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2/2005 ▶ Was the North Pole Once Ice Free? ▶ Robotic Football for Science ▶ Life from the Depths of Space ▶ Measurements in the Magnetic Field ▶ The Fate of Weimar's Renowned Anna Amalia

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In this issue

On the Fate of Anna Amalia

The Duchess Anna Amalia Library in Weimar was struck by a devastating fire, which destroyed more than 100,000 books and manuscripts. The historical main building of the library, a UNESCO World Heritage site, was also severely damaged by the blaze. Reconstruction of the buildings and restoration of the books will give the library a new lease of life. **Page 6**

When Robots are "on the Ball"

Robots that can play football, showing off their skills at the RoboCup championship, fascinate the spectators. But not only do these public football matches give the public an opportunity to experience science first-hand, they also serve as a platform for putting research findings from the fields of artificial intelligence and mobile robotics to the test. **Page 20**

What Secrets do Marine Deposits Reveal?

Scientists participating in the international Arctic Coring Expedition have taken cores of marine sediment in the middle of the North Polar Ocean. These marine sediments give them amazing insights into the ups and downs of the climate over the millennia. In addition to this, the cores also give researchers new information on environmental changes which took place long ago. **Page 24**

Expedition to the Arctic Ocean

Drilling cannot begin until the ice cover is broken. Scientists use sedimentary samples to help unravel the mystery of climate change. (page 24)
Cover: Hannes von der Fecht, IODP

Impressum

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Dr. Reinhard Grunwald

Europe at the Centre, Sights Set on the World

Modern research does not stop at national boundaries. A DFG that has an international outlook can contribute to building international scientific relations

When Charlemagne, King of the Franks, was crowned as the first Holy Roman Emperor by the Pope Leo III in 800, he saw himself not as the founder of a nation state, but as the protector of the Roman heritage. He is identified with equally by the French and the Germans. Europe is currently undergoing a process of rediscovery, not only as an economic and political power structure, but also as a community that has grown through its common history, culture and values.

The Deutsche Forschungsgemeinschaft's mission – as declared in its statutes – to foster contacts between German and international scientific communities, has a very strong European character. Alongside its European activities, the DFG has expanded its international contacts, especially in the past decade, expressed not least by its branch and liaison offices in Beijing, Washington and Moscow. Europe at the centre: The DFG's European involvement spans from its membership in the European Science Foundation (ESF) in Strasbourg and the EUROHORCs (Heads of European Research Councils) to the European Liaison Office of the German Research Organisations (KoWi), which it operates as a central research facility. In discussions concerning the creation of the European Research Council (ERC) for the Seventh Framework Programme (FP7), the contributions made to the discussion with the European Commission or the Council of Ministers and the European Parliament by both the ESF and EUROHORCs play an important role. All those involved know that once basic research becomes an integral part of FP7, new funding mechanisms need to be put into place in addition to those which have existed so far, which have been strongly reliant on funding from industry. The sole criterion of scientific quality, competitive selection of the best projects and a corresponding involvement by the scientists in decision-making processes are all on the agenda and need to be moulded into a coherent organisational structure. KoWi provides primarily German scientists and researchers with assistance regarding all European funding activities, acting as a source of information on funding opportunities and conditions, and conversely helps make the link between German scientists and universities and the Commission. KoWi gives young researchers advice and holds regular seminars for applicants. With offices in Brussels and Bonn, KoWi plays a key role in improving the success rate of German scientists in Europe, who receive more funding from the current EU Framework Programme than is contributed by Germany.

Not only did Gottfried Wilhelm Leibniz develop the concept of the Prussian Academy of Sciences, he also proposed the model for the Russian Academy of Sciences to the Russian tsar Peter the Great. He corresponded with the Chinese emperor on the subject of the calendar and, last but not least, stands as an icon for the combination of theory and practice. German-Chinese scientific relations grew significantly in the 19th and especially in the 20th century. Tongji University in Shanghai was founded by a German, just as the Wuhan Medical College (now the Huazhong University of Science & Technology), which was formed by the merger of the Medical College of National Tongji University with the Medical College of Wuhan University. Studying, especially on a PhD-level, in Germany, is held in very high esteem in China. In 1995, the DFG and its Chinese partner organisation, the National Natural Science Foundation of China (NSFC), agreed to jointly establish the Sino-German Center for Research Promotion, which was opened in 2000. This centre provides conference facilities for up to 300 delegates, a library as well as guest rooms to accommodate visiting scientists. The workshops, designed to bring together scientists from China and Germany, not least

young researchers, have proven particularly successful. These workshops frequently provide the stimulus for bilateral research projects, which are funded on a competitive basis and are peer-reviewed by a Sino-German panel.

When Albert Einstein left Germany in 1932/1933 and – like so many other scientists – emigrated to the United States of America, he met up with other scientists with whom he was already acquainted, and was able to continue his work in Princeton almost uninterrupted. As the scientists in exile grew older, the natural cooperation between American scientists and their European colleagues was lost. Access to the top American universities and research institutes for young German scientists and researchers no longer worked through the old, established networks, since the younger American scientists concentrated more on cooperation within America and in the Pacific region and viewed the inclusion of young Europeans less as culturally beneficial for all those concerned. This was the point which the Deutsche Forschungsgemeinschaft aimed to address in the late 1990s, in particular to provide information both to those interested as well as to disseminators such as journalists, teachers etc. The DFG Washington Office is not only intended to keep the existing channels of information and communication open, but also to open up entirely new avenues, both to the research centres in the USA for German scientists and, conversely, for American scientists interested in coming to Germany or even elsewhere in Europe.

One of the main priorities of the liaison office, which was opened in May 2002, is to provide assistance and advice to the 500 or so DFG fellowship and grant holders from Germany at universities in the USA as well as to assist German scientists and researchers currently working in the USA who are considering returning to Europe, in particular to Germany. Russia possesses not only great economic and military potential, but also has world-class scientists and outstanding educational institutions, especially for natural scientists and engineers. Collaboration with Russian scientists was one of the DFG's first areas of international cooperation. The expedition to the Caucasus is a famous example. Maps up until the 1940s even show a "DFG glacier" in the region.

World War II resulted in a breakdown in German-Russian relations in science and research too. The two-track system which developed in the post-war era, with close cooperation between scientists and institutions in the GDR on the one hand, and links between Soviet researchers and scientists and West Germany in the broader international context on the other hand, led to rapid development of the contacts in many areas after German reunification. Set against this backdrop, scientific links with Russia have developed very dynamically. In July 2003 the Deutsche Forschungsgemeinschaft opened a liaison office in Moscow, which aims to strengthen cooperation between Russian and German scientists and scientific organisations for mutual benefit and to raise the mutual awareness of scientific activity and research potential.

The planned establishment of a Deutsche Forschungsgemeinschaft liaison office in India – where the DFG will cooperate closely with the German Academic Exchange Service (DAAD) and the Alexander von Humboldt Foundation (AvH) – will complete the DFG's international presence. The web of modern science transcends national borders. A DFG that has an international outlook can contribute to this through its funding activities.

Dr. Reinhard Grunwald
Secretary General of the
Deutsche Forschungsgemeinschaft

Of Inquisitors and Informers

A look behind the walls of the Vatican: Records on book censorship provide insight into the strictly guarded internal affairs of the Inquisition and Congregation of the Index

Erasmus of Rotterdam, Immanuel Kant, David Hume, Heinrich Heine – these are just a few of the names from the who's who of world history found in the book-censorship records of the Roman Inquisition and the Congregation of the Index in the archives of the Congregation for the Doctrine of the Faith, names that are part of a well-rounded education, that exemplify literary, philosophical, or scientific schools of thought. Some still stimulate minds today as they did in the authors' lifetimes. But appearing alongside these luminaries etched in human memory are those who were denied eternal fame, authors who managed only to produce a long-forgotten manuscript at which some likewise forgotten informer took offense. The informer sent a letter to the Roman Inquisition or Congregation of the Index, which often meant the end of a once promising career. As diverse as the assessment of the status of these personalities was in retrospect, the motives leading to the reporting of their books to Rome was equally diverse. Sometimes an informer with theological, political or philosophical motives saw in them a threat to the Catholic view of life. Or perhaps it was envy of an aspiring competitor against whom the informer knew of no other defense than to silence him – in ideological guise.

Whatever the deciding motive was for reporting authors, the way of incriminating books led to Rome. There they were examined by the relevant authorities. Handwritten or printed opinion statements *(vota)* of widely varying quality were prepared, or outside specialists were summoned. Not seldom experts, who were overstretched, would allow for failure or supposed specialists would reveal their superficial knowledge. Now and then tolerant and narrow-minded members of the curia would get into verbal battles over their views at the expense of the accused. Those finally condemned by the church for the protection of Catholics found each other again on the list of banned books, the so-called *Index librorum prohibitorum.* The acquitted, however, hardly ever learned of the action brought against them, so that in countless cases only the informer had knowledge of its failure. Just as today, after a case is closed, records find their way first into the files and then into the house archives, where they slowly sink into oblivion. The course of events at the Inquisition and the Congregation of the Index was comparable.

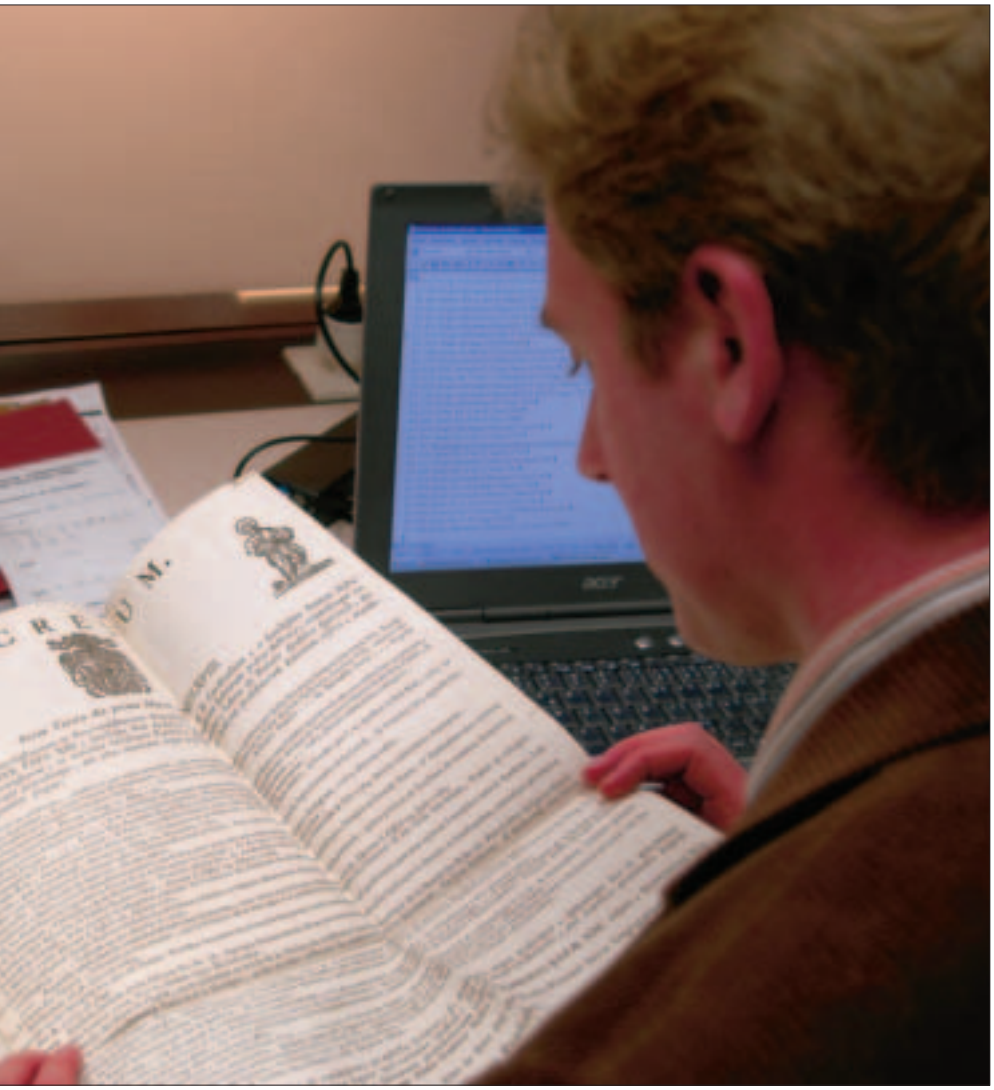
Not until 1998, when in the wake of Pope John Paul II's acknowledgment of guilt the opening of the archival holdings was announced and actually carried out, did anyone know the full extent of the history of these institutions, which covered more than 400 years. Never-before-examined volumes of records that had disappeared in the storeroom, now filthy with the dust of centuries, many held together only by a cord, were made available for research.

The first time you enter the inner courtyard of the Congregation for the Doctrine of the Faith armed only with a notebook – in contrast to the Swiss Guard – and request volumes from the book censorship series and the archivist lays them on the table, you are struck not just by this unfamiliar world but also by the (at first glance) seemingly chaotic content of the volumes. It is not unusual for a volume to contain records of over 50 separate proceedings. There are letters of denunciation from local inquisitions and customs stations in the church state, from private individuals and dignitaries from Germany, France, America – from the whole world, in short. Some are wrapped around the books like a cover and bear notations made by the informers themselves or the curial examiners. One-page opinion statements on banned French, English, or Hungarian books are followed by entire bundles of disparate votes, which question not only the books under consideration

but also the foregoing opinion statements and even the orthodoxy of their colleagues themselves, thus documenting the discussions within the curia. With this insight into the once closely guarded internal affairs of the Inquisition and Congregation of the Index – their factions, their open discussions, their concealed debates – the image of the Roman curia as a monolithic institution is modified. The banning in the *Index librorum prohibitorum* says little in itself. But with the books, contemporary discussions were carried inside the Vatican walls.

Even the assumed final results of a proceeding – which meant large-format placards, called *bandi* or "banns", posted on the doors of the main Roman churches immediately following the decision, or small leaflets for the Pope's diplomatic representatives around the world – are shown in the records to have gone through various stages of development: Titles mangled by the typesetter were corrected. Errors in the year of publication of a work were revised. The banning of entire book titles was even prevented at the last minute with a stroke of the pen. Often the penstroke was explained on a small, inconspicuous slip bearing an illegible signature, which, because it was written by an influential expert or cardinal, had caused the proceedings to take a surprising turn. In addition we find dispatches affixed with the seals of the papal secretariat of state and directives issued by the pope himself for or against the banning of a book, for or against an expert's judgment.

In the archives of the Roman Congregation for the Doctrine of the Faith, records on book censorship in the 19th century are analyzed. In the course of this analysis banning books are found time and time again. Large placards were used in former times to announce the decisions of the papal Congregation of the Index.



The goal of this long-term project "Roman Inquisition and Congregation of the Index" being conducted at the University of Münster is to rectify this ordered chaos. This means reconstructing the procedural paths, deciphering the names of the denounced authors, compiling a bibliography of their books and manuscripts, or verifying the opinion statements and entering bibliographic details about their authors in a database. The transcribed decrees will also be published and made available to the general public. In numeric terms this means over 3000 book and manuscript cases heard in the 19th century alone, roughly 250 sessions of the Congregation of the Index, 800 experts with 3500 votes, and 240 banns. Among the records are also curious finds: for instance, experts who with gnashing of teeth admit to having written an opinion statement on the wrong book but who note, in the hope that their faux pas will be forgotten, that through their error a heretofore unnoticed work deserving to be banned was fortunately discovered.

Undoubtedly one could write an entertaining book about these aspects of the Roman Inquisition and Congregation of the Index. But our attention is currently focused on the final proofreadings of the seven-volume basic work on the book censorship of the Roman Inquisition and Congregation of the Index in the 19th century. Meanwhile the work of mastering the "ordered chaos" of the 18th century and giving a face to its yet unknown protagonists has begun.

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▶ www.buchzensur.de

The Fate of Weimar's Renowned Anna Amalia

Charred books, sodden paper, scorched paintings: What is to become of the treasures from the Duchess Anna Amalia Library in Weimar? More than 100,000 books and handwritten manuscripts fell victim to the flames – and the water

These are the light casualties," says Matthias Hageböck and approaches a table on which lie book victims, large and small. "They survived the inferno on the night of the blaze," the library's book restoration workshop manager says with relief, "and have just returned to Weimar from the Leipzig Book Conservation Centre". Some still wrapped in gauze bandages, the books exude the penetrating stench of smoke and soot, as if they still bore the burden of the devastating blaze on 2 September 2004 – for instance the volume "Letters written by Jonathan Swift" dating from 1700, which suffered water damage. Its leather binding is

warped, the pages stuck together, stiff but at the same time fragile.

Not only this volume, but also baskets full of books damaged by water were sent to Leipzig even on the night of the blaze. They were followed by the seared or charred books recovered from the debris of the fire, many resembling charcoal briquettes, a total of 62,000 rescued volumes. "A race against time started," recalls Hageböck, "because after the paper becomes soaked by water used to extinguish the fire, mould and microbes can begin to grow within hours". At the Leipzig

Book Conservation Centre (ZFB) the worst of the debris is removed from the victims of the flames and the water before being viewed and sorted according to the degree of damage, then freeze-dried at minus 20 degrees in special large freeze-dry chambers and pressed back into shape. The special drying process used, developed for freeze-drying food, exploits water's ability to sublime directly from the frozen to the gaseous phase at low pressure, without first returning to the liquid phase. And thus the battle against the water is won – allowing the actual work of restoration to begin, after this "first aid" treatment. However, Hageböck, manager of the book restoration workshop run by the Weimar Classics Foundation (SWKK), dampens down any unrealistically high hopes. After all, the freeze-dried books are not all expected back until some time this year. Only then will it be possible to carry out a detailed assessment of the damage. "After all, for each volume," explains Dr. Michael Knoche, director of the Duchess Anna Amalia Library, "we need to make a decision. To reach this decision the responsible librarian and the restorer need to consult to decide whether salvage makes sense, is feasible and, at the end of the day, whether it is financially viable. This applies in particular for the books which suffered severe fire damage." Experts estimate that a little over half of the works that were rescued will be able to be salvaged. You get an idea of the scale of the task at hand by watching the restorers in the workshop sorting through individual fragments of pages re-

On left: Before the fire, the rococo hall was an all-encompassing artwork, a symbiosis of architecture, art treasures and the historical book collection. The devastating blaze destroyed the second gallery of the rococo hall and the roof above it – the hall, declared part of the UNESCO World Heritage, was severely damaged by water and fire.

The spine of a book with a charred leather binding. The backing, previously concealed, shows a playing card motif. Below: A book rescued from the flames is wrapped in cling film before being taken to the Leipzig Book Conservation Centre, where first aid can be administered.

covered from the rubble. The good into the pot, the bad into the crop, as Cinderella would have said, except that in this instance the cinders go in the crop and any fragments which are still at least half legible go into one of the cardboard boxes lined up at the ready with labels such as "pictures", "text", "title" or "music". "The restoration of the books is a challenge that will occupy the library for more than ten years," estimates Knoche, "assuming we have sufficient funds".

The extent of the damage to the books and handwritten manuscripts was immense. At least 50,000 volumes were totally lost to the flames and, as already mentioned, 62,000 were damaged by water and fire, some badly. "This amounts to more than two fifths of all of the historically significant books published before 1850," says Michael Knoche, speaking from his temporary office in the Rotes Schloß (Red Castle) in Weimar. But what use are figures and statistics when what we are talking about are literary treasures in which Goethe, Schiller and Herder wrote? These immaterial losses can neither be estimated in financial terms, nor replaced. For instance, the valuable sheet music collection which had belonged to Duchess Anna Amalia (1739-1807), consisting of 2,100 printed musical scores and over 700 music manuscripts, as well as the 35 oil paintings with ducal portraits dating from the 16th to the 18th century, which were lost to the flames in the library's second gallery. The library's Website now contains a database of the lost and damaged works, providing an impression of the extent of the losses suffered.

"Anna Amalia" has been severely hit by the worst library fire in Germany since the end of World War II. Now it is certain, however, that the historical main building of the library, once an intellectual centre of the muse-kissed city of Weimar, will rise from the ashes within the foreseeable future. Although the ravaging blaze claimed the roof and destroyed the second gallery of the famous rococo hall, the building itself, declared part of the UNESCO World Heritage, will be able to be restored. Those responsible therefore remain confident that it will be possible to reopen the badly damaged building by 2007, the 200th anniversary of the death of Duchess Anna Amalia – with the help of the state of Thuringia, the national government and private donors. The impressive three-storey library hall, dating from 1766, one of the most beautiful library halls in Germany, will then once more be accessible, allowing it to be experienced as an all-encompassing artwork of rococo architecture, art treasures and historical books.

People in Germany and around the world were deeply moved by the fate of "Anna Amalia". In the wake of the fire the library, which is world famous for its collection from the Weimar Classical period, was flooded by a spontaneous wave of generosity. Pre-school children donated money, the "Ameri-

The lower stairs in the rococo hall, covered in fire-extinguishing foam. According to the fire fighters' estimates, approximately 110,000 litres of water were used on the night of the blaze. Right: Fragments of pages sorted in cardboard boxes at the restoration workshop in Weimar. Approximately half of the books that suffered severe fire damage are classed as being "restorable".

can Friends of the Anna Amalia Library" made a donation of $ 10,000, and even prisoners sent € 10 notes from prison. To date, over € 8 million have been donated by private individuals, businesses and foundations, and have been raised by benefit events and support projects. This is in addition to the immediate help provided by the German government (€ 4 million), the state of Thuringia (€ 5.5 million over a period of five years) and the DFG (half a million euros). A dedicated investment fund has also been set up, the interest from which is to be used for the difficult task of purchasing replacement copies of lost books. The name of the fund, "Fruchtbringende Gesellschaft" (Fruitful Society), serves as a reminder of the first German language society, founded in Weimar in 1617. Many texts written by its members fell victim to the blaze.

> Sixty million euros will be needed to repair the damage done to the books just in the next few years

In spite of "the overwhelming help given in such a short space of time", Knoche cautions, "the three rescue operations – reconstructing the library, restoring the books and replacing losses – will take an enormous amount of time and even more money". Just to repair the damage done to the books, an estimated € 60 million will be needed. A lot therefore depends on the management of donations in the future, for example by means of the book sponsorship scheme. Nevertheless, new doors have also opened. In early February the Duchess Anna Amalia Library inaugurated its new Study Centre, where researchers will be able to access the approximately 900,000 books and manuscripts not destroyed by the fire. The new extension directly opposite the old library had been planned long before the fire. Also, for the first time since Goethe's day, all of the books have been brought together to a single location and stored in an underground storage facility. This enabled the library to reopen to the public just five months after the devastating blaze. Even as a modern research library working in 21st century conditions, the "Anna Amalia" library will remain true to its mission, to serve German literature and cultural history from the Enlightenment to the Late Romantic period.

"Geheimrat Goethe," who became director of the library in 1797, wrote of his impressions of its treasures "one is in the presence of a great capital that silently yields incalculable interest". What more can one add?

Rembert Unterstell

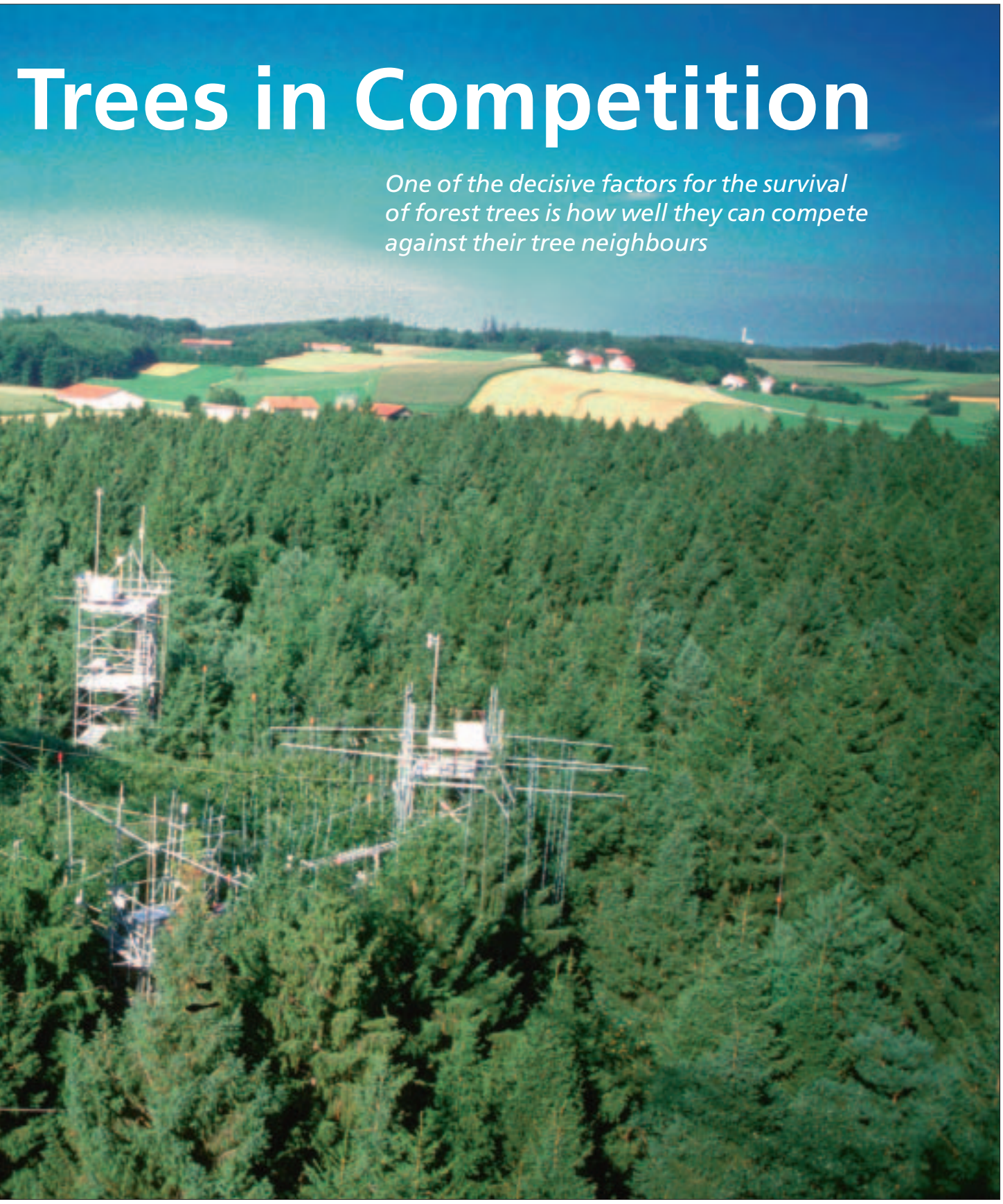
▶ www.anna-amalia-bibliothek.de

The

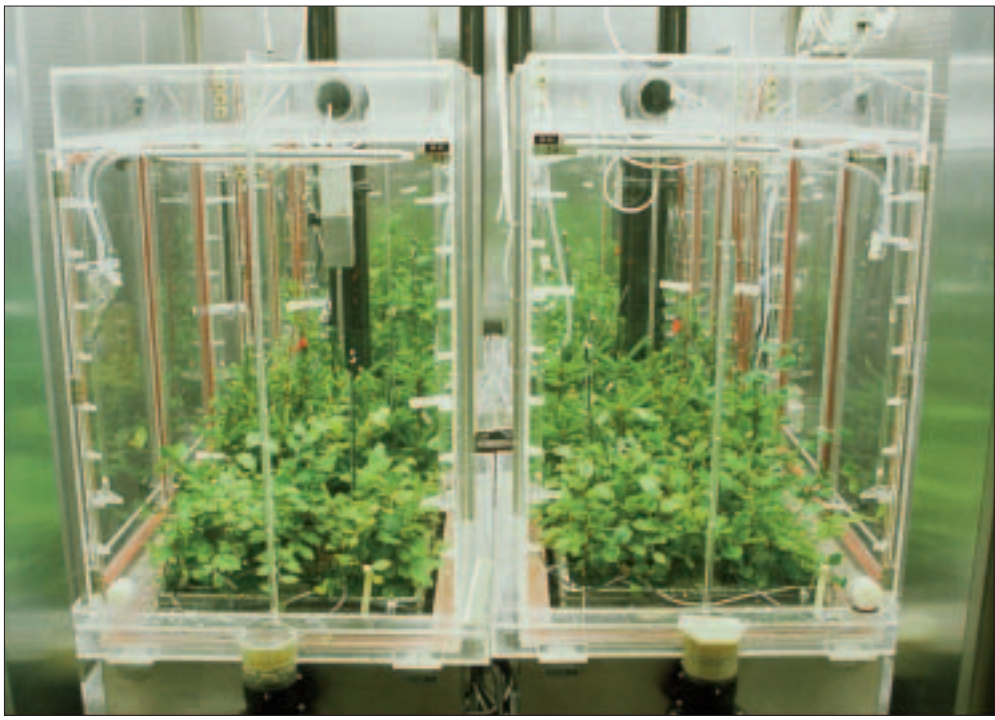
A lofty laboratory: Four scaffolding towers connected by platforms and a crane allow researchers direct access to the crowns of beech and spruce trees at heights of up to 30 metres.

Trees in Competition

One of the decisive factors for the survival of forest trees is how well they can compete against their tree neighbours



In commerce, companies succeed against the competition by using resources efficiently. Similar principles can also be observed in the competition between forest trees. Whether a sapling is able to survive is primarily decided by its ability to extract water, nutrients and, in particular, light energy from the sun for photosynthetic carbon fixation from its surroundings, and then to make use of these resources. To what extent plants can take up the various resources is decided by the amount of competition put up by neighbouring plants and by the plant's ability to fend off parasites. The balance of the competitive uptake of resources and defence of these resources against animals, which eat plants, and parasitic micro-organisms, which attack them, is a measure of the plant's "fitness". This "fitness" is also decisive for the plant's ability to reproduce.



The Collaborative Research Centre "Growth and Parasite Defense – Competition for Resources in Economic Plants from Agronomy and Forestry" aims to determine this balance and the associated cost-benefit relationships of resource allocation. Growth, in terms of biomass accumulation per se is of secondary importance. Of greater significance is the plant's ability to compete against other plants through growth. Competition between plants is governed by how strong growth – both of the crown as well as of the roots – is, i.e. in terms of the plant's ability to occupy space. A plant, which occupies a large volume of space, forces out competitors and can use that space. This throws up the question of whether it is possible to quantify a plant's competitive ability in terms of a cost-benefit relationship, as a comparison of the space sequestration (occupied space per unit of resource investment) and the space exploitation (resource gain per unit of occupied space). The study focuses on beech and spruce, which pose a particular challenge due to their contrasting spatial extension and foliage longevity.

> The key question is how the battle between the beech and the spruce for resources is organised

Whereas herbaceous plants grow noticeably over the course of a year, forest trees appear fairly "static" in the short term. An apparent solution is to measure the space-related resource turnover in branches and roots and to compare these to competitors. This makes it possible to determine the "competitive behaviour" of each tree. This approach is currently being tested in the "Kranzberger Forst", a mixed forest stand of beech and spruce planted approximately 60 years ago and approximately 30 metres in height, near Freising in Germany. A complex infrastructure of field laboratories and specialised measurement and analytical methods was required for the study. Scaffolding towers connected by platforms at heights ranging between 17 and 27 metres and a canopy crane approximately 45 metres high and with a 50 metre

Top left: Young saplings in a climate chamber. Below: Out in the open the crane gondola used to get amongst the treetops, whilst on the forest floor (top) tree root growth is analysed using digital imaging methods. Below: A beech leaf that has already suffered visible injury due to ozone.

working radius allowed access to the sun and shade tree crowns.

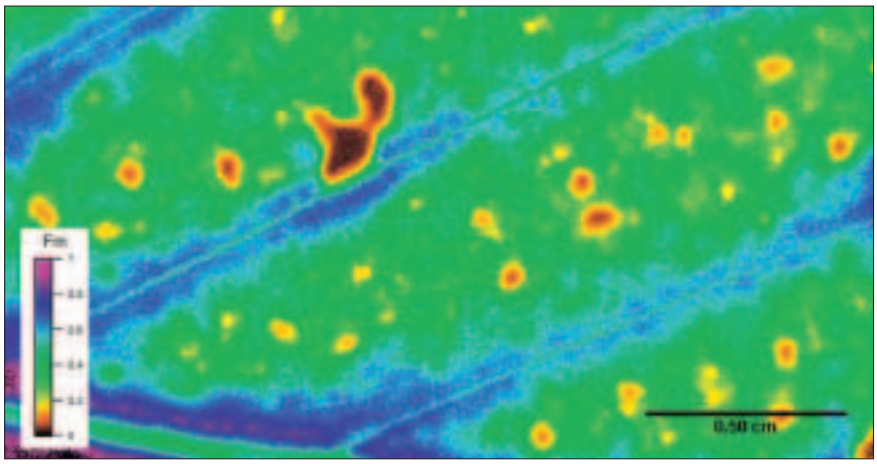
Space exploitation by beech and spruce, in other words the carbon gain along the branch axis, was found to be very similar. This applies to both sun and shade branches of both species. The "running costs" in terms of transpiration and respiration to keep branches functional are also very similar. This may come as a surprise, bearing in mind that the contrast in photosynthetic capacity, respiration and transpiration at the level of single leaf organs (low in coniferous spruce and high in broadleaved beech) between two Central European tree species could hardly be greater. It becomes apparent that the available sunlight is used equally efficiently for carbon gain by both species per unit of occupied space. There is, however, a significant difference between the species in terms of the efficiency of space sequestration. The competitive advantage of the beech, which is observed at many locations in Central Europe, appears to be as a result of the lower investment into foliage required for space sequestration relative to spruce.

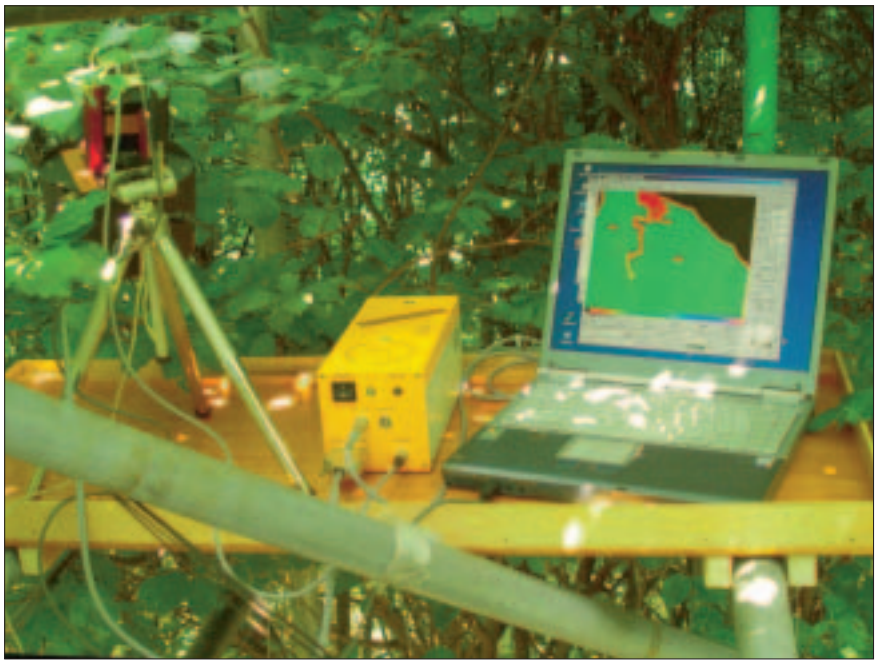
Below ground it is harder to analyse the competitiveness, since allocation into the space occupied and exploited is less clearly defined due to the high degree of intermingling between neighbouring root systems. Additionally, the mycorrhizal fungi, which form on the roots, greatly increase the "catchments area" for water and nutrient uptake by the fine roots. A combination of methods was used to measure the gain and loss of fine roots, their "running costs" (respiration) as well as that of the mycorrhizal fungi, and the resource uptake. The observed root length may be significant for the belowground competition. The significance of belowground competition for resources relative to aboveground competition is still under investigation.

The efficiency of space sequestration depends on the regulation of resource allocation by each plant. Reaction to stress provides information on the sensitivity of this regulation and its mechanisms. One example of a substance that causes stress is ozone, which attacks the leaf tissue after uptake via the stomatal openings in the epidermis of the leaf and disturbs resource allocation. A unique "free-air" ozone fumigation system (i.e. without enclosure of branches and plants in bags or cuvettes) was used to fumigate a 2000 m^3 volume of the crown canopy of the Kranzberger Forst. This system was used to achieve twice ambient ozone concentrations in the canopy, while restricting ozone concentration to avoid peaks and acute injury. Trees exposed to the unchanged ambient air and ozone levels prevailing at the forest site served as a control.

> These studies are only possible using field laboratories and complex measurement and analytical methods

The aim of this experimental approach was not to view ozone as an air pollutant, but as an ecophysiological tool to quantify the sensitivi-





Modern analytical methods clearly show the effect of artificially increased ozone concentrations on foliage. On this beech leaf the yellow and red spots in the computer-generated image indicate photosynthetic deficiency by altered chlorophyll fluorescence. Below: The data recorded is collected and analysed immediately using a special computer programme.

ty in space-related allocation (of relevancy for competitiveness, as pointed out above) to induced changes by exposure to chronic ozone stress. So far, however, no structural effect on the crowns or the fine roots of large trees was observed as a result of elevated ozone concentrations. The elevated ozone concentration did, however, stimulate a response in the beech at the molecular and biochemical level by way of reduced foliage age, leaf injury and premature senescence, and initial reduction in photosynthesis.

If the phenomenon of space sequestration with its associated resource turnover is indeed a key factor in competition between plants, then it should be possible to demonstrate this not only in mature trees in the field, but also in saplings under controlled experimental conditions. This was demonstrated in an experiment conducted in climate chambers lasting three years, with beeches and spruces that were initially equal in height and planted in monoculture and as a mixed stand and which were four years old at the end of the experiment. Ozone and carbon dioxide were applied as stress factors. Under these experimental conditions the beech was found to be competitively weaker, in contrast to the findings in the mature mixed stand. These findings could not, however, be explained in terms of the aboveground space exploitation and "running costs" in terms of respiration and water demand. Below ground the beech even demonstrated greater efficiency than the spruce in terms of root length. Once again, the aboveground investment into space sequestration by the foliage differed between the two species, whereas beech as the weaker competitor under these controlled chamber conditions was also less efficient. The decreased competitiveness of the beech in the early stages of growth reflects similar findings in mixed forest stands where beech and spruce of the same size are planted at the same time. The ozone and carbon dioxide concentration applied was of secondary significance for the sensitivity of the trees used for the experiment in the climate chamber. Under such competitive conditions the trees evidently react more strongly to neighbouring plants than to disturbance in the atmosphere by ozone or carbon dioxide.

Overall it was found that space-related resource allocation could be used to draw conclusions on the cost-benefit relationship associated with the competitiveness of each plant. The results of such cost-benefit analysis cannot be generalised for an entire species, however, but apply primarily to the stage of development of the plant and the growth conditions, as is emphasised by the comparison between the young and mature trees in the climate chamber and in the field.

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▶ www.sfb607.de

Measurements in the Magnetic Field

Doctors are banking on the new possibilities offered by magnetic resonance imaging to give them a better view of the blood circulation in the human cardiac muscle

The majority of deaths in western industrialised nations are caused by diseases of the cardiovascular system. These are often the result of changes or constrictions in the coronary blood vessels that can lead to a heart attack or weakness of the cardiac muscle, drastically restricting the patient's physical fitness. Ideally scientists attempt to prevent disease or at least to delay its progress once it has occurred. To achieve these goals it is necessary not only to have access to sensitive diagnostics, which form the basis of preventive therapy, but also to gain a better understanding of the condition in order to develop treatments for it.

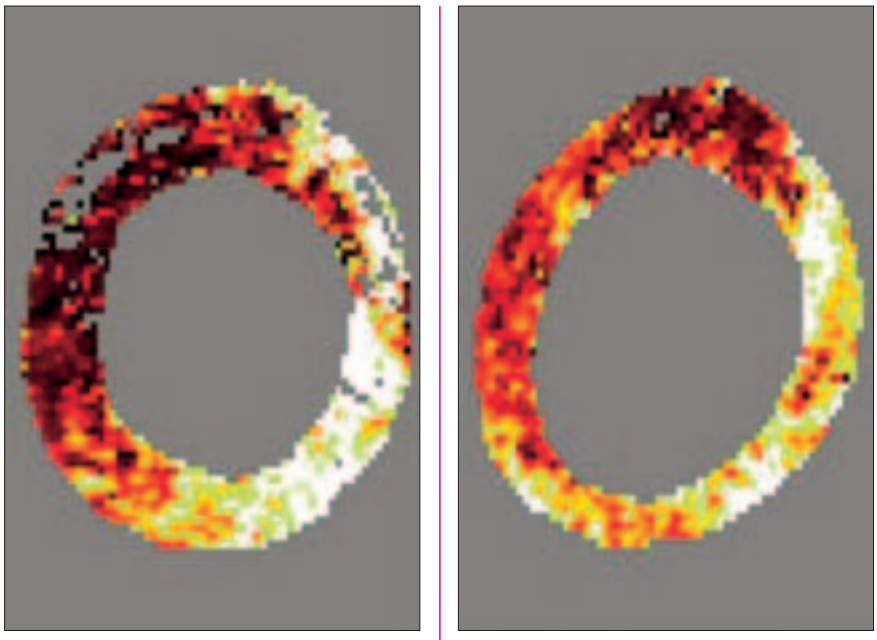
One indicator that plays a fundamental role in both diagnosing and understanding heart disease is the blood circulation in the cardiac muscle. Because the cardiac muscle is working continually, its energy requirement is particularly high. It gets this energy from the oxygen and nutrients in the blood. The heart therefore needs an adequate blood supply to work properly. The blood initially passes from the large coronary blood vessels running across the surface of the heart, through smaller arteries and into the tiniest branchings inside the cardiac muscle, the capillaries. Since these capillaries are very thin-walled and lie deep inside the cardiac muscle, this is where the mass transfer takes place. Oxygen and other vital substances are passed from the capillaries into the surrounding tissue, while in the other direction "metabolic waste" passes from the tissue into the blood, where it is drained away through the veins. Circulation problems are particularly detrimental because they interfere with the heart's ability to function.

Until recently doctors relied on examining the large coronary blood vessels using a catheter to look for constrictions. The problem with this is that it is not easy to assess the relevance of this kind of constriction to the blood circulation using this method of examination, as the heart can form collateral circulations. It can also happen that despite the constriction a patient may not have circulation problems at all and therefore undergoes possibly high-risk treatment unnecessarily.

Other diseases which restrict the circulation in the cardiac muscle can occur after a heart attack or as a result of a hypertrophic cardiomyopathy. For these conditions it would be extremely important to use methods of investigation that enable the number of capillaries and their circulation to be assessed. Traditional diagnostic methods are only partially suitable for this, since they expose the patient to nuclear radiation, require intervention or are not accurate enough.

In collaboration with the German Cancer Research Center (Deutsches Krebsforschungszentrum) in Heidelberg, scientists in Würzburg are making use of magnetic resonance imaging. This procedure, also known as magnetic resonance tomography, produces images of the heart in slices. The image is formed using magnetic signals emitted by hydrogen nuclei, an element existing plentifully in the body. Normally, atomic nuclei move like small magnetic gyroscopes (magnetic resonance). In a strong exterior magnetic field, the hydrogen nuclei react like small compass needles. This now rectified arrangement of the atomic nuclei is then jumbled up by a short pulse of radio waves. As soon as the source of disturbance is switched off, the hydrogen nuclei settle back into the orderly position dictated by the exterior magnetic field. This action produces a characteristic echo, or resonance, which is captured by special sensors and

With magnetic resonance imaging, images of the patient's heart are taken in slices. Now a new procedure is making it possible to measure the bloodstream in the coronary blood vessels more accurately.



Cross sections of the left ventricles of two patients. Areas of the heart muscle that are not supplied with enough blood or oxygen appear dark. This technology enables heart disease to be detected at an early stage.

converted by a computer into a digital cross section. This imaging method has proved so successful that its inventors Paul C. Lauterbur and Sir Peter Mansfield were awarded the Nobel Prize for Medicine in 2003. Traditional magnetic resonance imaging gives only an imprecise view of the circulation in the heart capillaries. An interdisciplinary group has now developed a technique that can detect circulation problems in the cardiac muscle. This procedure uses the physiological reaction of the capillaries to a reduction in circulation, similar to that produced by a constricted vessel. Under normal circulatory conditions, not all the capillaries of the heart are full when at rest. If the circulation is reduced, the heart reacts, opening the previously unused, unfilled capillaries in order to lower resistance and maintain the blood supply. A regional build-up in the number of coronary blood vessels now supplied with blood can indicate, for example, a severe narrowing of one of the coronary arteries supplying this area of the heart. The degree of recruitment of previously inactive heart capillaries is now measured using one of the body's natural contrast mediums, haemoglobin that is not bound with oxygen, called deoxyhaemoglobin. Deoxyhaemoglobin is present in large quantities in the heart capillaries, since the energy-hungry heart tissue is constantly taking oxygen from the haemoglobin. In the presence of an exterior field, as in the MRI scanner, deoxyhaemoglobin becomes magnetic and accelerates the backward oscillation of the magnetic fields of the atoms and thus of their magnetic resonance. From the speed of this process it is possible to estimate the number of capillaries that are filled with blood: the faster the magnetic resonance along the exterior magnetic field, the larger the proportion of deoxyhaemoglobin in the area of the heart being examined and the higher therefore the density of capillaries supplied with blood. Using extensive theoretical examinations, the group was able to investigate the corollary between the density of the capillaries and the speed with which the spins oscillate back. In patients with a constriction in a coronary blood vessel and typical pain, both indications of circulation problems, a faster backward oscillation in the spins in the area of the cardiac muscle with a lower blood supply was observed.

Using another approach, the group also managed to measure the amount of blood flowing into the capillaries in the heart tissue. The researchers did not use a contrast medium for this, rather they discovered a way to magnetically mark the inflowing blood differently from the heart tissue, enabling them to create an image. However, because the blood flows into the cardiac muscle tissue, the different markings get mixed up. The stronger the circulation, the greater the intermixing and vice versa. And because there is no need for a contrast medium, the procedure can be repeated as often as required, giving ever more precise results. This technology makes it considerably easier to obtain a truly quantitative measurement of the circulation in the capillaries than with traditional procedures. The technology was used to examine the cardiac muscles of patients who had suffered a heart attack. During a heart attack, part of the cardiac muscle dies and is replaced by scar tissue. The remaining cardiac muscle has to work harder and tries to balance this by becoming thicker. Experiments have shown that a thickened cardiac muscle leads to reduced circulation and consequently to a reduced blood supply. The reduced circulation also results from a reduction in the density of the capillaries, which at the same time grow longer, increasing resistance for the blood. This circulation problem in the cardiac muscle explains why a thickened cardiac muscle becomes increasingly weaker over time. For patients who have had a heart attack, this means that their fitness declines until their lives become very restricted. For these cases, the new procedure of magnetic resonance imaging has contributed to a better understanding of a disease that has important economic and public welfare implications.

More than that, it is also contributing to finding better treatments for this disease in the future.

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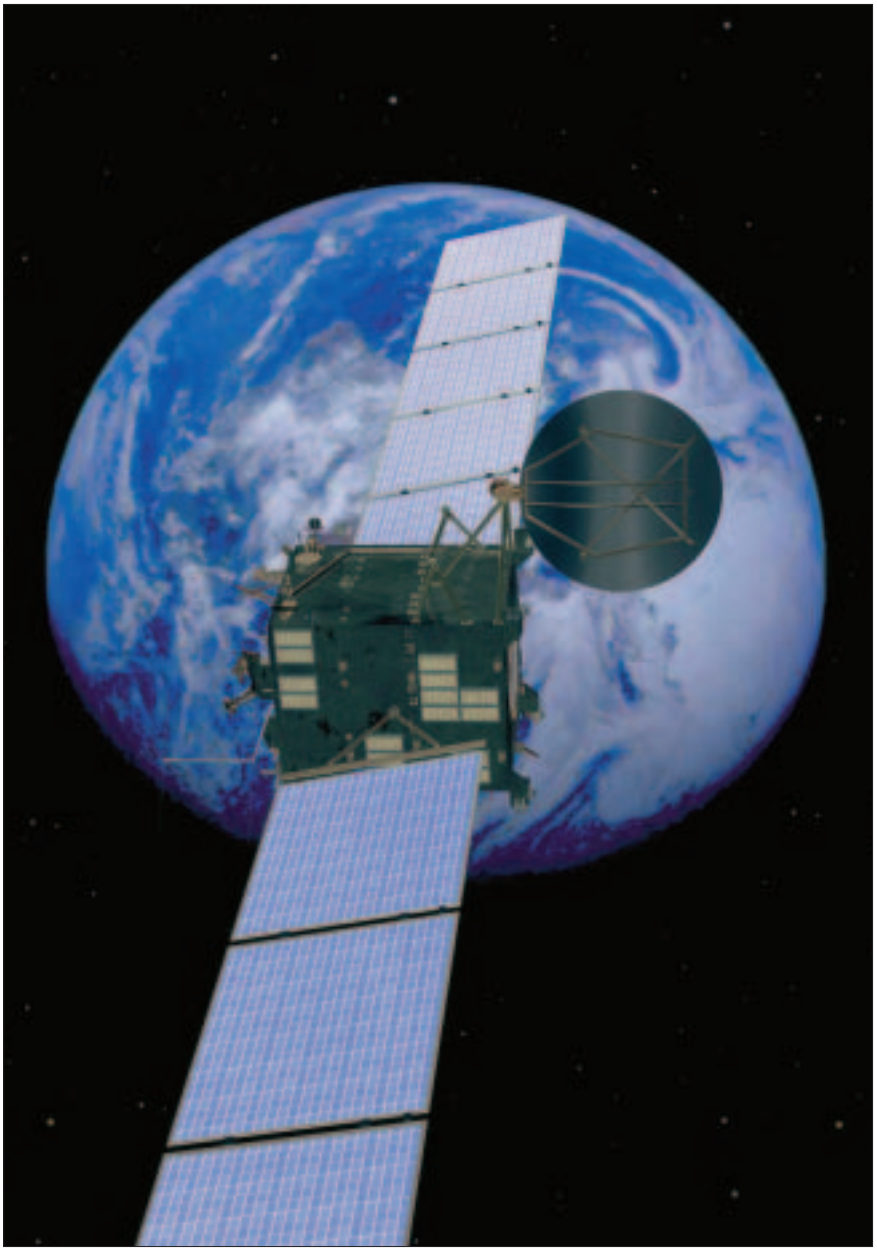
Life from the Depths of Space

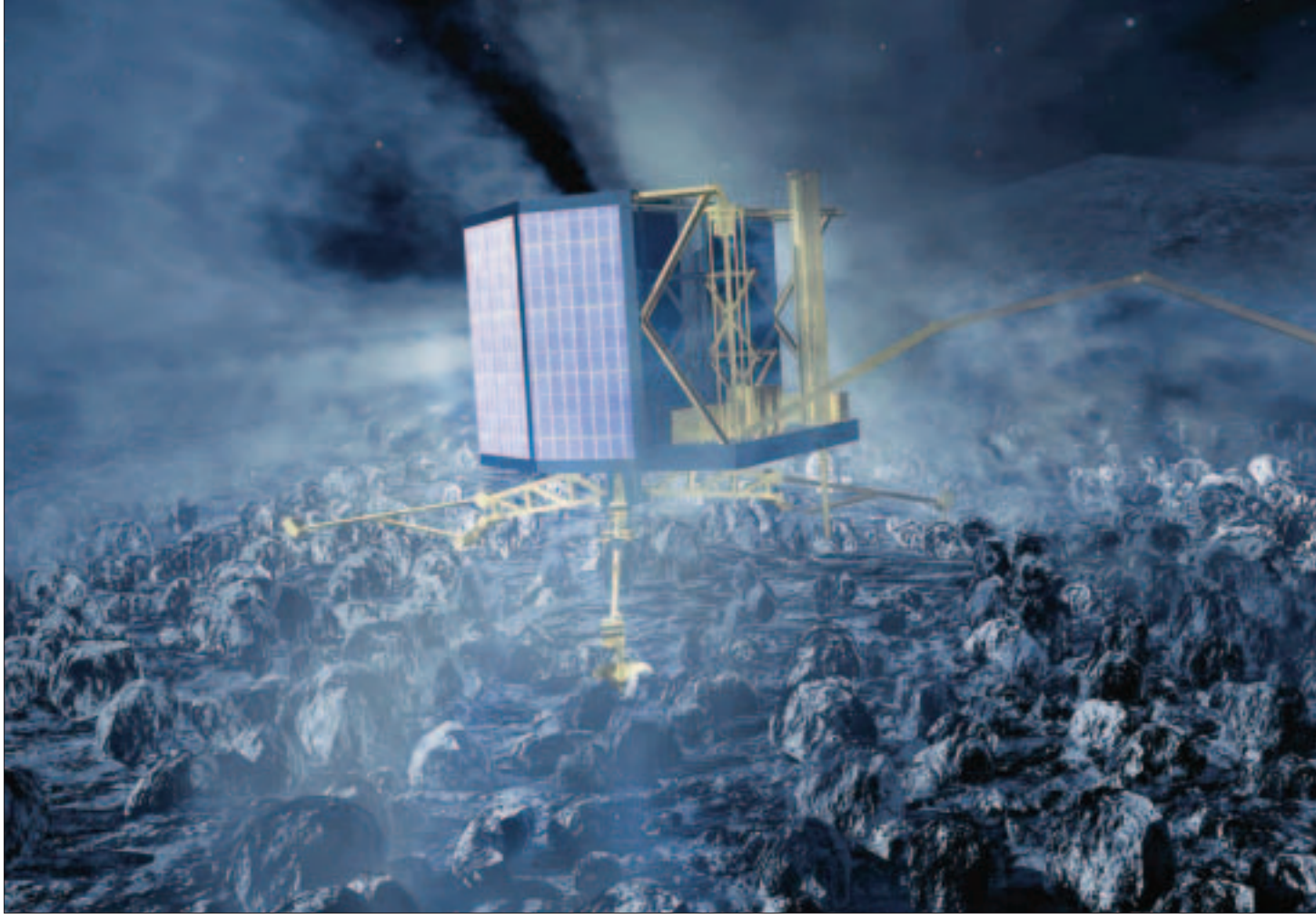
Some of the most important building blocks of life were carried to Earth by meteorites and comets, according to studies by a Franco-German team of chemists using a new method of analysis

About a hundred kilogrammes surviving from the Murchison meteorite may be responsible for changing our view of the world by proving that life may not have originated on Earth at all. Some of life's critical components came from outer space and were brought to Earth by meteorite strikes, according to new studies by a Franco-German team of chemists from the University of Bremen in Germany and the University of Nice-Sophia Antipolis in France. The researchers were able to show that the meteorite was carrying so-called di-amino acids that are thought to have played a key role in the emergence of life. Scientists are also hoping to confirm these results on the Rosetta Comet Mission being undertaken by the European Space Agency.

Since 1953, when Watson and Crick identified deoxyribonucleic acid, or DNA for short, as the carrier of genetic information and discovered the unique information storage capacity of its double helix, there has been speculation on the origins of DNA and of life itself. Theorists currently believe that DNA and proteins are composed of molecular building blocks. Various amino acids, for example, are re-



To gain sufficient momentum the Rosetta comet probe has to orbit the earth three times. Only then will it reach its maximum speed. It should reach its destination, the comet Churyumov-Gerasimenko, 450 million kilometres away in 2014.



After landing, harpoons need to be launched to anchor the lander because the comet has almost no gravitational force. A drill will be used to take rock and soil samples and data will be transmitted to the ESA's satellite control centre in Darmstadt via an antenna.

garded as the building blocks of proteins. It is well known that these acids are also found in meteorites. To investigate these building blocks of life in more detail, the working group and its international partners took a closer look at the Murchison meteorite.

The Murchison meteorite landed in the Australian desert in 1969. Its material is regarded as being "pure", i.e. not altered by materials from earth. The research team used a new method of analysis that they had developed themselves. They ground down a gram of meteorite, powdered it and extracted a sample using highly purified water before subjecting it to the new method of analysis.

Surprisingly these experiments suggested a second "new" class of amino acids. These so called diamino acids have an additional amino group. They are thought to have played a key role in the emergence of life in the chemical evolution of genetic material. Molecular-biological investigations indicate that the stages of chemical evolution before DNA involved the formation of another nucleic acid, so-called RNA, that was itself formed by PNA, a peptide nucleic acid. The backbone of the PNA consists of diamino acids. The results of the research thus indicate that what are assumed to be the building blocks of original genetic material, PNA, are to be found in the Murchison meteorite. The fact that this "new" class of amino acids has not previously been detected in meteorites is ascribed to the analytical methods used in the past. Analysis of meteorite samples usually involves the use of capillary fractionating columns 30-50 metres in length. Such columns are generally too long to enable rinsing out of heavy diamino acid derivates in the static phase. For the new studies a short column only 12 metres long was used.

The Murchison meteorite landed in Australia in 1969 and its contents are regarded as "pure"

These findings call the existing model for the synthesis of amino acids in the course of chemical evolution, which assumes that amino acids were formed in the atmosphere of the prehistoric earth, into question. Two years ago, during their preparations for the ESA's Rosetta comet mission, the University of Bremen and its partners in other European countries proved that structures of amino acids that form the basis of protein molecules could already be synthesised spontaneously and

Top: A laboratory on the surface of a comet. For the experiments cometary material from drilled samples will be vaporised and analysed by the probe's instruments. This method is designed to locate and identify organic molecules. The yellowish condensate (left) contains organic molecules.

continuously by photochemical reactions in interstellar space, i.e. in specific areas of the cosmos. Such interstellar ice particles accumulate over the course of time, initially forming so-called cometissimals, and subsequently comets. It is currently assumed that organic material could have been transported to the early earth from areas of the interstellar medium via (micro)meteorites or comets. Following the simulations of comets, scientific interest is now focussed on the direct analysis of cometary material with the assistance of the Rosetta comet research mission. By taking measurements of the ice from an actual comet it is hoped the probe will confirm the results gained so far. After the successful launch of the Ariane 5+ rocket from Kourou in French Guyana, South America, the mission is now looking for the molecular building blocks of life itself. Currently it is expected that the destination, the comet 67P/ Churyumov-Gerasimenko, will be reached in 2014. The probe will orbit the comet and take measurements for six months before the Philae lander is set down on the comet's surface for the first time in history. After this novel device lands on the surface of Churyumov-Gerasimenko it will analyse the substance of the comet. Interest centres on identifying organic molecules such as amino acids and diamino acids, the molecular building blocks of life.

Apart from simply identifying organic molecules the studies of meteorites and comets may also shed light on another phenomenon, the so-called chirality of molecules. Chirality, or handedness, describes how biological molecules have two forms that are not the same, but symmetrical. Biological molecules are composed of components that are either exclusively right-handed or exclusively left-handed, i.e. they have one, and only one, of these two symmetrical forms. For example, proteins are exclusively made of L-amino acids, whereas their mirror-image D-amino acids do not occur in proteins at all. Similarly, carbohydrates and DNA exclusively use D-sugars and have no use for any L-sugar molecules that may occur. A key question for scientists is now the issue of when, during the early stages of evolution, the geometrical difference became decisive in the biological process and why it plays a role at all. There are currently many reasons to believe that this symmetrical distinction did not take place on earth, but had already taken place in outer space. If this is the case, chiral molecules, such as amino acids or sugars, should already occur in cometary material in unequal proportions.

Scientists hope to calculate the corresponding proportions of chiral molecules from the measurements taken on the comet. This could allow significant conclusions on the theories concerning the initial asymmetric synthesis are to be reached. If the same excess of L-amino acids or D-sugars is found in the core of the comet as in biological molecules on earth, it would be a strong indication that the first molecules of this kind were brought to the early earth from space. That would also indicate that meteorite strikes may have triggered chemical evolution. Such a result would also support theories suggesting that the first asymmetric molecules that led to DNA first came into being in space.

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Robotic Football for Science

The autonomous robots taking part in the RoboCup matches not only delight enthusiastic domestic spectators but also benefit researchers worldwide

Football in Stuttgart. Hundreds of spectators await the kick-off on the pitch. The ball is red and round and rests within the centre circle of the five by seven metre playing surface. The teams taking part in the tournament are gathered behind the blue and yellow goals, Brainstormers Tribots from Osnabrück, CoPS from Stuttgart, FU Fighters from Berlin and AIS-Robots from Sankt Augustin. What is special about the tournament is that all of the players are robots. Robots in action – robot football as a spectator sport like at last year's Science Summer in Stuttgart.

When researchers first thought of using football as a platform for demonstrating research results and technology to the public, they had no idea of how this idea would catch on around the world. Nowadays there are more than a hundred universities, institutes and research establishments that regularly field teams to match their skills publicly against sides from all over the world in robot tournaments and join in with the scientific symposia on research that accompany them.

Football matches are used as a standardised scenario to compare results from research on artificial intelligence, robotics and other disciplines. For this reason, the international RoboCup Federation has been organising annual world championships and conferences since 1997. In the various RoboCup leagues mobile wheeled or humanoid robots play football, with rescue robots and disaster management, as well as encourage young people into robotics, forming various additional aims. The leagues that use real robots are primarily interested in researching robotic behaviour where robots make their own decisions in a situation that is continuously and rapidly changing. The robots are not remote controlled and thus have to register their surroundings by means of their own sensors. On the basis of the information from the sensors, they have to then make sensible decisions about what actions to take. In simulated leagues virtual robots controlled by so-called agent programmes play one another. Information from sensors does not pose a problem in this case. Instead strategies, learning of response patterns and cooperation with other players are the key factors.

The rules for competition are being developed and modified step by step in terms of the framework conditions. This is intended to make the games faster and more exciting and also to incorporate features relevant to future robot applications. Whereas a few years ago RoboCup robots could only play with a blinkered view and under precisely defined and very bright artificial lighting, these days, they can cope with natural or dim lighting and without blinkers. In addition they can safely distinguish the red ball from similarly coloured objects outside the field of play.

As part of the Priority Programme "Cooperative Teams of Mobile Robots in Dynamic Environments" football-playing robots represent a demonstration application and testing ground for research projects in artificial intelligence and mobile ro-

The whistle starts the RoboCup: Football-playing robots display their skills at the German Open.The tournament serves as a scenario for comparing research results in the fields of artificial intelligence and mobile robotics.

botics. The range of topics includes research into methods, components and development tools needed for mobile robot teams intended to move and act of their own accord towards specific ends in dynamic environments. The RoboCup with its real and simulated robot leagues provides an ideal scenario for this. It makes it possible, among other things, to compare the results gained from researches and also allows the competitive potential of those results to be tested in a worldwide robotics community that is actively engaged in research into autonomous, mobile robots.

Registering the environment in real time, making rapid decisions, planning and working in a team are all key aspects that will be relevant for future technical applications. At the same time so-called control architectures for robot behaviour play a key role. They make it possible for the robot to react quickly and surely to the information from its sensors and also to plan and undertake longer term and more far-reaching actions. The range of actions goes from coordinated control of complex leg movements for a robot dog to the planning of the best motion for wheeled robots. Investigation of learning and evolutionary methods with regard to the basic capabilities of individual robots or the automatic instigation of cooperative behaviour for a team of robots is another key feature. The question of transferring capabilities learned in simulations to real robots is a particularly interesting aspect of this.

Apart from the highly specialised research work on the individual topics the Priority Programme also highlights in particular the cooperation between research groups at 14 different locations. The league for Germany's active four-legged robots has already spawned a German national team. The individual solutions of the participating universities were compared with one another and the best component systems selected and then formed into a new unit. This close cooperation paid off. The German team became world champions at the RoboCup championships in Lisbon in 2004. The FU Fighters also took home the world championship title in the league for miniature robots. Cooperation between the individual leagues is now being extended. The best results from a variety of leagues are now being forged together. This means that RoboCup teams that have previously been restricted to working in simulation leagues now have the opportunity to demonstrate the results of their research on real robots, for example using the modular VolksBot platform that has been made available as a flexible and extensible basis for robot experiments.

As part of the Priority Programme, the Fraunhofer Institute for Autonomous Intelligent Systems has

No more chances to use the laptop to interrupt the match. The autonomous robots act of their own accord. They have to register the surroundings with their sensors and make sensible decisions on that basis. Right: The audience is also delighted by the small-size robot league.

held the RoboCup German Open every year since 2001. With support from the DFG and in cooperation with the Heinz Nixdorf Museum Forum the fourth German Open was held in April 2004. Over 150 RoboCup teams from 13 countries, encompassing 600 active participants, took part in the biggest RoboCup competition outside of the world championships. As in previous years several thousand spectators were drawn to Paderborn for the event.

RoboCup competitions are not only matches between university research teams but are now becoming an ever more attractive spectacle for the public and one that gives them a tangible experience of real science. Robot experiments are particularly exciting to children and teenagers. This is clearly shown by the increasing participation year by year in the RoboCup Junior tournaments. The RoboCup thus makes an important contribution to the inspiration of young scientists. It is not just a demonstration scenario for robotics researchers but also an attractive instrument for interdisciplinary technological education in schools, universities and business. Robots can perceive themselves and their environment and thus gather and structure knowledge of their own accord. In the space of a few years they will be capable of making sensible real-time decisions as to the actions they should take even in complex situations. Robots working to systematically record environmental data in unknown terrain, searching wrecked buildings for survivors or carrying out transport tasks in public spaces will require techniques that can only be developed by means of close cooperation between researchers in many disciplines. The research results achieved so far make fundamental contributions to these future applications, not only in terms of service robotics.

RoboCup competitions make science tangible and provide a key platform for research

It remains to be seen whether the visionary aim of the RoboCup Federation, to beat the human world champions with a team of humanoid robots by the year 2050, is a realistic one. Whether or not it happens, a host of results will be achieved in robotics along the way, and not only that. The RoboCup will also educate the young scientists who may yet one day achieve the seemingly unattainable objective. What is certain and predictable even today is that the tenth anniversary of the

RoboCup in 2006 will see Germany as the venue for the world championship for the first time ever and the event will take place in Bremen simultaneously with the FIFA World Cup from 13-19 July.

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▶ www.ais.fraunhofer.de/dfg-robocup
▶ www.robocup-german-open.de

Inspiring Public Interest in Science

Wolfgang Heckl one of the winners

Approximately 300 invited guests from science and politics gathered in the historic Rudolph Gallery in Prague Castle for the award ceremony of the "Descartes Prizes" by Václav Klaus, President of the Czech Republic, and Janez Potočnik, the newly appointed EU Science and Research Commissioner. The European Commission has awarded the Descartes Prize – which is worth € 1,000,000 in total and is shared among the laureates – annually since 2000 in recognition of outstanding achievements in European scientific cooperation.

The "Descartes Prize for Science Communication", worth € 250,000 (€ 50,000 for each laureate), was awarded for the first time. Two outstanding communicators, the physicist Professor Wolfgang Heckl from Munich and the British zoologist and broadcaster Sir David Attenborough, received the award in the category "Professional scientists engaged in science communication to the public".

To qualify for this prize, candidates must have already been awarded a prize or comparable distinction at national level. The DFG nominated Wolfgang Heckl, winner of the Communicator Award 2002. This is awarded to scientists and researchers who have shown exceptional passion and dedication in communicating their research to the public. The Descartes Prize Grand Jury, installed by the European Commission, described Wolfgang Heckl as a "youthful and dynamic personality (who) has achieved widespread renown in his home country through his ability to explain hard science to young and old in a fun, entertaining way". A total of 47 nominations were received from throughout Europe, of which 19 reached the final shortlist and gave presentations at the ceremony in Prague.

Wolfgang Heckl was born in 1958, and after leaving school studied physics at the Technical University of Munich. After receiving his doctorate in biophysics he first spent a year as a postdoc at the University of Toronto in Canada in 1989, before joining Professor Gerd Binnig at the IBM Research Laboratory in Switzerland. He completed his "Habilitation" (the German qualification for a university lecturer) in physics in 1993 and, in the same year, accepted an appointment as Professor of Experimental Physics at the Ludwig Maximilian University in Munich. In 1993 he received the Philipp Morris Research Award. Since October 2004, Wolfgang Heckl has also been the Director General of the Deutsches Museum in Munich.

For over ten years, Wolfgang Heckl has been dedicated to communicating his research results to the general public. He became known for his ability to communicate science as far back as the early nineties, with various television documentaries showing his scanning tunnelling microscope examinations of human DNA, which for the first time allowed DNA bases to be seen. Heckl has since given the public insights into the world of nanotechnology in regular scientific TV appearances. In his endeavours to promote better understanding of science and technology Heckl uses a wide variety of methods to communicate his subject and make it relevant and accessible to people of all ages and from all sections of society. Wolfgang Heckl is involved in projects for exhibitions and science fairs on a variety of topics relating to the natural sciences and continuously seeks dialogue with those who are sceptical of science and critical of nanotechnology, which is his area of specialisation. His commitment to the public understanding of science also encompasses politics. In this respect, just as in his work with young people, Heckl regards his campaign for an understanding of and enthusiasm for science as an investment in the future. In the summer of 2004 Wolfgang Heckl agreed to act as chairman for the next pan-European EuroScience Open Forum, due to take place in Munich in 2006.

One of the other categories of the Descartes Prize for Science Communication is for "Innovative action for science communication." In this category the Hungarian Professor Peter Csermely was awarded the prize for a project to help youngsters find their way into science, and the Belgian Professor Ignaas Verpoest for his mobile exhibition "composites-on-tour".

In the third category (of a total of five) "Popularising science through audio-visual and electronic media" the French television producer Vincent Lamy was recognised for his documentary, which revealed the strange world of the "stick insect".

Eva-Maria Streier

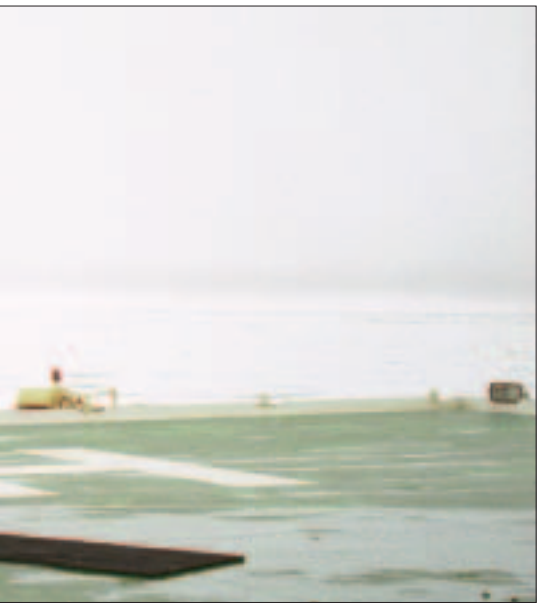
Was the North Pole Once Ice Free?

An international expedition to the central Arctic Ocean has drilled sediment cores that reveal unexpected results on the process of climate change and reflect the most important long-term changes in the Earth's environment

Bremen, 9 November 2004. This is the day that scientists from the Arctic Coring Expedition (ACEX) have been awaiting for so long. Thirty-two geologists, palaeontologists, chemists, microbiologists and other scientists from ten countries are meeting in the sediment-core repository of the Integrated Ocean Drilling Program (IODP) at the University of Bremen. The two-story brick warehouse at Europahafen was once a warehouse for tobacco, cotton and other goods. It has now been converted into a treasure vault for the geological sciences. "Our shelves contain a good 75 kilometres of sedimentary cores drilled from the beds of the Atlantic Ocean, the Mediterranean Sea and the Southern Ocean, all of them cut into one-and-a-half metre sections and packaged in white plastic containers," states Professor Gerold Wefer, director of the DFG Research Centre Ocean Margins.

Recently, 340 metres of especially valuable sediment core were acquired. They were drilled in August and September 2004 during a six-week expedition not far from the North Pole. "This Arctic Coring Expedition has allowed us to obtain large quantities of sediment core from the Arctic Ocean for the first time," said expedition leader Jan Backmann, geology professor at the University of Stockholm.

Tromsö, 7 August 2004. At midnight, the "Oden" casts off. The



108-metre long, 31-metre wide Swedish icebreaker, with its 24,000-hp engine, sets out for the North Pole from northern Norway. The "Vidar Viking", an 84-metre long tug that normally serves oil rigs, follows in its wake. It was converted to a polar drilling platform in the preceding weeks. Amidships there is now a 34-metre high drilling rig. Nineteen scientists from eight countries, including a geological science staff from Bremen University and the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven board at Tromsö. They will be spending a good six weeks in this barren white wilderness.

10 August 2004. North-west of Franz-Joseph Land, at 82 degrees latitude, the two ships rendezvous with the "Sovetskiy Soyuz" a 148-metre long, atomic-powered Russian icebreaker, which completes the polar convoy. Its 75,000-hp engine will help to ensure that the expedition reaches its goal. The intended location for the work is expected to be capped by a practically unbroken ice cover. Changing winds and currents cause the motions of the drifting ice to change continuously. This means that even a relatively powerful drill ship like the "Vidar Viking" will find it difficult to maintain its position. This, however, is essential during drilling operations, since otherwise there is a danger of the drill string breaking. The "Oden" and "Sovetskiy Soyuz" will thus maintain positions at the drilling location not far from the drill ship in order to break up the huge ice floes, which are up to four metres thick, to a size where they no longer pose a threat to the "Vidar Viking".

Scientific drilling in the Arctic is an expensive undertaking. That is why such projects can only be achieved through international co-operative programs such as the Integrated Ocean Drilling Program (IODP) that began in 2003. It is financed by the USA, Japan and the European Consortium for Ocean Research Drilling (ECORD). Fourteen European countries plus Canada have come together to form ECORD. The consortium conducts special drilling campaigns in shallow coastal seas or in ice-covered regions that are inaccessible for the two IODP drill ships "Joides Resolution" and "Chikyu". Technical coordination and quality assurance for the scientific data is the responsibility of the ECORD Science Operator (ESO). This is coordinated by the

Scenes from an expedition to the Arctic Ocean: A helicopter takes off on an ice-locating mission. The drill ship "Vidar Viking" can be seen in the background. Left: The scientists on board rely on working and lab containers. Bottom: The atomic-powered icebreaker "Sovetskiy Soyuz" breaks ice floes so that they do not pose a risk to the drill ship.

British Geological Survey. Bremen University is one of the three main partners of the ESO and, among its many other tasks, it operates the Bremen IODP core repository, the only one in Europe. The Arctic Coring Expedition, which cost 12.5 million dollars, was Europe's first contribution to the "Integrated Ocean Drilling Program". The DFG provided 2.25 million dollars of this. In addition to the DFG, the Bundesanstalt für Geowissenschaften und Rohstoffe Hannover (BGR, Federal Institute for Geosciences and Natural Resources in Hannover) also plays a key part in the IODP collaboration. It coordinates Germany's scientific contributions to the international oceanic research program.

1 September 2004. The thermometer indicates minus 5 degrees Celsius. In a slight northerly wind and under clear skies the drilling is progressing successfully. With help from the "Oden" and "Sovetskiy Soyuz", the "Vidar Viking" has already maintained position for 125 hours. Despite 80 to 100 percent ice coverage, the drill ship has not moved more than 20 metres from its intended position. A sediment layer with a thickness of 427 metres on the Lomonosov Ridge has already been penetrated to within the last 40 metres.

The nine micropalaeontologists on the expedition all have their hands full. They are working with the biostratigraphy, i.e., the age of the sedimentary layers in the drilled samples. While the plastic cylinders containing the cores will not be opened until they reach Bremen, small samples are being taken from the bottom of each 4.5-metre long drill core. These are then analysed by the scientists for all the usual microfossil groups in order to estimate the age of the sedimentary layers.

Two days later the drill strikes the hard sandstone of the Lomonosov Ridge. At about 2 o'clock p.m. on 5 September the last drill core is heaved onto the deck of the "Vidar Viking" and the expedition sets sail back to Tromsö.

Bremen, 16 November 2004. Just over two-and-a-half months after the expedition ended, the deposits from the North Pole were scientifically investigated in Bremen by the "Onshore Science Party". For two weeks, cores totalling 340 metres in length were opened. They had been taken from four locations in a total of six drilling operations and represent a time span of 80 million years.

The top 160 metres of the cores offer nearly complete documentation of climate change in the last 15 million years. The 200 metres at the bottom cover the middle and early parts of the Paleogene period, representing a span reaching back almost 56 million years. The sedimentary sequence is not complete, however. For reasons yet to be explained there are no deposits for the period between 15 and 35 million years ago.

The investigations showed that the climatic and environmental history of the central Arctic Ocean followed climatic developments of the globe as a whole. Microfossils indicate that the Arctic Ocean of 55 million years ago was warm, with temperatures that would be considered sub-tropical today. Sea temperatures of 20 degrees Celsius are not out of the question. Thus it was demonstrated definitively for the first time that the maximum worldwide temperatures at the transition between the Palaeocene and Eocene epochs were located in the Arctic Ocean.

The drilled cores provide nearly complete documentation of climate change for the last 15 million years

However, the cores had more surprises to reveal. Freshwater algae and, in particular, huge quantities of freshwater ferns in the middle Eocene of 49 million years ago indicate that the supply of water from the rivers of the surrounding continents was, in contrast to previous theories, of great importance to the hydrological cycle of the Arctic Ocean. Silicates and carbon-rich sediments in the middle Eocene in-

Once the ice cover is broken, the drilling can begin. In an emergency, a helicopter can also land on the water. Sedimentary samples are evaluated even on board the expedition ship, and described using a colour scale. On guard: A rifle for protection against curious polar bears.

dicate far greater amounts of biological activity in the surface waters than is the case today. These findings point to a considerable production of plants during this period.

Sand and individual silicate particles, possibly transported to the Arctic by ice floes and icebergs, appear regularly during the last 15 million years. This leads to the conclusion that sea ice has played a key role in the climate of the Arctic during this period. The question of whether the Arctic Ocean was frozen over only in winter or throughout the year can only be answered by further sedimentological and micropalaeontological study. Clear evidence of immense ice sheets on the surrounding continents has not yet been found in the sediments.

Particularly spectacular was the discovery of individual silicate stones from the Middle Eocene, the period between 40 and 46 million years ago. They must have been transported to the Arctic from the surrounding land by ice floes and icebergs, indicating that climatic conditions were cold at the same time that the western Antarctic was just starting to form a continental ice cover. This is astonishing. Scientists had previously believed that the initial formation of ice at the Antarctic had occurred much earlier than at Arctic latitudes. Does this mean we have to rethink our view of the world climate? Did the ice covers appear in both the Arctic and Antarctic simultaneously? For now, these questions can be addressed with no more than speculation.

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The Deutsche Forschungsgemeinschaft

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The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme,* any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of 12 years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. Transregional Collaborative Research Centres allow various locations to cooperate on one topical focus. Cultural Studies Research Centres are designed to support the transition in the humanities to an integrated cultural studies paradigm. Transfer Units serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

DFG Research Centres are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

Research Training Groups are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focuses on a coherent, topically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In International Research Training Groups, a jointly structured doctoral programme is offered by German and foreign universities.

Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme.*

Humanities Research Centres were created in the new federal states to improve the existing research infrastructure. These centres have been established for a specific time period and serve to promote interdisciplinary research.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals submitted within the framework of the *Hochschulbauförderungsgesetz*, a legal act which provides for major equipment and the construction of institutions of higher education in Germany. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

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Illustrations

von der Fecht, IODP (cover, pp. 24-27); Querbach (p. 3, back); Busemann (p. 4/5); Hemke (pp. 6 l., 7 r.); Schuck (pp. 6/7, 8 b.); Michaelis/TLZ (pp. 8 a., 9 r.); Mende (p. 9 l.); Matyssek, SFB 607 (pp. 10-14); Bauer (pp. 15, 16); ESA/AOES Medialab (pp. 17, 18/19); MPI für Aeronomie, Katlenburg-Lindau (p. 19 r.); Leiden Observatorium (19 b.); SPP 1125 (pp. 21, 22); Streier (p. 23)

Layout of pictures: l.: left; r.: right; a.: above; c.: centre; b.: below

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