flowers once observed, begins as small science. Sometimes this science is on scales so small or so fleeting that most people don't even know it exists. Femtochemistry is chemistry in a hurry. A femtosecond is a million billionth of a second and is the time it takes light to travel one third of a millionth of a metre and it is the timescale at which chemical reactions happen, at which chemical bonds break and at which energy is transferred from one molecule to another. So researchers in the ESF Ultra programme who wanted to understand what actually happens at the smallest unit of chemistry or biology and at the shortest possible unit of time had to use the most advanced femtosecond lasers at wavelengths of 700 to 1,000 nanometres working with ultrashort pulses to measure, for instance, the speed of rotation in excited water molecules. With tools as sophisticated as these, researchers could monitor the dynamics of photosynthesis, or the uptake of oxygen in the blood, or the molecular machinery of vision. It turned out that most of the important biological processes began with a step that could be measured on the femtosecond scale.

Science at such a level of detail and measured in intervals so short involved a collaboration of leading laboratories, academies and institutions in 17 European nations. Some small science has to be big at the same time or it doesn't happen at all. In the year of femtosecond chemistry, at the turn of the century, 69 research groups from 17 nations also collaborated in the science of functional genomics, a discipline that – when ESF was founded – did not exist and could not have even been imagined. Functional genomics is the understanding of what goes on in a single biological cell, an entity invisible to the naked eye, yet in which tens of thousands of proteins are interacting every second, at the command of the genes in the nucleus. Yet another ESF-sponsored European network had already completed work on the molecular dynamics of the cell membrane, the thin wall between the entity and its environment. This protective yet permeable skin controls the flow of proteins, lipids, ions and water into the cell, along with bacterial toxins and pharmaceutical drugs.

MEMBRANES, MATHEMATICS AND A NEW WORLD OF MATERIALS

This represented, in 1991, a new frontier for science, but by then science presented a bewildering number of frontiers and boundaries. One of these, at around the same time, prompted an ESF programme on the Mathematical Treatment of Free Boundary Problems, an all-purpose term for the numerical and computational difficulties that underpin subjects as diverse as combustion, superconductivity and the mathematics of finance, as well as some curious things known as non-Newtonian liquids. These are liquids that do not always behave as Newton's laws of motion might predict, but which are important in new technologies such as injection moulding, or the design of liquid crystal displays, or in the manufacture of metals. The manufacture of polymers raised theoretical and practical problems that stimulated the formation of Supernet, a five year ESF programme to explore two great, interconnected puzzles. The same chemical formula, for instance, could make something stronger than steel or sensitive enough for an electronic circuit so what was it about the structure of the polymer molecule that dictated the physical properties of the substance extruded from the production process? The other question was, could a mix of mathematical modelling and experiment identify the rules that govern polymer behaviour? This detailed interest in the magical properties of modern materials has been sustained. MatSEEC is ESF's Materials Science and Engineering Expert Committee and in 2011, in partnership with the European Materials Research Society, it addressed the role of Materials for the Key Enabling Technologies that will manage Europe's energy, handle its data, and perhaps even deliver its medical treatments and fly its aeroplanes. Nanotechnology, nanoelectronics and nano fabrication – once again, science and engineering at the scale of a millionth of a millimetre – all exploit the properties of new materials in new industries and markets potentially valued at trillions of Euros, in solar energy, communications, biotechnology and even sophisticated engine control. Another such initiative grew into EuroGRAPHENE, a systematic transnational study of the peculiar properties of that layer of carbon just one atom thick, and which led to ESF's partnership in an EU-funded flagship project to turn these newly-discovered graphene properties into new industries, and new jobs. Who rules the waves and tunes in to the galaxies?

What unites all this research is that it depends on fine detail and precision measurement. But ESF committees, networks and research programmes also confronted complex problems and precision requirements that extended on an enormous scale. One of these in 1997 was how to share the airwaves. Broadcasters, the communications industry in general and the burgeoning mobile phone industry in particular all had investments in low earth orbiting satellites and were competing for radiofrequencies. But radioastronomers also urgently needed access to signals not just from interstellar space but from galaxies at the edge of the visible universe. Radiotelescopes could be sited in locations screened from terrestrial interference, but nowhere would be safe from orbiting satellites. Radioastronomy – which first caught the public imagination as it tracked the first satellite Sputnik 1 back in 1957 – had a spectacular list of achievements to its credit. These included the first detection of the cosmic microwave background that provided the first evidence of a Big Bang in which matter, space and time were all first created, and the first identification of more than 100 complex molecules – water, alcohol, cyanide, formic acid and so on – in the spaces between the distant stars.

ESF's Committee on Radioastronomy Frequencies could not itself decide on how the airwaves should be shared or apportioned, but its influential 1997 handbook set before international agencies the case for protecting important bands of the spectrum for pure science, and for preserving enough of it to ensure the future of ever bigger arrays of radiotelescopes to see ever further. Even local interference could present intractable problems. *"For an array of 20 telescopes to be fully operational, each telescope should be operational 99.5% of the time,"* the handbook warns. And within two years ESF clinched an agreement after "harsh and intensive"

Illustration page 48

Superconductor simulation. Computer model showing superconducting 'puddles' in a high-temperature (high Tc) superconductor. In this context, high-temperature refers to the temperature (Curie temperature, Tc) at which the material being modelled here becomes a superconductor (able to freely conduct electricity). This temperature is still very cold, but relatively much higher than the temperatures at which superconductivity is normally observed. This is an example of computational models being used to predict the properties of new materials.

negotiations with the Iridium satellite phone network management, to protect the frequency band that covers the hydroxyl emission spectrum, and that reveals information about the birth and death of stars, the evaporation of comets and other celestial secrets often hidden from optical astronomers by clouds of interstellar dust. This was an important agreement: Europe had several of the world's most sensitive instruments attuned to this frequency.

OF SONGBIRDS IN FLIGHT, AND CHANTS IN THE CHANCEL

Perhaps the most startling variety of detailed examination was delivered by a series of scientific networks, ESF's low-budget way of bringing scholars with bright ideas and big ambitions together. One network in 1989 linked economists worried about poor performance in the financial markets (*"Banks are particularly vulnerable to financial failure,"* observed Colin Mayer, of the UK Centre for Economic Policy Research and chair of the co-ordinating committee). Another linked 17 nations in exploring the great annual mystery of songbird migration from the Palaeoarctic to sub-Saharan Africa: what routes did they take, with what stopovers? What determined the starting date? What did they need from their African wintering sites? How did they fuel before migration? Yet another network took biologists to the Antarctic Ocean to address enduring questions such as how fish flourished at the freezing point of water, and how one family, the *Channicthyidae*, survived without haemoglobin in the bloodstream. Even in the humanities, unexpected questions kept researchers busy for years. Medieval liturgical tropes were those Latin verses that worked their way into the ritual of the mass after it had been unified by Charlemagne. Their function was to introduce base chants and exhort the singers to praise: these tropes gave birth *"to a new and highly original genre with subtle and rich variation,"* scholars argued. Their ambition was to establish co-operation, share a methodology, initiate new research and *"explain and clarify the almost unknown existence of the tropes."*

The song has ended. The medieval Latin trope scholars met, published and moved on. Networks, like the questions they pursue, have a limited lifespan.

Others represent ambitions that may never be quite completed, and deliver answers that will always provoke tantalising new questions. A four-year ESF network in 1995 to co-operate on a "mouse atlas" – a digital three-dimensional representation of gene expression in a mouse embryo – lives on, almost two decades later: Edinburgh University and the Medical Research Council in the UK still host EMAP, the e-mouse atlas project. At its launch, the challenge created, said one of the network "a horrendous computational problem." It benefited from rapid advances not just in computing power but in the advance of the WorldWide Web; it retained its importance because advances in human, mouse, and other genome sequencing meant that – like the laboratory mouse – the digital mouse atlas would become an increasingly valuable medical research tool. It lives on as another example of small science that long ago became Big Science.

"The European Science Foundation is the vehicle of expression for a vast proportion of the Research Community in Europe. It brings together a large number of scientific names from both Eastern and Western Europe. It must pursue its role as the prime contact and partner for the Commission and the programmes of the European Union."

Edith Cresson,
European Commissioner for Research and Development, speaks to the ESF Assembly, 1995

ESF Member Organisations in 1975

List as published in the first ESF annual report in 1975

AUSTRIA
- Fonds zur Förderung der wissenschaftlichen Forschung in Österreich
- Österreichische Akademie der Wissenschaften

BELGIUM
- Fonds National de la Recherche Scientifique

DENMARK
- Statens naturvidenskabelige forskningsråd
- Statens laegevidenskabelige forskningsråd
- Statens jordbrugs-og veterinaer forskningsråd
- Statens samfundsvidenskabelige forskningsråd
- Statens humanistiske forskningsråd
- Statens tekniskvidenskabelige forskningsråd
- Det kongelige danske videnskabernes selskab

FRANCE
- Centre National de la Recherche Scientifique
- Délégation Générale à la Recherche Scientifique et Technique
- Institut National de la Santé et de la Recherche Médicale

FED. REP. OF GERMANY
- Deutsche Forschungsgemeinschaft
- Max-Planck-Gesellschaft
- Konferenz der Akademien der Wissenschaften in der Bundesrepublik Deutschland

GREECE
- National Hellenic Research Foundation

IRELAND
- Royal Irish Academy
- National Science Council
- Medical Research Council

ITALY
- Consiglio Nazionale delle Ricerche

NETHERLANDS
- Nederlandse organisatie voor zuiver-wetenschappelijk onderzoek (ZWO)
- Koninklijke Nederlandse Akademie van Wetenschappen

NORWAY
- Norges Almenvitenskapelige forskningsråd (NAVF)
- Det Norske Videnskapsakademi

PORTUGAL
- Junta Nacional de Investigaçao Cientifica e Tecnologica
- Academia das Ciencias de Lisboa

SPAIN
- Consejo Superior de Investigaciones Cientificas

SWEDEN
- Statens Råd för Atomforskning
- Statens Humanistiska forskningsråd
- Statens Medicinska forskningsråd
- Statens Naturvetenskapliga forskningsråd
- Statens Råd for Samhällsforskning
- Kungliga Vetenskapsakademien

SWITZERLAND
- Fonds National Suisse de la Recherche Scientifique

UNITED KINGDOM
- The British Academy
- The Royal Society
- Agricultural Research Council
- Medical Research Council
- Natural Environment Research Council
- Science Research Council
- Social Science Research Council

YUGOSLAVIA
- Odbor za koordinaciju nauke l tehnologije u SFRJ

ESF Member Organisations in 2014

AUSTRIA

- Fonds zur Förderung der wissenschaftlichen Forschung in Österreich (FWF)
  Austrian Science Fund

BELGIUM

- Fonds de la Recherche Scientifique (FNRS)
  Fund for Scientific Research
- Fonds voor Wetenschappelijk Onderzoek-Vlaanderen (FWO)
  Research Foundation Flanders

BULGARIA

- Българска академия на науките (BAS)
  Bulgarian Academy of Sciences
- Научни изследвания
  National Science Fund of Bulgaria

CROATIA

- Hrvatska akademija znanosti i umjetnosti (HAZU)
  Croatian Academy of Sciences and Arts
- Hrvatska zaklada za znanost (HRZZ)
  Croatian Science Foundation

CYPRUS

- Ίδρυμα Προώθησης Έρευνας (RPF)
  Cyprus Research Promotion Foundation

CZECH REPUBLIC

- Akademie věd České republiky (ASCR)
  Academy of Sciences of the Czech Republic
- Grantová agentura České republiky (GAČR)
  Czech Science Foundation

DENMARK

- Danmarks Grundforskningsfonden (DG)
  Danish National Research Foundation
- Det Kongelige Danske Videnskabernes Selskab
  Royal Danish Academy of Sciences and Letters
- Det Frie Forskningsråd – Kultur og Kommunikation (FKK)
  The Danish Council for Independent Research – Humanities
- Det Frie Forskningsråd – Sundhed og Sygdom (FSS)
  The Danish Council for Independent Research – Medical Sciences
- Det Frie Forskningsråd – Natur og Univers (FNU)
  The Danish Council for Independent Research – Natural Sciences
- Det Frie Forskningsråd – Samfund og Erhverv (FSE)
  The Danish Council for Independent Research – Social Sciences
- Det Frie Forskningsråd – Teknologi og Produktion (FTP)
  The Danish Council for Independent Research – Technology and Production Sciences

ESTONIA

- Eesti Teadusagentuur (ETAG)
  Estonian Research Council

FINLAND

- Suomen Akatemia/Finlands Akademi
  Academy of Finland
- Tiedeakatemiain neuvottelukunta (TANK)
  Council of Finnish Academies

FRANCE

- Agence nationale de la recherche (ANR)
  French National Research Agency
- Centre national de la recherche scientifique (CNRS)
  National Centre for Scientific Research
- Commissariat à l'énergie atomique/ Direction des sciences de la matière (CEA/DSM)
  Physical Sciences Division of the Atomic Energy Commission
- Institut français de recherche pour l'exploitation de la mer (Ifremer)
  French Research Institute for Exploitation of the Sea
- Institut national de la recherche agronomique (INRA)
  National Institute for Agronomic Research
- Institut national de la santé et de la recherche médicale (Inserm)
  French National Institute of Health and Medical Research
- Institut de recherche pour le développement (IRD)
  National Institute for Development

GERMANY

- Deutsche Forschungsgemeinschaft (DFG)
  German Research Foundation
- Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF)
  Helmholtz Association of German Research Centres
- Max-Planck-Gesellschaft (MPG)
  Max Planck Society
- Union der deutschen Akademien der Wissenschaften
  Union of the German Academies of Sciences and Humanities

GREECE
- ΕΘΝΙΚΟ ΙΔΡΥΜΑ ΕΡΕΥΝΩΝ (NHRF)
  National Hellenic Research Foundation
- Ίδρυμα Τεχνολογίας και Έρευνας (FORTH)
  Foundation for Research and Technology – Hellas

HUNGARY
- Magyar Tudományos Akadémia (MTA)
  Hungarian Academy of Sciences
- Országos Tudományos Kutatási Alapprogramok (OTKA)
  Hungarian Scientific Research Fund

ICELAND
- Rannsóknamiðstöð Íslands (RANNIS)
  Icelandic Centre for Research

IRELAND
- Health Research Board (HRB)
- Irish Research Council
- Science Foundation Ireland (SFI)

ITALY
- Consiglio Nazionale delle Ricerche (CNR)
  National Research Council
- Istituto Nazionale di Fisica Nucleare (INFN)
  National Institute for Nuclear Physics

LITHUANIA
- Lietuvos Mokslo Taryba (LMT)
  Research Council of Lithuania

LUXEMBOURG
- Fonds National de la Recherche (FNR)
  National Research Fund

NETHERLANDS
- Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)
  Netherlands Organisation for Scientific Research

NORWAY
- Norges Forskningsråd
  Research Council of Norway

PORTUGAL
- Fundação para a Ciência e a Tecnologia (FCT)
  Foundation for Science and Technology

ROMANIA
- Consiliul National al Cercetarii Stiintifice (CNCS)
  National Council for Scientific Research

SLOVAK REPUBLIC
- Slovenská akadémia vied (SAV)
  Slovak Academy of Sciences
- Agentúra na podporu výskumu a vývoja (APVV)
  Slovak Research and Development Agency

SLOVENIA
- Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS)
  Slovenian Research Agency
- Slovenska Znanstvena Fundacija (SZF)
  Slovenian Science Foundation

SPAIN
- Consejo Superior de Investigaciones Científicas (CSIC)
  Council for Scientific Research
- Ministerio de Economía y Competitividad (MINECO)
  Ministry of Economic Affairs and Competitiveness

SWEDEN
- Forskningsrådet för hälsa, arbetsliv och välfärd (FORTE)
  Swedish Council for Health, Working Life and Welfare
- Forskningsrådet för miljö, areella näringar och samhällsbyggande (FORMAS)
  Swedish Council for Environment, Agricultural Sciences and Spatial Planning
- Riksbankens Jubileumsfond
- Vetenskapsrådet (VR)
  Swedish Research Council

SWITZERLAND
- Schweizerischer Nationalfonds (SNF)
  Swiss National Science Foundation

TURKEY
- Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBITAK)
  The Scientific and Technological Research Council of Turkey

UNITED KINGDOM
- Arts and Humanities Research Council (AHRC)
- Biotechnology and Biological Sciences Research Council (BBSRC)
- Economic and Social Research Council (ESRC)
- Engineering and Physical Sciences Research Council (EPSRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Science and Technology Facilities Council (STFC)

AFTERWORD

Pär Omling,
former vice-president of Science Europe and president of the European Science Foundation

I am on record in a previous scientific life as saying that we, in this diverse Europe, are not very successful when it comes to collaboration. At the time, I made some exceptions and I think anyone who reads this book will agree that the European Science Foundation has made itself one of these exceptions. It has done so perhaps because from the first it met the qualification necessary to be an exception: what it has achieved has been founded on a basis of scientific need, and in pursuit only of the highest quality of research. Back in 2002, while director general of the Swedish Research Council, I spoke up for the idea of European science enhanced by greater influence from the scientists themselves, and by less bureaucracy. That has been the strength on which ESF has drawn. So many of its networks, projects, partnerships, initiatives and even its foreword looks began as ideas sparked by individuals in laboratories and university common rooms across the continent; individuals who found kindred spirits and who began to gather a community of enthusiasts prepared to take the idea to Strasbourg for peer review, and then back to their own Member Organisations for support. Over the last four decades, these scientists and scholars can be numbered not just in thousands, but in hundreds of thousands, and they took part in thousands of workshops, conferences and committee meetings. Out of this sustained experience of collaboration, European competition and Peer Review, the once fanciful idea of a European Research Council took shape, and then became a reality. Of course, the ESF could not have achieved any of these things without the support of its Member Organisations, and once again without all the scientists and scholars that the Member Organisations in turn supported. But synergy is a wonderful thing: it delivers more than the sum of its parts. From the gathering of different disciplines and disparate institutions in a diversity of nations 40 years ago, something new and exciting has emerged, along with a new voice for science in Europe and a chronicle of European collaboration of which we can be proud. And this is certainly the moment to be proud.

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