FOCUS

Society in Conflict

PSYCHOLOGY
Fear in the Wake of Terror

ASTROPHYSICS
Only the Big Bang Was More Powerful

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Promising – One of the central concerns of the Max Planck Society is to constantly address new areas of study. After all, we cannot claim to “roll back the limits of knowledge” unless we are at all times aware of where these limits lie. That is why we regularly review our research portfolio. This year, we have founded one new institute and refocused a second on an entirely new concentration. Both will address complex challenges facing our society, as reflected in their titles: the Max Planck Institute for the Study of Religious and Ethnic Diversity in Göttingen and the Max Planck Institute for the Biology of Aging in Cologne. Following its reorientation, including an expansion to three departments, the institute in Göttingen will concentrate on the change in religious attitudes, social structures and identities in immigrant communities, and on political answers to religious and ethnic heterogeneity. The newly formed Max Planck Institute in Cologne will comprise four departments that focus on the long-term study of the basic biological processes responsible for the aging of all living organisms (see also page 82 ff.). An understanding of this field is essential to enable us humans to preserve our health into a ripe old age. I am certain that both institutes have a promising future ahead of them.

Humanistic – As a regular reader of MaxPlanckResearch, you are undoubtedly aware that, although the Max Planck Society is named after a physicist, our array of institutes also includes 19 that are devoted to the humanities. This issue includes insight into their areas of research, not least in its Focus on “Society in Conflict.” The German Federal Ministry for Education and Research has chosen the humanities as the focal point for the Science Year 2007. Taking as its theme “The ABCs of Humanity,” the central issue is language - a subject that is prominently represented at our institutes. For example, the Max Planck Institute for Psycholinguistics is devoted to, among other things, the correlation between thought and speech, and the question of how children learn their mother tongue, as well as how adults learn foreign languages (page 58 ff.). Scientists at the Max Planck Institute for Evolutionary Anthropology are researching such issues as the common features and distinctions between various languages and dialects. The Max Planck Institute for Human Cognitive and Brain Sciences observes what happens in the brain as languages are spoken and understood. And our Art History Institutes in Florence and Rome study the language of visual arts in the course of changing times. These examples highlight only a small segment of the humanities research conducted by the Max Planck Society. However, they do show how wide a variety of aspects we cover in this field.

Revealing – The ability to straddle the boundary between the humanities and the natural sciences is one of the particular strengths of the Max Planck Institutes. Evolutionary anthropology offers an excellent example. As you can read in the “Fascinating Research” section (page 44 ff.), scientists are using the very latest technology to study one of the central issues of humanity: the origin of Homo sapiens. Just how much importance attaches to this question, not only in the world of science, was recently highlighted in the American magazine Time. Tasked with compiling this year’s list of the world’s 100 most influential people, besides personalities such as Queen Elizabeth II, Brad Pitt, Al Gore and Anna Netrebko, journalists also singled out paleoanthropologist Svante Pääbo. The Director at our institute in Leipzig is currently engaged in decoding the Neanderthal genome in order to compare it with our human genes. As Time commented in its acknowledgement, by deciphering this exact data, Pääbo is contributing to a clearer understanding of human evolutionary history.

Expanded Portfolio

PHOTO : ANTJE MEINEN

Peter Gruss, President of the Max Planck Society

NOTES FROM THE PRESIDENT

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SKULL COPY: If the bones won’t come to the researcher, then the researcher must go to the bones. Using a mobile tomograph, paleoanthropologists are reconstructing fossilized skulls to investigate human development.

COSMIC FLASHES: Gamma-ray bursts bear witness to the most powerful explosions in our universe. At a congress in Schloss Ringberg, astrophysicists discussed just what might be behind these immense eruptions.

MIXED NEEDS: We can’t seem to get enough of traveling. Evolutionary economists suspect that this is our way of satisfying numerous needs - including the need for good health.

PLANETARY DYNAMOS: Ulrich Christensen goes way below planetary surfaces. He simulates their interiors and investigates their makeup in the search to clarify how their magnetic fields come about.

NOTES FROM THE PRESIDENT

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“We must be sure to win the contest for the finest minds”

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Research Establishments of the Max Planck Society

IN THE SPOTLIGHT
Bats cause a stir
Caught in the Act of Tunneling

We have to climb a mountain in order to conquer it. In quantum physics, however, there is a different way: instead of laboriously climbing over it, objects can reach the opposite side of a hill by simply tunneling through it. An international team of researchers working with Ferenc Krausz from the Max Planck Institute for Quantum Optics has now observed electrons in this tunneling process for the first time.

They watched how electrons escaped the atom by simply tunneling through it. An interstellar way to conquer a mountain: In classical physics, you must climb a mountain to get to the other side. Not so in quantum physics: Objects can simply move through the mountain horizontally – by tunneling through it.

SiNNUS’ problem was one of physics. The stone he incessantly rolled up the mountain was pulled back down to the valley again and again by gravity, only coming to a halt at the lowest point because that is where its energy was least. In physics, this means that it stopped moving at the minimum of the potential created by gravity. This principle became a curse for the mythical Sisyphus, but it is what holds our world – or more precisely, the atoms of our world – together.

It pulls every particle to the deepest point of a potential – even electrons. The negatively charged particles try to reach the lowest point of the binding potential created by the electrostatic force of the positively charged atomic nucleus. As the electrons move very quickly, they do not collapse into the nucleus, but circulate around it at a respectable distance. They are trapped in an electrostatic potential wall that is holding the electron in the atom.

In quantum physics, however, there is a certain probability that it will be somewhere where, according to the laws of classical physics, it should not be – in a potential wall, for example, or even on the other side of the wall. However, the likelihood that a macroscopic object, such as a boulder, would get to the other side of a mountain in the same way is infinitesimally small – which is why no one has yet observed a tunneling boulder. On the other hand, the chances that microscopic particles will manage to wangle their way through mountains, albeit electrostatic mountains, are pretty good.

However, not only electrons escape the attraction of their nucleus by tunneling. Alpha particles, too, detach themselves from radioactive nuclei in this way, and atomic nuclei tunnel toward each other in the fusion process. Although the tunneling effect is not rare in nature, it has not yet been possible to observe it in real time because it simply happened too quickly. Krausz and his team have now seen it live with the particular intensity of an attenuated light pulse. At the same time, they observed the electron’s escape only because they synchronized the pulses perfectly.

There is no instrument that can directly resolve the tunnel effect. Only the end products can be detected – the ions that remain when an electron tunnels out of an atom. The researchers therefore had to use the trick of experimenting with atoms of the noble gas neon, in which the electrons are bound to the nucleus particularly strongly and react the effort of the red laser pulse to detach them from the atom. However, when an attenuated flash of UV light hits a neon atom first, it excites an electron and moves it to the periphery of the atom.

The scientists then fire a red laser pulse, containing a series of a few wave crests and troughs, at the atom. Near the wave crest, the electrical field of the powerful red laser pulse depresses the potential wall that is holding the electron in the atom, making it possible for the excited electron to tunnel out.

“With the UV pulse, which lasted only 250 attoseconds, we moved an electron at any time within the red laser wave with attosecond precision to the periphery,” explains Krausz. They guided the peak of the UV pulse over the wave crest of the red laser pulse. At the same time, they counted the atoms from which an electron had tunneled out and that had thus become ionized. This allowed them to establish that the electrons tunnel only if the particularly intense wave peaks of the red laser pulse touch the atom shortly after it was excited by the UV pulse. In this way, they have also been able to set an upper limit on how long the tunneling process takes – less than 400 attoseconds.

“The experiments not only allow us insight into the dynamics of electron tunneling,” says Krausz. “We have also shown that the movement of electrons in atoms or molecules can be observed in real time with laser-field induced tunneling. Physicists use these findings to control the movement of the electrons. In the future, this will allow us to find out how the boundaries of microelectronics can be moved,” says Krausz. Optical electronics works more efficiently the more precisely the interaction between light and electrons is controlled. It might even be possible for physicists to develop compact X-ray lasers if they have more influence over the electronic processes in atoms. Such brilliant X-ray sources would allow better images of biological objects or improvements in radiation therapy.
The Search for Florigen

Why do crocuses bloom in the spring and asters in the fall? And why are the flowers of one species found in the high mountains while those of another are in the sand dunes near the sea? For generations of botanists, progress was first made in the 1930s by the Russian Michael Chailakhyan, who postulated the existence of a florigen, a hormone that induces flowering. However, the question of what this florigen actually is has provided work for generations of botanists. Progress was first seen in the late 1990s and in 2005, and the issue of how the florigen reaches the shoot tip has proved a particularly controversial subject.

The existence of a florigen was postulated as early as 1936 by the Russian Michael Chailakhyan, who said that flowering was triggered by a hormonal stimulus. It was, however, unclear whether this stimulus consisted of a protein, a nucleic acid or another substance. In the 1990s, Detlef Weigel and his team at the Max Planck Institute for Plant Breeding Research in Cologne were able to show that the protein that functions as the florigen (Science, April 20, 2003) — thereby casting doubt on another publication.

The breakthrough for Weigel and his team occurred just as researchers from the Max Planck Institute for Solid State Research in Stuttgart, the Fraunhofer Institute for the Mechanics of Materials in Freiburg and King’s College London from the Max Planck researchers had used GFP, a green fluorescent protein from a jellyfish, to track the FT protein. This allowed the scientists to trace the path of the GFP-FT fusion in Arabidopsis from the leaf to the plant tip under the microscope, and to show that the FT protein is indeed formed in the leaves, subsequently traveling through the whole plant to the growing points in the tips, where flowering is induced.

Further proof of the fact that it is the FT protein that triggers flowering in Arabidopsis mutants that do not create an FT protein, as they then do not have the relevant gene. These mutants were grafted onto normal Arabidopsis plants. The researchers have observed that the FT protein moves from the lower plant through the grafted FT-free plant, and how flowers then formed. Nevertheless, not all scientists believe that the experiments provide sufficient proof. And so the final chapter in the florigen mystery is yet to come. 

Plant Research

The Search for Florigen

Why do crocuses bloom in the spring and asters in the fall? And why are the flowers always found on the tips of the shoots and not anywhere else on the leaves or stems? Plants actually have molecular light sensors in their leaves that measure the seasonal differences in day length. At the right time, usually in the spring, the leaves send a messenger substance as a signal to induce flowering. The question of what this florigen actually is has provided work for generations of botanists. Progress was first seen in the late 1990s and in 2005, and the issue of how the florigen reaches the shoot tip has proved a particularly controversial subject.

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Stereochemistry

How Molecules Shake Hands

Life is teamwork on a grand scale: there are more molecules working away hand-in-hand in the human body than there are stars in space. An international team of scientists including researchers from the Max Planck Institute for Solid State Research has now observed how molecules recognize their partners in this joint venture. Using a scanning tunneling microscope, they observed how two chiral dipole molecules joined together to form a pair. Like many molecules, these molecules occur in our body in two forms that are mirror images of each other and that, like our right and left hands, cannot be perfectly superimposed on each other. In order for the dipoles to be able to form stable pairs and for biomolecules to be able to support life processes, molecules must be able to recognize those with the same chirality form a stable structure. The scientists discovered that the molecules modify themselves slightly during this recognition process, like two right hands enclosing each other.

(Anzenbucher, June 11, 2007)

Some 10^20 molecules in nearly a hundred thousand different forms make our bodies what they are. Each molecule carries structural information. “This information determines which molecules work together to make the body function,” says Magali Lingenfelder, one of the Max Planck researchers involved for example, biomolecules issue commands that make our muscles contract. They ensure that we use our food efficiently and they allow thoughts to form. The international team of researchers, which was made up of scientists from the Max Planck Institute for Solid State Research, the Fraunhofer Institute for the Mechanics of Materials in Freiburg and King’s College London, observed in detail how two diphenylalanine molecules interact as theydock with each other. While the Max Planck scientists were observing the molecular handshake, theoreticians at King’s College in London and at the Fraunhofer Institute for the Mechanics of Materials in Freiburg were creating mathematical models of the process.

“An important aspect of this information is stored in the chirality. This term is derived from the Greek word for hand and describes molecules that exist in two forms, like hands: the left-handed and the right-handed form. The two cannot be brought into spatial congruence. Using the hand image, either the palms or the backs of the hands are touching, or the thumbs point in different directions. In a handshake, only two right or two left hands fit together perfectly. In exactly the same way, only two molecules with the same chirality form a stable structure. Chemists refer to this joining of right-handed or left-handed molecules as chiral recognition. “It is highly significant for many processes in our body,” says Giovanni Costantini, who was also involved in the study, “because they take place only when the right-handed or left-handed molecules recognize each other. As in a handshake, however, it is not sufficient for two molecules with the same chiral form to meet; they must also adapt themselves to fit to the other.”

An international team of scientists including researchers from the Max Planck Institute for Solid State Research made image sequences of the process with a scanning tunneling microscope. The films reveal that molecules only recognize other molecules with the same chirality — that is, an identical structure. Only these matches are willing to join together to form pairs and chains. “This is how nature uses information that is inherent in the shape of the molecule to build complex structures,” says Magali Lingenfelder.

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Anthropology
How Long Does a Child Remain a Child?

Childhood lasted just as long 160,000 years ago as it does today. This has been established by an international team of researchers from the Max Planck Institute for Evolutionary Anthropology and the European Synchrotron Radiation Facility in France. The scientists found that the teeth of a fossilized Homo sapiens child were not any further developed than those of a modern child of the same age; early Homo sapiens experienced a long period of growth and development like our own. However, childhood in Australopithecus and early Homo sapiens lasted hardly longer than that of chimpanzees, which are mature at 10 to 12 years. (PNAS, April 10, 2007)

In purely biological terms, a long childhood has a high price: children cannot feed themselves, they are not prepared for the dangers in their surroundings and they cannot reproduce. “However, children learn social behaviors more easily when they are cared for and taught by adults,” says Dr. Tanya Smith, who led the project at the Max Planck Institute for Evolutionary Anthropology. Since modern humans must learn more complex social behaviors than other beings, their childhood lasts longer than that of all other primates. The lengthy period of youth also means that teeth and brains grow more slowly. And this was already the case shortly after our species developed from its evolutionary ancestors. This was shown by the international team of researchers using the growth profile of a human who lived 160,000 years ago in Morocco, where the fossil locality Djebel Irhoud is today. Scientists have used the fossilized remains of his teeth to establish that the child was almost eight years of age, and was no further developed than a child of the same age in our time.

This is by no means self-evident: Homo sapiens’ predecessors, Homo heidelbergensis and Homo erectus, and the earlier Australopithecus species were much more mature at eight years of age. Their youth is believed to have lasted only slightly longer than that of chimpanzees.

“Our results imply that Homo sapiens had the cultural and biological characteristics of today’s humans very early on in their developmental his- tory,” says Smith. “However, if we look at the development of hominids as a whole, these char- acteristics appear only very late in the record – namely in early Homo sapiens.”

The scientists deduced the biological age of the fossil from Djebel Irhoud from its teeth. The tooth enamel is marked by thin growth lines like the rings of a tree trunk, which allowed the scientists to reconstruct the timing of tooth growth and the age at which the incisors pushed through from the jaw. This age provides an orientation point from which it can be established how quickly a human grew – even millions of years after his or her death. However, it is possible to find out precisely how long a tooth had been growing only from the inside of the enamel, since that is the only place where the microscopic daily growth lines can be seen. It is not easy to look at this area without destroying the enamel, but it is now possible thanks to Dr. Paul Tafforeau, a scientist at the European Synchrotron Radiation Facility in Grenoble, who developed a method using microtu- morgraphy. Tafforeau uses synchrotron X-rays to create three-dimensional images of the very fine structures of the enamel without damaging it. The re- search team compared the structure of the Moroccan child’s 160,000-year-old enamel with that of modern children and other fossil species. “Traditionally, fossils have revealed how humans were constructed anatomically,” she says. “Now, using the record of daily tooth growth, they have allowed us to read the history of a human.”

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Rays from the Sun have never been seen to start a stone rolling on Earth. In space, however, things are a bit different: there, astron-omers from Europe and the US, including Herrmann Boehnhardt from the Max Planck Institute for Solar System Research, have now shown that light from the Sun exerts a force on 2000 PH5, a small asteroid not far from the Earth. The force is although very weak, is sufficient to make the asteroid rotate one millisecond faster each year. They have mea- sured the Yarkovsky-O’Keefe-Radzievski- Paddac effect (YORP for short), which has been theoretically predicted by astrophysi- cists for some time already. (Science Express, March 8, 2007)

Small asteroids generally bear very little similarity to a sphere. Asteroid 2000 PH5, for example, seems around space in the form of a flat piece of rock, approximately 120 meters square and slightly less than 60 meters high. Furthermore, bulges disturb its axis. Its symmetry and its surface is made up of differ- ent types of stone. It is not an attractive sight, but these characteristics, and its short rotation period of currently 12 minutes, make it a suitable candidate for measuring the YORP effect: a torque created by the Sun’s light that makes the asteroid gradually rotate faster. The effect is created by the tiny recoil effect on a body when it is illuminated by light and radiates thermal light back. However, the YORP effect can be observed only for small bodies in space that are not spherical and that have an irregular surface. Due to its irregular shape, some parts of 2000 PH5 heat up more than others and also emit more warmth as infrared light. The same applies to visible light: some ar- eas of this cosmic rock reflect the light better than others, which means that a number of them recoil more than others. All in all, this re- sults in a torque that gives the asteroid a little more spin year after year.

“However, the torque is so small that it was not previously possible to observe the YORP ef- fect,” says Hermann Boehnhardt. Now, however, the research team with which he has been work- ing has succeeded in doing this for the first time. The scientists observed the asteroid repeatedly over five years through optical telescopes, in- cluding the 8.2-meter Very Large Telescope Array and the 3.5-meter New Technology Telescope at the European Southern Observatory in Chile, and the 3.5- and 2.2-meter telescopes in Calar Alto, Spain. They calculated the speed of rotation from the rhythm with which 2000 PH5 revealed its lighter, then its darker side. “The acceleration tallyes quite precisely with the theoretical pre- dictions,” says Boehnhardt.

Keeping an eye on the asteroid 2000 PH5, photographed with the 3.5-meter telescope at Calar Alto in Spain. The researchers use the fluctuations in its brightness to calculate its rotational speed, which is increasing steadily under the influence of the Sun’s radiation.

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“Now, using the record of daily tooth growth, they have allowed us to read the history of a human.”

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“Now, using the record of daily tooth growth, they have allowed us to read the history of a human.”

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The oceans absorb almost a third of the carbon dioxide that humans pump into the atmosphere. This would imply that the amount of carbon dissolved in the sea should rise in tandem with the increasing amount of this greenhouse gas in the air. However, this is not the case. The Southern Ocean, for one, has been exhibiting a saturation effect over the last 25 years. This effect has been measured for the first time by an international team of researchers working under the leadership of the Max Planck Institute for Biogeochemistry in Jena. Although carbon dioxide emissions have risen by 40 percent since the early 1980s, the Southern Ocean has not absorbed more carbon dioxide. The blame lies with a feedback effect: climate change, which is caused at least in part by greenhouse gases, is affecting the carbon cycle of the oceans. (Science, May 17, 2007)

Geochemists call forest fires, smoking chimneys and also some regions of the world’s seas carbon “soda makers.” If a forest or an ocean absorbs more carbon dioxide than it gives off, they refer to a carbon sink. The more carbon dioxide the atmosphere contains, the more it should push into the sea. This is how the Southern Ocean changed from being a source to becoming a sink. Just a few decades ago, it was releasing carbon dioxide; now it has become a net absorber of carbon dioxide, since the concentration in the atmosphere has grown so drastically. This is a chemical balance that underpins, among other things, the flow of air, as the concentration in the atmosphere has increased significantly. Instead, absorption has stagnated during the last 25 years, as revealed by the observations analyzed by the team of scientists. The blame lies with climate change, which fans the winds over the Southern Ocean. These, in turn, alter the ocean currents, bringing to the surface water that is already saturated with carbon dioxide. Similar phenomena can be observed in other locations. “We have to assume that feedback mechanisms of this kind are increasing climate change in other parts of the world, as well,” says Heimann.

The stations (stars) where scientists have measured carbon dioxide concentrations in the air are distributed throughout the globe. This has allowed them to determine how much greenhouse gas the Southern Ocean is absorbing.

The oceans record the concentrations of greenhouse gases in their surroundings, and some of them have been doing so since the early 1980s. The intensity of the increase or decrease in concentration between the individual stations depends, among other things, on the flow of air, as well as on how much gas the sinks extract from the air. Working backwards from their measurements, the scientists were able to calculate how much carbon dioxide the Southern Ocean is absorbing, and how much its capacity has changed over the last 25 years. The Southern Ocean should actually be absorbing more greenhouse gas today than when the observations began; after all, the concentration of carbon dioxide in the atmosphere has increased significantly. Instead, absorption has stagnated during the last 25 years, as revealed by the observations analyzed by the team of scientists. The blame lies with climate change, which fans the winds over the Southern Ocean. These, in turn, alter the ocean currents, bringing to the surface water that is already saturated with carbon dioxide. Similar phenomena can be observed in other locations. “We have to assume that feedback mechanisms of this kind are increasing climate change in other parts of the world, as well,” says Heimann.
Fear in the Wake of Terror

Apart from their immediate consequences, terrorist attacks also have an indirect impact, as they arouse uncertainty and fears in the minds of many people – and thus trigger behaviors that often amplify the damage. For Gerd Gigerenzer and Wolfgang Gaissmaier, these fears are rooted in both the evolutionary history of humans and a lack of information, as well as in the incorrect assessment of risks. They conclude that improving education about these psychological factors could help people gain more control over fears resulting from a terrorist attack and reduce the indirect damage they cause.

In this world nothing is certain, except death and taxes,” wrote Benjamin Franklin in a letter in November 1789, on the eve of the French Revolution. What Franklin meant was that everything in life is uncertain and laden with risks, and we are constantly at the mercy of such uncertainty. However, the human mind is not fond of dealing with uncertainty, but instead always strives for certainty, even if it means influencing our perception.

This becomes apparent when we look at optical illusions, whose aim is to trick our perception: although we know we are looking at an optical illusion, the mind leads us to believe there is no ambiguity. Even when we are explicitly told that two lines are parallel, the mind can fool us into believing that they are not. And even when two objects are measured and clearly shown to be equal in size, as long as they are arranged in a particular way, our perception clings to its belief.

Our brain sells our consciousness the most probable conjecture as the definitive result. Even insight into how the error was created can’t eradicate it. This illusion of certainty is by no means limited to elementary perceptual experiences. In fact, illusory certainty is part and parcel of our emotional and cultural heritage. The esoteric sections of bookstores provide clear evidence of this desire, offering certitudes that can no longer be found in many areas of life. Such belief systems have existed throughout human history. People continue to seek solace in religion, astrology and divination – all the more so in difficult times.
The illusion of certainty

It soon became clear just how deceptive this certainty was when extensive tests also found BSE in German cattle herds. But it in turn was replaced by another illusion of certainty: okay, the story went, there are BSE-positive cows in Germany, but tests have detected them all. When the media then reported on the first BSE-affected cows that had been overlooked by the tests, the public was shocked a second time. Once again an illusion certainty was shattered.

All in all, the BSE crisis created huge waves. According to surveys by the Allensbach Institute, many people felt personally threatened by mad cow disease. Beef consumption plunged temporarily. The crisis even led to a reshuffling of the cabinet and high-ranking offices. And all of this despite the fact that, according to current studies, BSE is not even all that dangerous for humans. Across all of Europe, only about 140 people have died from the human variant, Creutzfeldt-Jakob disease, in the past 25 years. As Ortwin Renn from the University of Stuttgart ascertained, that is about as many deaths as resulted in the same period from drinking scented lamp oil. Although lamp oil deaths affected mostly small children, hardly anyone has ever felt the risk of dying from salmonella poisoning, which is no less than ten times greater, receive even remotely the same attention that was given to the threat of BSE. Similar media-induced waves of fear have since been triggered by SARS and the avian flu.

This does not mean that these risks deserve no attention or should not be investigated. Nor is it about portraying people’s fears as absurd and irrational. It is far more a matter of understanding these fears and recognizing why people just happen to be more afraid of certain risks than of others. Only such knowledge will make it possible to help people deal properly with their fears.

After all, fear itself can become a security risk. The unexpected consequences of the September 11, 2001 terrorist attacks in the United States illustrate this very well – consequences that reached far beyond the direct damages of the attacks. These consequences can be explained by the fear in people’s minds, aroused by the attacks. And they may have been avoidable if people’s fears had been better understood and given greater consideration.

Everyone likely still has the horrifying images in mind: the burning twin towers of the World Trade Center collapsing from the impact of passenger airplanes. These images were literally burned into collective memory. Some 3,000 people lost their lives in these attacks, including the 256 passengers of the hijacked planes. The material damage reached into the billions. The world will never be the same – this was heard again and again following the attacks. And indeed, the world has changed: for one, the feeling of vulnerability led to the so-called war against terror.

The Bush administration focused on direct damage from September 11 and established a commission to investigate the failure of the intelligence agencies to detect the attack, and to develop the necessary security measures to prevent such attacks in the future. New laws were enacted and stricter controls implemented. And, as any visitor to an airport can confirm, it’s clear that something has changed in Europe, as well.

Terrorist attacks, however, also cause indirect damage beyond the terrorists’ control. This damage results from people’s thoughts and behaviors in reaction to such attacks. In the case of September 11, 2001, it led primarily to heavy losses in the aviation and, hardly one year has passed since then, there were still 7 percent fewer domestic flights than before, and an estimated 1.6 million jobs were lost, most of which were in the tourism industry. Such indirect damage is by no means inevitable. The causes are of a psychological nature and could, in principle, be prevented. To do so, however, it must be understood that terrorist attacks are not directed solely at the body, but also at the mind. Events like the attacks on the World Trade Center are called dread risks. These are very improbable and rare events that, however, cause devastating damage to many at one point in time. People frequently react to such risks with avoidance behavior – and much differently than they do to risks in which many people die unexpectedly, as it were, over a relatively long period. For example, tens of thousands of people in hospitals each year from the consequences of preventable medical errors. Nevertheless, few patients would avoid hospitals, even if they were aware of these figures.

The avoidance behavior triggered by horrific events could have deep-seated evolutionary roots. In primieval times, people lived in small groups. Threats that affected an entire group at once were thus far more dangerous than the constant threat to individuals, even if the threat to individuals ultimately resulted in the deaths of just as many people. In addition to this evolutionary explanation, avoidance behavior can presumably be explained in part by a simple lack of information and, frequently, inaccurate assessment of risks.

When asked to estimate how many kilometers one would have to drive a car in order to have the same accident risk as for a non-stop flight from Boston to Los Angeles, many people will answer that they would have to drive tens or even hundreds of thousands of kilometers. In reality, however, such a non-stop flight is only as dangerous as 20 kilometers on the road. Arriving safely at the airport means having already survived the most dangerous part of the journey. In response to these figures, people often argue that airline passengers are at the mercy of the pilot, and many people are convinced that driving a car gives them complete control. Surprisingly, however, they often feel safer even as a passenger in a car than in an airplane.

So what might avoidance behavior arising from September 11 look like? And even more importantly, what are the consequences of such behavior? Answers to these questions are outlined in the following.

First, Americans might severely limit air travel following September 11. In this case, it is a plausible assumption that many will opt to reach their destination by car. People who tried to avoid the risk of a terrorist attack or a related hijacking after September 11 may then have lost their lives on America’s highways.

The aviation industry did, in fact, see a drastic decline after the attacks. In the months October, November and December 2001, the number of miles flown dropped 20, 17 and 12 percent, respectively, year on year. Of course, this does not necessarily mean that all of these air miles were instead traveled by car. Furthermore, such a shift is very difficult to observe directly. However, facts support the idea that many people chose to forgo airplanes and travel (presumably more safely) by car. In the months following the attacks, vehicle miles traveled increased by approximately 3 percent compared with the previous year.
deviations of 115 accidents, averaged across these months. In fact, August 2001, the month before the attacks, was a particularly normal month with just 9 accidents above average.

This consistency observed over the course of five years saw a dramatic change after the terrorist attacks. For a period of twelve months (from October 2001 to September 2002), there were more crashes each month than would have been expected based on the average of the preceding five years. In many months, the number of registered accidents exceeded even the highest values observed in the preceding five years. This increase in fatal traffic accidents coincides exactly with the period in which an increase in traffic was observed.

Parallel to the miles logged, after almost precisely one year, the number of fatal accidents also leveled off at the average value of the preceding years. This consistent pattern supports the hypothesis that the terrorist attacks caused additional deaths through the fear they created in people’s minds.

In total, from October 2001 to September 2002, there were approximately 1,500 additional crashes involving fatalities on America’s roads. As each of these accidents resulted in slightly more than one death, a total of some 1,600 people lost their lives in attempting to escape the risk of flying – or around six times as many as the 256 passengers who died in the aircraft on September 11.

Spaniards react very differently

This inevitably raises the question of the extent to which these findings illustrate an isolated case or whether similar phenomena can also be observed in other cultures. On March 11, 2004, two and a half years after the terrorist attacks in New York, bombs exploded in four local trains in Madrid during rush hour. The death toll was 200, with 1,460 people wounded. If these attacks had triggered similar avoidance behavior, it should have been reflected in a decrease in train passengers.

Spain’s railways did, indeed, see a drop in passenger numbers following the attacks, although the effect was not as pronounced and was noticeably briefer (only two months instead of twelve). However, it did not result in a simultaneous increase in highway traffic; on the contrary, Spaniards appeared to travel less in general after the attacks, so road traffic declined slightly, and with it, the number of traffic deaths. Thus, the Madrid attacks did not result in additional traffic deaths that could be explained by fear in people’s minds.

Unlike Americans, Spaniards did not turn to their cars out of fear of the presumably increased risk of traveling by train. But why were the reactions to the terror so different in Spain than in the United States? For one, there may be a more pronounced car driving culture in the US that made the switch to cars more likely from the outset. For another, the public transportation system in Spain is more developed and offered more alternatives. Finally, after decades of terror by the ETA, Spaniards may consider a terrorist attack more a calculated risk than a dread risk.

The 9/11 Commission report called for all elements of national power to be used to defeat global terrorism: diplomacy, intelligence, better law enforcement, economic policy and foreign aid. However, a closer look at the indirect damage resulting from a higher number of victims in road traffic shows that there should also be a second goal: namely, to fight the effects of terrorism in people’s minds. But people first need to be made aware of these effects.

Educating and informing people might not cause everyone to immediately change their behavior, but it might help many better comprehend their only too understandable fears in the wake of such terrible events. In this way, they could also learn to control and analyze these fears, which, in an event such as 9/11, would save lives. Otherwise, history threatens to repeat itself after every new terrorist attack.

The example makes it clear how important it is for a modern society to deal with risks in an informed manner. German chancellor Angela Merkel agrees with this assessment, as her words in the magazine CICERO clearly indicate: “Our society must learn to better assess risks, generally speaking. Living with chance and risk is a big problem. In a world that is becoming increasingly complex, I also think it is important to introduce children at an early age to such issues that will constantly demand their attention in later life.”

Psychologist Gerd Gigerenzer is Director at the Berlin-based Max Planck Institute for Human Development; co-author and psychologist Wolfgang Gaissmaier is a post-doctoral researcher at the same institute.
It is often said that safety is an illusion. Nevertheless, politicians are forever proposing new ways to provide greater security. In doing so, they may actually be reinforcing the feeling of insecurity that seems to pervade modern society. This feeling is based, not just on terrorist threats or everyday criminality, but on many things that were considered certain just a few decades ago. Globalization and technological progress are changing the world in incalculable ways. Researchers at the Max Planck Society are among the ranks of those who want to find out how society can deal with this.

UNTOLD opportunities for everyone – also for criminals – thanks to the Internet.

MORE SECURITY in large-scale housing developments – urban planners are doing their part, too.

ETHICS AND LAW must consider ways to account for progress in biomedicine.

ETHNIC CONFLICTS cannot be explained by ethnic differences alone.
David is like a man possessed. For days on end, he sits in his room in front of a black screen with glowing green script. Over and over, he types columns of cryptic letters and numbers into his computer. Actually, David Lightman is a high school student. At home, however, he turns into a hacker. The irreverent whiz kid hacks into his school’s computer database and manipulates the grades of his friend Jennifer. He out-Broderick his first Oscar nomination in 1983 – and gave the rest of the world its first uncomfortable inkling that an out-of-control computer could do enormous damage via the global data network. At that time, only a few experts were familiar with computing. Laypeople viewed hackers with a peculiar sense of admiration, seeing them as an exotic breed that navigates its way on invisible paths through a strangely abstract cosmos. In 1983, the virtual world was making its first tentative forays into kids’ rooms and living rooms with Atari and Commodore 64. Today, nearly 25 years later, the world looks very different. It is no longer just businesses and government agencies that are digitally linked. A dense data network has long since encircled the globe, linking billions of people worldwide. In Germany, logging on to the Internet is a matter of course for 75 percent of 18- to 34-year-olds. Information speeds around the globe in milliseconds – billions of e-mails, documents and images daily. X-ray images whiz back and forth between continents, from specialist to specialist. Engineers even service power plants remotely via data cables. With a simple key combination, anyone can bring the world’s knowledge edge into his or her home. In doing so, however, the user may unknowingly open the door to unwelcome guests. Alongside billions of law-abiding Internet users, there are thousands with malicious intentions. The dark side of the Internet now even has a name: cybercrime. The perpetrators are hooded terrorists who brandish their weapons in Internet videos and call for religious war, recruiting new fighters with their militaristic websites. Or swindlers who send trojans to snatch PIN numbers for online accounts. Or criminals who distribute photos of abused and tormented children in secret online marketplaces. The hackers of the early 1980s seem almost harmless in comparison.

**Manhunt in Cyberspace**

For most Internet users, Google Earth is a fascinating toy, but terrorists use it to scope out targets for attack.

The role of the naive-ingenious hacker David in the movie *WarGames* garnered the young actor Matthew Broderick his first Oscar nomination in 1983 – and gave the rest of the world its first uncomfortable inkling that an out-of-control computer could do enormous damage via the global data network. At that time, only a few experts were familiar with computing. Laypeople viewed hackers with a peculiar sense of admiration, seeing them as an exotic breed that navigates its way on invisible paths through a strangely abstract cosmos. In 1983, the virtual world was making its first tentative forays into kids’ rooms and living rooms with Atari and Commodore 64.

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**Construction Manuals for Bombs**

Today, cyberspace offers room for the entire spectrum of transnational criminal activity. And the law is not prepared for this. It reaches its limits particularly when the offenses become complex, when agencies are tracking organized crime and white-collar criminals around the entire globe, or when it has to untangle terrorist networks. Organized criminals and terrorists use encryption methods to communicate via the Internet. Terrorists publish construction manuals for bombs. They plan attacks through the data network and use search engines and Google Earth to scout potential targets.

Tracking down criminals in the anonymous, ephemeral and super-fast Internet is difficult enough, but prosecuting and convicting them is even harder. The main problem is with criminal law: the Internet is global, while criminal law is essentially limited to its respective national territory. In the case of traditional criminal activity, the perpetrator is usually physically present at the...
The Internet poses unfathomable depths of the legal landscape for criminal law. The world is becoming ever more compact. Bussinesses and private individuals are increasingly transacting their business online. The Internet is irresistible to criminals. Information that is of interest to criminals is constantly winding its way through this network. For another, the increased use of technology has not only made our day-to-day life easier, it has also ushered in new risks: attracting, distributing, and injecting thousands of people. Using the Internet, criminals can misapply technology even more easily, paralyzing electricity networks in a matter of seconds or causing command centers to go berserk. People are more dependent than ever on our computer networks, and correspondently vulnerable. For this reason, Sieber is of the opinion that the possibility of a far-reaching cyber-terrorist attack should not be discounted out of hand.

**Crime via Fiber-Optic Cables**

The myriad problems that have national crime control agents cracking their brains find expression in the prefix “cyber”: How on earth can criminal behavior be controlled and tracked in a virtual, global and technological-dominated space? There are two possible paths to this - good cooperation between countries or a supranational criminal law. Both solutions require, of course, a common denominator. This is particulary difficult for the Internet. As Sieber puts it, “The problems of international crime culminate in global cyberspace. Cybercrime is practically a Lehrstück for the problems of transnational crime.”

There are several reasons for this. For one, technological and economic globalization are on the rise. Thanks to the Internet, information on the data servers in Germany, but also throughout the European Union. For example, many legal authorities became aware for the first time of the difference between access and host providers in the criminal law context. Access providers – like the former CompuServe Germany – merely relay data. For them, it is technically impossible to check all the information. Thus, they cannot be held criminally liable for the content.

Host providers, on the other hand – providers that store data – can and must block illegal content as soon as they become aware of it. A corre-
spending notice and take-down procedure is now recognized in many countries. The host provider may, for example, receive tips through an international network of hotlines through which Internet users report suspicious websites. If the host provider does not remove the illegal data, it is liable to prosecution. Sieber calls this public-private co-regulation. The Max Planck researcher supports criminal policy initiatives that include these kinds of alternatives and additions to criminal law. Technical prevention is an additional example. Currently, the researchers in Freiburg, together with computer scientists, are investigating whether it makes sense for authorities to mandate national blocks against foreign Internet content. The result: in many cases, nationally mandated blocking orders prevent prohibited content about as effectively as a garden fence stops a burglar. Furthermore, such blocks often impair legal data traffic.

Nevertheless, German authorities can mandate such – more or less symbolic – measures because, for the most part, at the national level, there are as yet no better concepts. The research has thus shown clearly why the scientists are working intensively on developing internationally effective measures and regulations that encroach less on freedom of expression than the ineffective blocking orders.

To date, international cooperation in and harmonization of criminal law has often failed due to the fact that lawmakers in many countries continue to think in terms of traditional sovereignty. The Organization for Economic Co-operation and Development (OECD), for example, is not allowed to impose rules and regulations on any of its member states. Instead, it simply publishes the names of countries that fail to implement recommended reforms, a technique known as “naming and shaming”. This method of applying pressure has often been successful. In many cases, it has led to the subsequent amendment of national laws.

In the meantime, many countries have begun to harmonize various aspects of their criminal laws on cybercrime. The most important consensus worldwide is likely the Council of Europe’s Convention on Cybercrime, which has been ratified by a number of countries, including Canada and the US. The Convention prescribes, for example, that punishing certain online offenses uniformly, such as accessing data without authorization, deleting data without authorization and distributing child pornography. Furthermore, participating countries want to standardize Internet investigation measures. And the Convention on Cybercrime demands one more thing of its member states: the establishment of national contact centers that are available on a twenty-four-hour, seven-day-a-week basis.

Covered Tracks in Cyberspace

Hackers attack through many computers from one continent to another in the same way. Hackers are using the weaknesses in their tracks. This makes it difficult for investigators to trace the route back to the source because connection data is seldom stored for very long. Since hacker attacks touch the territory of multiple countries, tracking back the perpetrators has, to date, been particularly troublesome. Thanks to the national contact centers, the affected countries can now quickly and unambiguously communicate search data and cooperate in international investigations. Thus, the fight against cybercrime is proving to be a role model for cooperation in international criminal law. The models and solutions used here can also be transferred to other areas.

The Council of Europe recently commissioned the institute in Freiburg to analyze the Convention on Cybercrime and other international conventions. The researchers were asked to evaluate the currency of international regulations pertaining to cyberterrorism. Sieber concludes that there is a lot to be done. "The criminal law, which is historically harmonizing various aspects of their criminal laws on cybercrime, has not yet been ratified by a sufficient number of countries. In addition, the international conventions lack "a general obligation to criminalize general terrorist threats," as the German media recently pointed out. The investigation measures in the Convention on Cybercrime are also in need of an update.

To determine just what this encompases, above all, the researchers compare criminal laws: they regulatory comb through the criminal codes of various countries, compare them and develop innovative approaches. The institute’s shelves contain some 1,700 professional journals and around 40,000 books – enough material for ample research. "While we have special country sections for key countries, we are unable to cover all of the world’s legal systems," says Sieber. "That is why we frequently ask experts in other countries to compile detailed reports for us with international insurance statements or personal communications. Ultimately, we must consider how much security we need and how much freedom we are prepared to sacrifice for it," says Ulrich Sieber.

As a result, the prevention of cybercrime affects the foundations of society. The institute in Freiburg is thus researching not only the extent to which cybercrime can be fought effectively, but also how deeply this fight affects civil rights – such as anonymity and the privacy of citizens on the internet.

The current risks lead to fundamental changes in criminal laws because, very often, traditional deterrents fail: terrorists are not afraid of punishment. It is hoped that preventive measures can forestall suicide attacks and mass shootings.

The new dangers of the modern risk society are thus changing the traditional criminal law paradigm of repression. Since time immemorial, cybercrime has taken action only after a wrong has been committed. The new dangers of complex crime, however, call instead for a security law that focuses on prevention. Using novel monitoring methods, this security law is designed to discover and prevent crimes while they are still in the planning stage.

The group working with Ulrich Sieber wants to find out how the new security law affects the entire legal system, as well as the criminal law, not only with a view to cybercrime, but also to existing terror-related laws. The Internet clearly show just how important this is. One current example is the online search, which Germany’s Federal Court of Justice has just declared illegal – in no small part because of an article by Sieber: in a conventional search, following a particular order, searches are often completed quite quickly.

Warning against Terror Hystera

Online searches for ephemeral digital information are a disproportionately more severe invasion of the privacy of persons who may have years worth of personal data stored on their computers, such as tax returns, insurance statements or perhaps even personal journal entries. And they are not even aware of the government’s hack attack. A similar situation applies to dragnet searches for wanted persons and new central databases to which prosecutors, secret services and numerous other agencies have shared access.

There is no doubt: the new risks and the technical changes of the information society require new concepts and regulations in criminal law as well as new alternative approaches. But the researchers in Freiburg warn that terrorism hysteria may lead to the unnecessary curtailing of civil rights – much like the current fight against cyberterrorism. Citizens are wiretapped and monitored with no court order – purely as a preventive measure.

According to Ulrich Sieber, the new challenges should not only stimulate creativity with regard to new intervention and monitoring measures – it is just as important to develop new mechanisms for protecting civil rights. The Max Planck researchers are doing that, too. “Our major focus is on basic research,” says Sieber. However, he and his colleagues also in corporate concrete, day-to-day problems of criminal law in their work. The Internet is of particular interest to Sieber. “It is a gigantic source of knowledge and a valuable good,” he says. One of his visions is to make the Internet into a globally protected legal interest, safeguarded by a global convention, just like has already been done for the high seas, Antarctica and outer space. The Norma
It takes a lot to ruffle the average Berliner. The atmosphere in the rumbling commuter train is oddly devoid of emotion. Tired eyes stare listlessly at the end of the working day. Even when an expressionless voice announces over the loudspeakers that the train will terminate in Lichtenberg and passengers must continue by bus, no one complains. In Munich, this would have caused quite a clamor. The journey from

berlin's city center to the far north-east takes nearly two hours. The warmth of the late afternoon provides some consolation, the bizarre cloud formations torn between sunshine and storm. In this light, the suburb of Marzahn appears almost idyllic; with swaths of green between the high-rise blocks.

The sheer monotony of the façades, between which springtime clamsors for its due attention, is somehow fascinating to anyone who grew up in a small-town terraced house of average age, size and medi-ocrity. And yet residents, in particular, regard Marzahn as a problem area. Those same people who remain oblivious to the vagaries of the public transport system are apt to lose their cool when it comes to the safety of their local environment. Many feel increasingly under threat – and this despite the slight downward trend in crime statistics. This inconsistency between perception and reality is one of the central findings in a study conducted here and in the suburb of Gropiusstadt by sociologist Tim Lukas, who is working on his doctorate at the Max Planck Institute for Criminal Law.

Wandering through the neighborhood, Lukas doesn’t look much like a scientist. The 31-year-old sociologist knows his way around well enough to serve as a guide on the city tours that have recently begun to make forays into the hinterland of the eastern part of Berlin. Have these pre-fab concrete blocks suddenly acquired cult status? Are the clichéd concepts of high vacancy rates and simmering social unrest mistaken? These are the questions that attract the interest of tourists “on the lookout for locals,” irrespective of whether they were drawn here from Berlin, Saxony or even Russia.

Walking among the high-rise pre-fabs leads past “Kiek,” the local community center. Here, the sun beams down from a billboard that proclaims in Vietnamese and Russian: “Come on in and have some fun, there’s something for everyone here!” – a local situational analysis in a nutshell. For Tim Lukas and his team, this was also the starting point for their research project on crime prevention in sprawling residential developments.

Fighting Crime by Improving Standards

Flashback to fall 2003, and to a small group of people from England, Germany, Hungary and Poland who share a common interest. As part of a special program funded by the European Commission, they aim to empirically assess whether structural and architectural modifications are effective in preventing crime in high-rise developments. Does improving the standard of their constructed environment mean that residents feel less afraid of crime? Does the degree of social control increase, and do they perceive a greater responsibility? Does the residential structure alter in certain areas because people like to live there and because the fluctuation rate is lower?

To substantiate its findings, the project looks to two sources, explains Tim Lukas: “In each of the individual countries, we are circulating questionnaires among residents in select large housing developments, asking them about their attitudes toward crime and their feelings of insecurity. We are also interviewing experts from the police and organizations that provide the housing. The teams also travel around on a sort of research carousel to visit the areas their partners are studying and compile reports on positive and negative developments.” Given that the re-

Planning for Security

The view from the 30th floor of one of the apartment blocks in Berlin’s Gropiusstadt is stunning – but as a place to live, it’s not the most popular choice. Yet here, as in the rest of Europe, the image of these high-rise developments has supposedly been rehabilitated both socially and structurally. Tim Lukas, a doctoral student at the Max Planck Institute for Foreign and International Criminal Law, has been investigating whether crime levels have fallen and whether tenants now feel safer.
In the larger developments, it was no longer enough just to fix a few defective heating systems. In Germany, not only the housing associations, but also the federal and state governments stepped in: a federal government report presented in 1995 struck a nerve as it laid bare the widespread, due in no small part to a lack of social control. Since 1999, urban renewal programs such as the “Societally Integrative City” have targeted areas with “special development needs.” These programs take an integrated approach: they aim to improve both housing and living conditions and the economic basis in a given area, as well as to raise its image in the hopes that residents will identify more strongly with where they live. At the same time, efforts are made to broaden the life choices open to residents through education and training.

Tim Lukas has been studying whether these programs give residents a greater sense of safety and has drawn comparisons between a high-rise development built in East Berlin before the Wall came down and one in the West. One difference between housing developments under the two systems is obvious: whereas, in what used to be West Germany, they are home to only 1.7 percent of the population, in the former East Germany and East Berlin, they house almost one in four.

Berlin was an obvious choice for further research: in Marzahn North and Gropiusstadt, Lukas defined two areas of study, each of which had around 17,000 inhabitants in 2005. Just over 500 men and women over the age of 18 participated in surveys in each area. In line with the population structure, in Gropiusstadt, three times more people over 65 and twice as many between the ages of 56 and 65 were surveyed compared with Marzahn North, and here, in turn, three times as many 18- to 25-year-olds took part. The population in Marzahn North fell by 3,000 between the years 2000 and 2005. Now it is slowly rising again, not least because the numerous improvements are taking effect. Of course it makes sense to tailor these to individual cases, explains Lukas. “But in principle, the guidelines laid down by the Interior Ministry in Lower Saxony are worth following.” These define changes in urban planning and in design and structure to be made in critical aspects of individual housing units, buildings and residential districts. Social management of the organizations tasked with providing housing are aimed at contributing to citizens’ responsibility and good neighborhoods. It is also helpful for housing providers to cooperate with the local police, community administration agencies and institutions, local social and youth workers, and the crime prevention council. And lastly, targeted leisure activities are expected to integrate those groups of residents that cause problems.

Urban Planners Playing with Lego

A little bit of everything has gone into Marzahn North, with the result that the trepidation experienced by visitors unfamiliar with Berlin’s high-rise developments quickly gives way to a memorable lesson in urban development. As the rows of brightly-painted apartment blocks bask in the sunlight and the Ahrensfelder Terrassen project comes into view, one cannot help but chime in with the research teams from abroad: all of them have praised the downsizing of East Berlin’s pre-fab blocks. Following a pattern set in Britain, a few floors were simply lopped off the 11-story blocks. “A bit like Lego,” as one team described it. This resulted in some attractive new building designs – a metamorphosis in Marzahn. But that’s not all: the dismantled components were sold and reused by grateful purchasers in St. Petersburg. A relatively small-scale structure rising above a row of shops, entrances featuring better security, flowerbeds lovingly planted by local residents, and several attractive playgrounds give the impression of a well-consid-
Room for expression: Youngsters in Marzahn practice tricks on their skateboards. Room to let off steam: The playground in Gropiusstadt in the calm before the afternoon storm.

The part of residents is evidenced and is actually generating pride on area. The fact that the plan works Marzahn residents’ ties with their local employment also help strengthen Marzahn’s image of the district. In the north of Neukölln, the tenements were replaced by cooperative housing, while the south became the site of Gropiusstadt.

Barricades Are Not the Answer
Who would have expected to find small, detached houses scattered among the massive tower blocks? But the architect Walter Gropius wanted to create a varied residential landscape with leisure facilities. Yet there is a lack of illumination, rampant vegetation blocks the line of sight, and youths hang around the subway stations – which are some of the reasons for the security problems in Gropiusstadt. The Walter Gropius school saw no alternative but to erect a tall barbed-wire fence around their plot – a fatal idea, since the fence creates a prison-like atmosphere that contrasts with the modern architecture, which is genuinely worth seeing.

In reality, Berlin’s tallest residential building sets an example of how easy it is to get inside: as the buzzer sounds to admit an ambulance crew, Tim Lukas slips in after them. The elevator takes us to the 30th floor, where the view from the – unglazed – hallway takes in half Berlin. Do the people who live here still admire this amazing vista? The Polish research team in particular was torn between the pros and cons of Gropiusstadt: “Impressive, somehow even fascinating,” was their assessment. “But fundamentally, a real monstrosity.”

A harsh judgment with which one need not agree. However, Lukas’ survey of the residents also reveals a conflicting, and sometimes unfaltering, picture. They were asked whether they found their residential environment pleasant, safe, quiet, attractive and clean, and how they would have rated these same aspects five years ago. Clearly, the residents of Gropiusstadt believed themselves to have been more satisfied five years ago, in every respect. The greatest decrease was in a feeling of security – only 24 percent of the 500 people polled feel safer now. Around 60 percent think they felt safer in 2000. Half of them would leave Gropiusstadt today if they could.

In Marzahn North, the situation is entirely different: there are quite a few who perceive their environment today as being less safe and less quiet, but 65 percent of men and women still find their neighborhood pleasant and around 7 percent even find it attractive. The majority of Marzahn residents obviously consider the improvements to be a success. Looking back five years, only 41 percent of tenants then regarded the area as attractive. Nevertheless, 38 percent of those surveyed in Marzahn North would move away if they could.

A Growing Feeling of Insecurity
The questions on perceptions of security yielded similar results. Whether at home or in the public open spaces around the housing blocks, on the adjacent streets or in public transportation, whether by day or by night, the residents of both areas felt less safe in 2005 than they had in 2000. Especially in Gropiusstadt, where 85.7 percent of those surveyed are unwilling to travel by public transportation after dark. The residents of Marzahn North are generally less timid. To Tim Lukas, however, this doesn’t necessarily mean that East Germans are braver. He believes the reason lies in the high proportion of older people who live in Gropiusstadt, and who are fundamentally more prone to fear than younger people.

However, there is little difference between people’s perceptions of problems in the two developments: 21 and 16.4 percent, respectively, think there are a lot of problems in the pre-fab blocks that typify the East.
their district, while 65 and 61.9 per cent think there are a fair number. The main concerns are groups of youths hanging around, drunks, garbage and dirt in streets and parks, and too much noise.

**Crime Is Decreasing**

The increasing feelings of insecurity are, at least to some extent, inconsistent with crime rates in the two areas under investigation. In 2000, for example, there were 132 crimes per 1,000 residents in Marzahn North, and 125 per 1,000 in Gropiusstadt. In the following two years, the figures rose to 183.5 in the western area and 173.4 in the east. In Gropiusstadt, where residents feel significantly less safe, the number of crimes per 1,000 residents dropped to 116.3 in 2004 – in other words, below the initial figure for 2000. In Marzahn North, the number of crimes had fallen further than 164 by 2004. Despite this, Marzahn residents feel more comfortable in their environment, maybe because some individuals feel less isolated than in the far more heterogeneous area of Gropiusstadt. Not to mention the fact that the widespread illegal sale of cigarettes in Marzahn does not even appear to be perceived as a crime. Here, the average evening trip to the supermarket is concluded outside on the street, where packs of cigarettes change hands openly, albeit speedily.

A European comparison with high-rise developments in Krakow and Budapest – the survey in Bristol had to be excluded for lack of response – is interesting. This clearly shows what the greater satisfaction in Marzahn already hinted at: in both Eastern European countries, residents of the high-rise developments included in the study feel far greater ties to the environment in which they live. On a scale of 1 to 4, where 1 indicates the strongest tie, the loyalty score in Gropiusstadt was 2.7, in Marzahn it was 2.46, in Budapest 2.33, and in Krakow 1.99.

A clear East-West division is discernable in the fear of crime: on a similar scale of 1 to 4, it was highest in Gropiusstadt, at 2.31, and in Marzahn North it stood at 2, whereas in Krakow it was just 1.67, and in Budapest 1.66. On the other hand, contact with the neighborhood is roughly equally good or bad in the four areas, even though the communities in the Eastern European countries are more homogeneous and enjoy a higher social status. This means that relationships with neighbors have far less influence on fear than the feeling of “homeland loyalty” to one’s local district. Conversely, the less comfortable people feel in their environment, the more they are likely to be afraid.

“And that applies even if people have lived in these high-rise developments for years,” Tim Lukas adds. “Literature on the subject always assumes that contacts with the neighborhood improve and loyalty to the local area increases the longer one lives there. But we have been unable to verify that in our survey.” As a sociologist, Lukas tends to view anonymity as a normal condition in many cities, and one that increases with each ascending floor of a high-rise building. “But that need not mean not knowing anyone in the building,” he explains. Nor are neighborhood activities any more vital in the smaller apartment buildings found in inner cities.

The question remains of how to deal with the fact that people are anxious even though crime rates do not reflect any disproportionate level of threat. Even the participating experts, representing the police, neighborhood management teams and housing providers, admitted to being at a loss. One can’t just tell people that their fears are unfounded. But likewise, as police crime prevention officer Hardy Telge wrote in an answer to the survey, Gropiusstadt is not some kind of Sodom and Gomorrah, it’s just not like that.

The feeling of insecurity is largely self-induced. As no one ventures out of their apartment after dark, the streets are populated by people, and thus indeed become more dangerous. Ultimately, this latent fear can be overcome only by a massive police presence. The feeling of insecurity is largely self-induced. As no one ventures out of their apartment after dark, the streets are populated by people, and thus indeed become more dangerous. Ultimately, this latent fear can be overcome only by a massive police presence.

**The Housing Style Is Not the Problem**

All sides agree that the extensive alterations and construction work carried out in and on the tower blocks and their surroundings have improved the situation. They have also helped to halt the exodus from Marzahn North and contain crime in Gropiusstadt. The only criticism raised by scientists and experts alike concerns the CCTV surveillance: with the cameras giving the impression that everything is being watched and every transgression punished, there is even less incentive for people to get involved and lend a hand. A degree of social control, such as that imposed by the presence of the conscripts, would be far more effective. Despite being cautiously optimistic, Tim Lukas has no illusions: “The many improvements that have been made in Marzahn North and Gropiusstadt are all sensible and good,” he believes. Likewise, he welcomes the “Socially Integrative City” program. But, there is no disguising the fact that all these measures address the symptoms rather than the causes. “The focus is on social problems,” Lukas says. And even if crime is decreasing, it is by no means certain whether some of it is not simply being transferred elsewhere. “It can even affect the up-market inner city areas. The housing style alone is not the problem,” Susanne Bürk.
What do penguins have to do with international law? More than you’d think. When Silja Vöneky from the Heidelberg-based Max Planck Institute for Comparative Public Law and International Law speaks about the benefit of declarations, she always likes to mention the Antarctic as an example of the extremely drawn-out process of reaching international agreements. Just recently, an Annex to the Protocol of Environmental Protection of the Antarctic Treaty was negotiated – and it took 13 years alone for the State parties to even agree on the text. It will very likely take another eight years for the Annex to be ratified. Only then will it actually be binding.

In comparison, soft law declarations, such as those done and planned by UNESCO on the internationalization of biomedical standards, have certain advantages. “Because they are far less legally binding than a contract or agreement, nations find it easier to accept them, and they can be pushed through more quickly,” says Vöneky, an expert in international law. Her work focuses on the difficult relationship between ethics, morality and law in view of the advances made in biotechnology and biomedicine at the national and international level.

Ethical decisions in the biotechnology sphere are at least as complicated as they are in the field of environmental protection. “What makes them especially difficult is that pluralistic societies are rarely able to reach common ground with regard to their political and legal views,” says Vöneky, describing the crux of the problem relating to morality and the law. This research field does not have any established, universally accepted moral standards that could serve as a basis for legislation. The whole area is unknown territory – from a scientific and an ethical perspective. Vöneky argues that, at the social and legal level, there must first develop some kind of a shared ground and then a possible consensus on the question of whether we should actually do the things that are now medically or technically possible. And it can take time for such a shared ground to develop. As a result, bioethics is repeatedly pushed to its limits. The incredible speed at which research is moving means that many legal rules that are agreed upon only after much wrangling become obsolete before they even make it to print. The MPI’s international law expert mentions the cloning ban enshrined in Germany’s Embryo Protection Act of 1990 to exemplify the problem. Some scholars argue that the Act’s content could actually be construed so as to exclude from its scope cloning techniques that use the “Dolly” method.

In addition, bioethical issues often get right down to fundamental values of a society, as, for instance, the value of life – specifically its beginning and its end. Attempts to translate such moral standards into some sort of binding legal form quickly encounter yet further constraints – nationally, but even more so at the international level. The latter, in particular, is due to the fact that the legally established ethical maxims of one country may not apply on the other side of its borders. What is allowed over here might be prohibited over there – and vice versa.

Turning Morality into Legitimate Law

Artificial insemination, stem cell research and research into population genetics are just a few examples of research fields that raise fundamental ethical questions such as: Are we allowed to do this? A junior research group led by Silja Vöneky at the Max Planck Institute for Comparative Public Law and International Law in Heidelberg is examining how well biomedical ethics and morality in biomedicine can be translated into legal regulations.
ing her dissertation on the subject of bioethics in international law, examining in particular the question of whether human rights are a suitable instrument for coping with disagreement. “Strategies for managing disagreement” on an international level are also the subject of Cornelia Hagedorn’s dissertation. She compares legislative procedures in the field of biomedicine in Japan, the Netherlands and the United Kingdom.

Her work focuses on more than just Japanese legislation, looking also at the processes involved in managing differences of opinion. “Since opinions are split within and across political parties on such ethically sensitive issues as those in the area of bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through bioethics, the parties find that they cannot raise their political profile through...

**EMBRYO PROTECTION**

Embryo protection – and specifically the protection of embryos created outside of the womb – is another example of the delicate relationship between ethics and the law, or of the way this relationship is handled in the decision-making process. It means that parliamentarians often try to avoid enacting legislation on ethical subjects altogether. She cites the lack of a law on assisted suicide in Germany as an example. Cases like this are still dealt with under regular criminal law. Consequently, if a terminally ill patient asks his doctor to help him die, such a “termination of life on request” is treated in the same way as when a healthy person asks someone to kill him.

Besides avoiding the issue altogether, legislators have also resorted to other strategies when faced with the difficulties arising from attempts to reconcile different moral opinions. These include setting minimum standards under which regulations are made only for areas in which consensus can easily be achieved, enforcing a strict majority principle, and enacting specific procedural rules for dealing with these issues.

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**INTERNATIONAL LAW**

The diversity of opinions and beliefs on matters of bioethics remains as to whether obtaining the expert opinion of advisors on the content of laws diminishes the democratic legitimization of legislation. After all, the involvement of experts in the legislative process could clash with one of the key tenets of democracy: the sovereign decision-making powers of the citizens of a given country. Many see this as opening the doors to expertocracy. Silja Vöneky does not share this view. In her research, she has studied the possibility of using national ethics councils as an integration factor. “Things are even more complicated in international law,” says Vöneky, explaining that, “for a country to be bound by a convention, it needs to give its consent.” This means that the majority principle does not apply here – consensus must be reached instead.

And achieving consensus is no easy task, as demonstrated by the European Biomedicine Convention. “Although the negotiations took place against a relatively homogeneous cultural background, it proved impossible to formulate detailed, substantive rules on predictive genetic testing and on embryo research.” Where substantive standards cannot be formulated, Vöneky believes that the procedure for determining standards needs to be designed in a way that fosters agreement. “This shifts the focus from the content of the decision to the decision-making mechanisms themselves. The aim is not true: although the guarantee of human dignity is recognized in the EU as a binding legal proposition, the protection it provides does not extend to the embryo in vitro, as their examination of European law found. They concluded that, “at the European level, embryo protection is more of a vulnerable plant than a strong tree.”

**INTERNATIONAL LAW NEEDS CONSENSUS**

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**INHERENT IN THE DECISION-MAKING PROCESS**

The question of acting on ethical subjects altogether.” Whereas Vöneky only discusses the major challenge for lawmakers. How can a democratic solution be achieved? This is another question that the research group from Heidelberg is examining. While the work is still ongoing, what is already clear is that there is no one-size-fits-all solution. In part as a result of a deliberate attempt at strong protection for embryos.

Such differing views stem from “frequently irrefutable ethical premises, and point to the disappearance of value consensus in modern society,” Heidelberg-based junior researcher Jelena von Achenbach discovered. She is working on her dissertation with Silja Vöneky and is examining the democratic legitimation of biomedicine and human biotechnological legislation at the European Union level.

In Vöneky’s opinion, Europe’s basic laws could potentially provide an appropriate framework for protecting the embryo. This was also the result of her previous studies that she undertook together with fellow scientist Niels Petersen. The study specifically addressed the question of how the laws of the European Union could be used to protect in vitro embryos. According to their findings, the guarantee of human dignity and the right to life seem, at first glance, to be a good basis from which to derive regula-
How Enemies Are Made

MAXPLANCELResearch: Professor Schlee, your book Wie Feindbilder entstehen (How Enemies Are Made) is intended to refute a variety of clichés. You are particularly opposed to the theory that ethnic and religious differences have been the main cause of wars and crises since the 1990s. How did you reach this conclusion?

Schlee: I am not the first to maintain that ethnic groups are not naturally occurring entities. Ethnic groups are social constructs – that has been the prevailing opinion among social scientists for years. It is also generally recognized that religious boundaries can be drawn more narrowly or more broadly, and that religion, while not itself a cause of conflict, is often instrumentalized in varying ways in political rhetoric.

Very few historians would maintain that religious wars are fought primarily over issues of theology. Similarly, ethnicity is not the cause of ethnic conflicts.

MPR: And yet the media is full of reports about ethnic and religious factors that cause states to collapse and civil wars to erupt ...

Schlee: If you consider such conflicts empirically, you will discover that ethnicity is something that develops and changes in the course of a conflict – for example, in response to the imposition of boundaries, to exclusion, or to the need to form alliances. This is how concepts of enmity arise. In times of conflict, one delimits one’s own group much more strictly than would otherwise be the case. Unfortunately, the social scientific insight that ethnic groups are not naturally distinct does not appear to have made much headway either in popular understanding or in some scientific theories of conflict. Recently, it has become fashionable among conflict analysts to distinguish between identity-based conflicts and resource-based conflicts. I consider this distinction to be nonsensical.

Schlee: In the broadest sense, every conflict is a battle for resources. But that does not answer the question of who the opposing parties are, and where the front lines are drawn. The fact that some conflicts are fought over oil or water does not itself determine who is allied with whom and who is opposed to whom. One way or another, the weaker side will have to seek allies with whom it might later have to share the spoils of success. That is as far as you can go with an explanation that deals exclusively with the value of resources and with the cost of the effort made to acquire or defend them. In this way, you might be able to explain why any given party needs a certain number of allies. But who these will be is not subject exclusively to such economic logic. The choice of allies is also determined by a shared sense of identity. We tend to pick allies with whom we share a common language, culture or religion.

MPR: The Balkan wars have often been attributed to historical differences between ethnic groups and religions. However, back in the 1970s, the communities lived together peacefully in what was then Yugoslavia, sharing a common identity and language, as you show in your book. How do you explain the bloody conflicts of the nineties?

Schlee: It is helpful to consider the beginning of these conflicts topographically. The breakup of Yugoslavia started in the northwest and progressed toward the southeast. The first republic to break away was Slovenia. The area that was most advanced economically had every reason to keep its resources for itself and to stop sharing them with others. Of course, there had been nationalisms and even micro-nationalisms in the Balkans since the 19th century, but the mere existence of such tendencies did not necessarily mean that they were bound to prevail politically. First, the relevant groups of actors had to be confronted with particular circumstances and corresponding incentives, and only then could all sorts of nationalist feelings be instrumentalized in order

There is a mistaken perception that many conflicts are caused by ethnic differences. GUNThER Schlee, Director at the MAX Planck Institute for Social Anthropology, is an analyst of armed conflict. In most cases, resources are the cause of war. In the ensuing struggle for water, oil or grazing land, members of one’s own ethnic or religious grouping become obvious allies.
to usher in a new political order. Under such conditions, there is an interplay between calculated economic interests and social processes of inclusion and exclusion. These factors color every political decision regarding all areas of life, from education to war, and every political process can easily be triggered by radical minorities. Today, in Afghanistan and Iraq, they occur frequently. It takes much less effort and is less costly to commit a specifically targeted political murder or assassination than it does to prevent such attacks. The advantage always lies with the aggressor, no matter how horrifying their justification. Actually, it is rather improbable that decisions are made strictly according to individual interests.

**MPR:** Your description might well fit present-day Iran, where a caste of religious leaders seeks to monopolize authority, both in religion and in politics. However, the elite controlling such processes need not always be concentrated in a separate category: betrayal, exclusion from power, and political murder were well known. The fact is that one cannot live in peace. In my book, I explained the process of “purification” in this context. An increasingly strict and narrow definition of who is a true Muslim or a true Christian is used to determine which social groups should be excluded from power, simply by insinuating that they do not exhibit this doctrine. This process of purification is not just about authoritative theological interpretations — that is, matters of belief. Often, tangible worldly interests are involved — for example, the struggle for political power and the elimination of possible opponents.

**MPR:** To what extent has the character of conflicts changed since the end of the Cold War? It is noticeable that the script of ideology is almost entirely absent in your book.

**Schlee:** The conflict between East and West ended some time ago, but now we have new fronts opening up to replace it. Since 1990, and especially since September 11, 2001, NATO has sought new enemies, with Islam specifically being cast in an unfavorable light. Western politicians have, for their part, contributed to the construction of new enemies. In this way, they are playing into the hands of ideologues in opposing camps — for example, among militant Islamic fundamentalists — who seek to promote the polarization and radicalization of conflicts. As radical forces gain momentum, it becomes appreciably more difficult for politically moderate Muslims to live in peace. In my book, I explained the process of “purification” in this context. An increasingly strict and narrow definition of who is a true Muslim or a true Christian is used to determine which social groups should be excluded from power, simply by insinuating that they do not exhibit this doctrine. This process of purification is not just about authoritative theological interpretations — that is, matters of belief. Often, tangible worldly interests are involved — for example, the struggle for political power and the elimination of possible opponents.

**MPR:** Scholars speak of the asymmetry of contemporary wars and conflicts. How, then, do concepts of hatred, fear and enmity arise at the level of the state? Are they generally quite complex. The actors may include the poltical order. Politicians, too, contribute to the creation of arbitrary boundaries by gathering potential supporters in their electoral districts, while expelling groups that are less likely to vote for them. On the one hand, local conflicts are influenced by the modern administrative system and competition for political offices; and on the other hand, the causes can often be found in traditional disputes over pastures and water. Different groups have different perceptions of the issues at stake. Being on the same side does not mean sharing the same goals.

**MPR:** What can conflict researchers, and indeed what can all scholars, learn from an encounter with Africa?

**Schlee:** The basic forms of conflict can be studied in all human societies — large or small, agricultural or industrial, past or present. In order to gather sufficient material for our analyses, it is advantageous to draw on and compare a wide variety of cases. The societies that are usually studied by ethnographers do not constitute a separate category: betrayal, exclusion from power, changes of allegiance, demagoguery, and the complex relations between leaders and followers can also be found in African villages, for example. The role of the organized crime syndicates of the next generation is as close to ours in structure than we like to believe. But there is another reason to take a closer look at African societies. Currently in Africa, the most important actors in many violent conflicts are not necessarily sovereign states or their representatives. Many of these actors are not linked to states in any way. The front lines in African conflicts are generally quite complex. The actors may include the police, the armed forces and local administrators, but even they do not necessarily represent the state. More often, they are pursuing private interests.

**MPR:** Political scientists, for whom the state is still a very important factor, are likely to have problems with such diversity.

**Schlee:** Well, in many of these countries, the boundary between governmental and non-governmental spheres is fluid, not least because, alongside these quasi-governmental agencies, pre-governmental power structures such as clans, lineages and tribes are still in place. The experience of the former colonial rulers shows how difficult it is to define political boundaries in these regions. The British in Kenya drew district boundaries and, in the face of resistance from many sides, attempted to sort out the groups of inhabitants and assign them to specific territories. Now, however, actors involved in violent disputes appeal to rights or claims that date back to the colonial era as if they were part of the natural order. Politicians, too, contribute to the creation of arbitrary boundaries by gathering potential supporters in their electoral districts, while expelling groups that are less likely to vote for them. On the one hand, local conflicts are influenced by the modern administrative system and competition for political offices; and on the other hand, the causes can often be found in traditional disputes over pastures and water. Different groups have different perceptions of the issues at stake. Being on the same side does not mean sharing the same goals.
FOCUS

Without colonial control and the exertion of massive external influence, there would never have been a unified Somalia. Both of these autonomous de-facto states that existed side by side or in opposition to one another: there was Somaliland in the northwest and Puntland in the northeast. Somalis were in conflict with one another. These ringleaders wanted to demonstrate their capabilities, both to their own clientele and to their competitors. Even during the conference in Eldoret, Kenya, they were still directing skirmishes by mobile phone.

In the 1990s, warring factions in Somalia attempted to seize control of development aid by force – now the UN distributes aid only in the presence of security forces.

MPR: Why did the collapse of state institutions take on an extent in Somalia?
Schlee: That’s right. In Somalia, in the 1990s, there was nothing left to divide up, apart from UN aid. So, ultimately, development aid became the resource that was being fought over. The warring factions wanted to take control of the state so they could channel this aid – into their own pockets. Somewhere along the line, the international community lost interest in Somalia. As a result, the state became less important as a prize over which rival groups competed. Instead, a mosaic of smaller groups developed, with the warlords maintaining a wary respect for one another at a relatively low level of violence. Without question, if development aid is poured indiscriminately into areas where peace has yet to be restored, it can often be counter-productive.

MPR: As a researcher working in Africa, you have direct contact with people there. How should an anthropologist proceed in Africa?
Schlee: The most important research tool is open conversation. You won’t get far by handing out standardized questionnaires to groups that have never even seen such a thing. More particularly, you never know precisely which questions are most pertinent in the local situation: anthropologists must be able to respond to the realities on the ground. It is thus most important to possess language skills and to observe existing social conditions with care. Diaries and detailed records of conversations are part of the daily routine of a field researcher.

MPR: How many languages do you speak?
Schlee: Ten, of which I’m fluent in seven or eight. But languages are regions in which I have no language knowledge, such as central Asia, which is another important focus of research in my department. I speak a little Arabic with the Islam in a mosque and make a good impression. But I speak neither Russian nor any of the Turkic languages, and when I visit our research projects there, I am soon lost without my colleagues.

In the 1990s, warring factions in Somalia attempted to seize control of development aid by force – now the UN distributes aid only in the presence of security forces.

The consequences were quite serious. Those who see no opportunities for themselves will not bother going to school. And a civil servant whose salary is only enough to cover the first few days of each month will tend to seek alternative sources of cash. So corruption is frequently a concomitant of this hopeless situation. The state must have something to offer; it must be in a position to reward loyalty. Otherwise, people will either withdraw from the state or subvert it.

MPR: Is Scandinavian development aid there at all?
Schlee: That’s the right position. At the conference in Eldoret, Kenya in 2002, a conscious attempt was made to bring attention to development aid for specifically defined projects.

If individual groups can “qualify” for participation in a peace conference through the conspicuous display of violent behavior, then the system of incentives is entirely wrong. At the conference in Eldoret, Kenya in 2002, a conscious attempt was made to bring about an actual “firepower” – that is, all of the warlords – to the negotiating table. The result was that, prior to the conference, the warlords set about trying to eliminate one another. These ringleaders wanted to demonstrate their capabilities, both to their own clientele and to their competitors. Even during the conference in Eldoret, Kenya, they were still directing skirmishes by mobile phone.

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InterVIEW: CHRISTIAN MAYER
An anthropologist in Leipzig is working on a virtual collection of early human fossils.

This will completely transform anthropological research,” declares Jean-Jacques Hublin, jumping out of the chair on which he’d just sat down. He goes over to the window and points to the courtyard below: “Do you see the container down there? We use that to transport one of the highest-resolution computer tomographs around the world to scan the unique finds we uncover on-site. The objects do not need to be taken to the scanner, the scanner comes to them.”

Paleoanthropologists who wish to study the origins of mankind are dependent on bone finds. However, fossilized hominids are among the rarest finds of all. If a museum finds itself in possession of such a treasure, then it becomes a well-guarded secret. The especially important pieces, the ones that all researchers would love to have in front of them in the original, are available as a plaster cast, at best. “But castings are not really exact enough, and many bones are far too brittle to make a cast out of them anyway,” says Hublin. But all these issues are about to be resolved. The French researcher’s vision is to create a comprehensive virtual collection, thereby making unique early human bone finds accessible to all. This opportunity is why Hublin came to Leipzig in 2004 to join the Max Planck Institute for Evolutionary Anthropology.

“Our research field is multidisciplinary these days,” explains the 54-year-old scientist. “We no longer restrict ourselves to describing the bone finds; we now use biochemical methods, sequential analyses and computer technology to try to glean more information from the bones so that we can learn something about how early humans lived, the conditions they lived in and the course of their lives in general.”

It was a unique opportunity for the anthropologist, who was then teaching at the University of Bordeaux, when the Max Planck Society offered him the opportunity to establish a Department for Human Evolution at its Leipzig-based institute three years ago. Jean-Jacques Hublin has spent many years studying the world’s great paleoanthropological collections and is one of the top experts on hominid fossils.

In the field of medicine, tomographic technology is used as a standard diagnostic tool. But there is nothing to stop it from being used...
to study fossilized bones. The way it works is the same: a rotating X-ray source screens the object layer by layer from different directions; the X-ray is weakened to different degrees depending on the density of the structures. The detectors positioned opposite the X-ray source receive this weakened signal, process it electronically and transmit it to a computer for analysis. In this way, several different projections are created of each layer and the computer then translates them into a shaded image.

However, the resolution of medical CT machines is not particularly high. “Doctors don’t need high spatial resolution images to make a diagnosis; all they need is half a millimeter,” says Jean-Jacques Hublin. Moreover, medical devices are designed to record data quickly – patients should not be exposed to the damaging X-rays for longer than absolutely necessary. But for the study of early human bones, scientists need detailed CT images. “Nowadays, there are CT machines for the industry that can provide resolution on the micrometer scale,” explains Hublin. And the length of time the fossilized bones can stay in the tomograph is not limited either. Being thousands of years old, the remnants of ancient hominids have nothing to fear from the damaging X-rays.

**Resolutions below the Micrometer Level**

The institute in Leipzig has two computer tomographs: the BIR ACTIS 225/300 achieves resolutions in the range of one millimeter to five micrometers; the Skyscan 1172 can even go down to 0.8 micrometers. “There are only four CT scanners in the whole world with such high resolution for use by paleoanthropologists,” says Hublin, not without a hint of pride. “This means that we can even analyze minute structures, such as dental enamel.” These abilities enable the scientists to draw conclusions about the growth rates of hominids.

The BIR ACTIS is located in its own room on the fourth floor of the Max Planck building in Leipzig. Ten millimeters of lead line the walls from ceiling to floor to protect the surroundings from the X-rays. The whole arrangement weighs in at nine tons. In the operator’s room next door, Heiko Temming and Andreas Winzer are packing up cables and computers, preparing for the CT’s upcoming trip to Morocco. The man-
The French made Rabat the country’s administrative capital and generals’ residence during the period when it was a French protectorate in the mid-20th century. The tight schedule allows them only a brief excursion into the old royal city.

The unassuming gray steel walls conceal lead shields inside the container, into which the super-scanner fits snugly. Securely bolted down, the machine is ready to begin its journey together with its companion computer equipment, which is packed in shockproof crates. Early in the morning of October 3, 2006, a loading crane heaves the container onto the back of a truck. It then sets off on the three-day, 1,187-kilometer drive from Leipzig to Marseille in the south of France. Upon reaching the Mediterranean, the container is loaded onto a ferry, which takes a day and a half to transport the valuable cargo to Africa’s northwest coast. The destination is Rabat, the capital of Morocco.

In the meantime, Heiko Temming and Andreas Winzer have also set out on the trip, but they are flying from Leipzig to Paris, then on to Casablanca. A car will pick them up at the airport and take them to Rabat. The truck with the container doesn’t arrive until late in the evening. The crane is ready and waiting; offloading the cargo takes until midnight and even attracts a small audience. The container is allotted a space right next to the little archeological museum. The only thing the two technicians from Leipzig need now is a power supply for the air-conditioning system.

Temming and Winzer spend the next three days calibrating the highly sensitive measuring device. Only after this crucial task can the real work begin. Temming and Winzer will be scanning 30 bones: three skulls, six lower jaws and various skull fragments. Although Rabat’s archeological museum looks rather unassuming from the outside, its interior houses a valuable collection of hominid bones. These bones could be the remains of the ancestors of the humans who left Africa around 50,000 years ago, constituting the European continent’s founding population. This possibility is the reason these bones have piqued the interest of Hüblih and his team.

The bones, despite their rarity and importance, are stored in simple cardboard boxes. A member of the museum staff carries them out to the container. Andreas Winzer gently lifts a skull out of the box and places it on the measuring table. He carefully adjusts the scanner. Then he leaves the X-ray room and checks the settings on the computer. The Moroccan who brought him the cardboard box does not let the skull out of his sight for even a second.

Communication is difficult, as the Moroccans speak very little English. French, the country’s second official language, would be better. Unfortunately, neither Temming nor Winzer speaks more than a few words of French. Reconstruction Exceeds the Data Memory

"The CT machine takes four to six hours to scan a complete skull," explains Heiko Temming. In the process, the measuring table with the skull on it is rotated around its vertical axis so that the machine can scan the object from all sides. Some 7,000 individual images are created per rotation, with the total number exceeding 70,000. "That’s an enormous amount of data," says Temming. "The data record for a complete skull takes up about 70 to 80 gigabytes, and a high-resolution tooth scan is double that, at 150 gigabytes." Even a terabyte of memory capacity is not enough to hold such a large cache of data. To compensate, the technicians have to send their tape drive back to Leipzig to have the data transferred onto a large-capacity server.

Temming and Winzer’s working days are packed—a brief excursion to the old royal city of Rabat is about all they can manage in six weeks. When their work is done, they pack everything up again, fasten it all down and send the container off on its homeward journey. It arrives in Leipzig on November 12. Heiko Temming and Andreas Winzer return by plane.
The computer translates these recordings into a shaded image. Its vertical axis so that the machine can scan the object from all sides.

The process, the measuring table with the skull on it is rotated around the axis of symmetry. Computation algorithms are used to realign these landmarks and correct the distortions.

Virtual Reality – Fossils in 3-D

Putting a fossil together is tricky business. “In the past, the fragments were glued together and then taken apart again when it was thought that the positioning should be different after all,” explains Philipp Gunz. “The finds suffered some fairly serious damage as a result.” On the screen, however, a paleoanthropologist can rotate the virtual fragments, tip them, look at the pieces from every angle, and then fit them together in completely new ways – without damaging or destroying a single thing.

Gunz starts up the computer in the virtual reality laboratory of Hulin’s department, which is the modern lab of its kind. He clicks on a file and the skull of an early human immediately appears on the screen. Two projectors project a stereo image of the object onto a screen. It is also possible for a researcher to view the interior of the fossil he has projected. If one looks at the image through a pair of 3-D glasses, it looks as though it could actually be touched. “The first thing we need to do is correct the deformations that arose during the fossilization process,” explains Gunz. To do this, hundreds of measuring points on the skull – the researchers call them landmarks – need to be determined, and their divergence from the axis of symmetry identified. Computation algorithms are used to realign these landmarks and correct the distortions.

Missing parts can be added by making mirror images of the matching parts on the opposite side. Here, too, the in calculable advantages of modern electronic image processing are brought to light. In the past, a physical mirror image had to be made after weeks of painstaking work, but now the image can be conjured up on the computer in seconds. Another way of completing an image is to copy parts from another skull and then adjust them fit, which proves to be no problem for the computer, either. “However, the whole thing is still an extremely tricky 3-D puzzle,” stresses Gunz.

For that reason, the anthropologists – despite all of these possibilities – still like to hold a real 3-D object in their hands. This gives them a better idea of the physical relationship between the structures. These kinds of physical objects communicate tactile information; they can be touched, examined, and fitted together under far more realistic conditions than virtual objects on a screen.

The lab’s 3-D printer works just like a conventional inkjet printer, but in three dimensions rather than two. At the end of the process, the skull is taken out of the plaster bed and cleaned with a brush.

A 3-D printer is used to translate the computer reconstruction into a plaster model. The printer works just like a conventional inkjet printer, but in three dimensions rather than two. The print head applies a transparent bonding agent to the appropriate areas, which quickly causes the plaster to stick together locally. It then applies another layer of plaster powder and repeats the process layer by layer, a three-dimensional skull appears. Teeth are also reconstructed, many times magnified. The whole process takes just over half a second: the ZCorp Spectrum Z510 is currently the fastest 3-D printer in the world.

Back in Leipzig, researchers have already begun reconstructing the raw data. Initially, the tomographic cross-sections don’t look like much. In order to put the information they contain in an appropriate form for analysis, the massive volumes of data need to be processed with powerful graphics programs and translated into spatial images. This would take one computer six to eight weeks. To speed up the process, the scientists set 10 computers to work on the task. With such great computing power, it takes just a week to reconstruct the 70,000 images into a 3-D object that is as good as the original.

“The big advantage is that we can look into the otherwise inaccessible interior of the fossil and analyze, for example, the structures of the inner ear,” says Philipp Gunz. The Austrian scientist has spent the past two years working in Jean-Jacques Hublin’s department as a post-doctoral researcher, sponsored by an EU project. “Neanderthals display small but characteristic differences to the morphology of the inner ear of Homo sapiens. We only discovered this thanks to the conclusive classification of certain fragmentary fossil finds.”

Moreover, human fossils can also be reconstructed on the computer. Few paleoanthropologists are lucky enough to come across an intact skeleton or a complete skull on one of their digs. They usually have to be satisfied with fragments – fragments of an ulna or radius, a lower jaw, a skullcap. Geological processes such as rock displacements, sand deposits, erosion and weathering, and sometimes wild animals, as well, have usually ripped the bones apart and dispersed them widely throughout the area. The ability to reconstruct complete fossils is thus especially useful.

A Human Skull to Touch

The lab’s 3-D printer works just like a conventional inkjet printer, but in three dimensions rather than two. The print head can move over a surface in any direction. First, it covers the surface with a thin layer of plaster powder. Then, in line with the shape of the object reconstructed on the computer, the print head applies a transparent bonding agent to the appropriate areas, which quickly causes the plaster to stick together locally. It then applies another layer of plaster powder and repeats the process layer by layer, a three-dimensional skull appears. Teeth are also reconstructed, many times magnified. The whole process takes just over half a second: the ZCorp Spectrum Z510 is currently the fastest 3-D printer in the world.

Jean-Jacques Hublin estimates that his research field will be completely transformed within 15 years. By then, scientists will no longer be studying the actual bone finds, but only their virtual likenesses. The Max Planck Director’s goal is to record the data, build up a virtual collection and eventually pioneer this field of analysis. Naturally, he will need the cooperation of international partners to do this, particularly museums. His two technicians, Heiko Temming and Andreas Winzer, have already been to Croatia, home of the world’s largest collection of Neanderthal bones. Their next destination – naturally enough – is East Africa, the cradle of mankind.
FIRSTHAND KNOWLEDGE

A Short Process in a Chemical Reactor

Some chemical processes behave like good-natured monsters: they can be controlled, but they remain fairly unpredictable – and that’s why they cost the chemical industry millions.

KAI SUNDMACHER and his team at the MAX PLANCK INSTITUTE FOR THE DYNAMICS OF COMPLEX TECHNICAL SYSTEMS are radically simplifying just such unruly processes. Sometimes they are able to do this in a single step where the industry previously needed two.

Carpets, raincoats, ladies stockings – the list of products containing nylon fibers is long. More than four million tons of the strong and stable polyamide are manufactured by the chemical industry every year – and this can only be done in multiple stages, some of which are tricky. Making one of these complicated process steps more effective saves a great deal of energy, raw materials and, of course, money.

That is precisely our goal – or, to be more exact, one of our subgoals. The method of manufacturing nylon is but one example of where we apply our approaches. Our ultimate goal is to develop a model that we can apply to all manufacturing processes. What we are not concerned with is optimizing chemical processes by two or three percent. Ideally, we want to improve efficiency by several orders of magnitude. We call this process intensification. We focus primarily on processes in which complications cause a particular complexity – either because the reaction doesn’t go as planned, the reaction is especially tricky, or the products are very difficult to separate.

In order to dramatically intensify one of these processes, it is not enough, for example, to merely change the temperature and increase the pressure a little. To be successful, we need to question everything about the process: the energy source, the solvents, the catalysts and, of course, the pressure and temperature, as well. But most of all, we need to consider whether we should perhaps change the process completely – whether there is another reaction method we could use to produce the desired product more efficiently, whether we should start with different input substances, or whether one step could be enough in place of the two previously needed within the chemical industry. However, sometimes it makes sense to add another reaction step, when it makes the entire process more efficient overall. This kind of chemical detour, for example, might help us find an easier way to make cyclohexanol (one of the basic substances used to make nylon). There is still room for improvement in its production.

WHY HAVE TWO STEPS IF ONE IS ENOUGH?

The reason why cyclohexanol can ultimately be manufactured more efficiently despite having to take a chemical detour is because some of the process steps can be combined. We refer to this as process integration. This may sound obvious enough, but it is actually very complicated when one gets down to the nitty-gritty of it. Many of the chemical, physical and technical basics that would make process integration easier to pull off are still unknown. Chemical engineers thus usually take the following approach: they allow one reaction step to proceed on the way to the desired product. Then they separate off the intermediate product, purify it and use it to start the second step of the reaction. So it is easy, as with nylon, to end up with a half dozen consecutive reactions, each of which are followed by a separation process.

Separation can refer to any of a multitude of methods used to isolate a product out of a reaction mixture and clean it. This is necessary because a chemical reaction rarely delivers the desired compound exclusively. Quite apart from this, reaction mixtures often contain catalysts or other additives, and the solvents in which most reactions occur also have to be removed.

Thus, as a possible method of process intensification, we are experimenting with a process in which the reaction and the separation happen simultaneously. In doing so, we are shaking up the principle of unit operations, where the steps always take place consecutively. There are various options for this form of process integration. One is reactive distillation, which is used in the process of creating cyclohexanol or nylon.

When chemists distill a mixture of substances, they take advantage of the fact that most liquids boil at different temperatures. If they heat a
mixture of various liquids slowly, the individual components ideally evaporate one after the other, starting with the one with the lowest boiling point. However, in order to distill products, we need to heat them. This is one of the ways we might be able to achieve process integration. Many substances react with each other only at high temperatures, or even release energy in the form of heat as they react with each other. We use this heat to distill the reaction mixture while the chemical reaction is still under way.

This is a particularly sensible approach if the product we are after breaks out of the reaction mixture at the lowest temperature. Not only is energy saved that would otherwise be needed in the post-reaction distillation, but smaller reactors can be used. From our perspective, the reaction carried out in the last step went out of control at the chemical plant in Flixborough, England, in 1974. The reaction could not be stopped, and 28 people died. Furthermore, cyclohexane can be reacted only in low concentrations, so as not to produce too many byproducts; the reactor is very complicated, and the subsequent distillation consumes a lot of energy. That is why we built in our technical center the Japanese company Asahi Chemical to develop a new process: they also react benzene with hydrogen, but only partially, and make cyclohexane. At this point, only water was needed to turn the intermediate product into cyclohexanol. However, this reaction is anything but complete. It reaches equilibrium after only 14 percent of the raw material is converted, and works only with large amounts of catalyst (which floats in the reaction mixture as finely distributed sediment). Chemists refer to this kind of mixture as a slurry. The reaction slurry wears out the equipment quickly, and is difficult to pump and hard to separate. A lot would be gained if it were possible to fix the catalyst into a finely woven three-dimensional net instead of having it dispersed through the reaction mixture in the form of fine particles. Then we would be able to conduct the process in a reactive distillation column. The catalyst in the Asahi process is not suitable for such a process, as it is sufficiently active only at low temperatures and 28 people died. Furthermore, cyclohexane can be reacted only in low concentrations, so as not to produce too many by-products; the reactor is very complicated, and the subsequent distillation consumes a lot of energy.

The start holds the key: What quantity. Only then can we figure out what product is produced, and in what quantity. Only then can we control the process correctly to enable us to distill cyclohexyl formate off during the reaction. The start holds the key: What quantities of input substances do we have, and how high is the temperature and the pressure? These factors determine what product is produced, and in what quantity. Only then can we study these questions in the lab. With the findings we come up with, we will develop a miniaturized industrial plant that can be built in our technical center.

**Taming a Good-Natured Monster**

One of the reactors stands a good three meters high, yet it is thin enough for one person to encircle it with both arms. The reactors are cylindrical and pressure sensors reach into the reaction chamber with placement intervals of a hand’s width apart. The acute bend, the reaction chamber, well wrapped in insulating material, is not even as wide as the drainage pipe on a roof gutter. Throughout its entire length, we have layered metal nets, one on top of the other, some of which are filled with a catalyst. At the top and bottom of the column, there are groups of pumps and measuring devices, as well as two barrel tanks at each end, each with a window. The top tank is where the formic acid distilled from the reaction mixture accumulates. The bottom tank mostly collects cyclohexyl formate. That is where the intermediate product remains for the time being. At a later date, we plan to run it into a second, very similar reactor for which there is currently space available next to the first one. That is where we will split the cyclohexyl formate into cyclohexanol. But first we must come to grips with step one. What is learned there can be transferred further complicates the matter. The only difference is that the reaction will take place in a vessel having a width of at least one meter rather than just a few centimeters. The data collected in our technical center during reactive distillation helps us understand the principles of the process while enabling us to fine-tune our simulation models. In conjunction with our fellow scientists from Aschem Kienzle’s group, we use these models to develop optimal process strategies for these kinds of chemical processes. Doing this also enables us to identify whether other chemical reactions are suitable for such process integration as reactive distillation, as well. Whenever the chemical industry tries to find the optimum conditions in which to manufacture a certain
substance, the engineers must often rely on empirical science. This means that they have to try things out and, if they are lucky, they will identify the conditions in which their reactor works best. However, beware of the cases where changing even the slightest thing might stop the whole process or, on occasion, turn it in a completely undesired direction. We have already come up against such “good-natured monster” (as the engineers dubbed the process) in one of our ventures with a customer in the industry, but we managed to tame it.

Time and time again, the monster refused to do what the process engineers wanted. When we proceeded to systematically examine the process, we found that it cooperated only under a very narrow set of conditions. Our theoretical investigations subsequently delivered a recipe that the process engineers could use to control the process. In order to develop models that do not just depict one process correctly, but apply to numerous processes, we need to take into account many chemical and physical effects that, in turn, are closely coupled with each other. Sometimes, even a model can become a monster – albeit one of the mathematical variety. In doing so, we do not consider process units in the industry’s sense – such as re- action and distillation.

The approach we pursue is a novel one. It occurred to us that the process unit could be broken up into elementary physical and chemical functions. One can define five such functions: the process needs to be fed with substances; these substances must find each other and may require activating. As soon as they have reacted with each other, the products need to be separated. Finally, we need to take the energy balance of these functions into account, as some functions consume energy and others release it.

The models we construct from these functions then provide the guidelines for whether and how to intensify a process. We can thus exploit positive energy balances, such as those resulting from reactive dis- tillation. However, there are functions other than the transport of energy and separation that can also be combined. Our colleagues from the department headed by Andreas Seidel- Morgenstern simultaneously carry out chemical activation and separation in a chromatographic reactor.

In chromatography, chemists slowly channel a mixture of different liquids or a solution of various substances through a column-shaped vessel. The vessel is filled with fine grains of a carefully selected solid to which the various components of the mixture adhere to differing degrees. As the mixture slowly makes its way through the column, its components are either degraded at various points along the way, or not at all.

This method can also be used to separate a substance through which the membrane in present commission first formed during a reaction in the actual column. When this happens, we call the column a chromatographic reactor. Volker Zahn is studying the splitting of esters in chromatographic reactors. These chemical compounds, consisting of acids and alcohols, are what give many fruits their aroma. Separating them into their individual components is important for many industrial processes.

Ester splitting is particularly suitable for the chromatographic reactor, because the process creates two products from one input substance that should be almost completely consumed at the end. However, Zahn does need to use a catalyst to spur the reaction along. Using this approach, he uses one of the tricks of process integration: he chooses a catalyst that separates the products at the same time. With this catalyst, he coats the fines grains in the chromatography column. Additionally, Zahn built a chromatographic reactor around a technical center to test the process under industrial conditions, as well.

Reiniging Rampant Oxygen

Process integration is not just about separating products during a chemical reaction. Effective methods of carefully metered input substances can also be combined with the metering of activating them chemi- cally. This is useful especially when the chemistry is difficult to control in a conventional reactor. An example of this would be in the case where two substances are to chemi- cally interact only up to a certain point. A reactor would normally overstep this boundary.

Oxygen is a substance that has a hard time controlling its chemical appetit. It can pick up a few hydro- gen atoms from hydrocarbons and convert them into more complex compounds based on whatever the chemical industry requires. Usually, though, it breaks up the whole molecule, leaving only carbon dioxide behind. It can be controlled only with a catalytic membrane. Membranes that allow the oxygen to flow to moderation in the hydrocarbons make this possible.

Andreas Seidel-Morgenstern and his department work with porous ceramic membranes. These work at all temperatures, but also let nitrogen through, as well as oxygen, if the oxygen from the air is used without first removing the nitrogen. Liisa Rihko-Struckmann is developing her part by studying reactors with solid elec- trolyte membranes. While they do not work optimally below 600 degrees Celsius, they can be designed to allow only certain ions, such as oxygen ions, to pass through. Such reactors also have the advantage of not releasing any gases. In many cases, useless heat, but as electrical current, instead – a kind of bonus in a process that is easier to handle. The fuel cell can be considered a special kind of such a membrane reactor; it is concerned solely with chemical reactions. Andreas Seidel-Morgenstern is now looking for the sites in this region. Furthermore, the elec- trodes need to be positioned close to the reaction site. We have now reached a point of using the mem- brace, catalysts and electrodes to- gether so that there is still space for the furthermore. At the moment, we are studying what the ratio of butane to oxygen needs to be in order to produce the most maleic acid anhydride, and

into maleic acid anhydride. This is used by the chemical industry to make polyester, as well as the surfac- tants that go into detergents.

In an EMR, the cathode first supplies the oxygen with electrons, re- sulting in the creation of oxygen ions. The oxygen ions then diffuse through the membrane in present concentration to the anode, thereby oxidizing the butane. Electrons are set free in the process and, in turn, flow back to the cathode. Finding ceramic materials that allow the passage of oxygen ions remains a challenge for the field of materials development. Regulating the Reaction

In addition, we need a catalyst to control the oxygen’s chemical cravings. This catalyst serves to ensure that oxygen and butane react to be- come maleic acid anhydride and nothing else. To properly facilitate the reaction, the catalyst requires a specific substance. Therefore, we have to place it behind the mem- brane in such a way as to make the input materials come together in this region. Furthermore, the electrolytes need to be positioned close to the reaction site. We have now reached a point of using the membrane, catalysts and electrodes to- gether so that there is still space for the further development. At the moment, we are studying what the ratio of butane to oxygen needs to be in order to produce the most maleic acid anhydride, and

whether we should allow both gases to flow continuously or bit by bit. We have already simulated various scenarios. These indicate that we need to re-consider our model to make it superior to other methods.

Which method is more efficient depends not only on the choice of membrane reactors, but also on many other different details. The type of chemical reaction, the properties of the substances involved, the volumes that need to be produced and much more are what determine which method makes the most sense economically and ecologically. It will often be extremely difficult to make the right choice. We want to do our part to systematically classify processes of models so that a chemical process need not be just a matter of experimental luck. To add to this, we want to consider options that have not yet been established in the chemical industry – but that may prove to be far more efficient.

FIRSTHAND KNOWLEDGE

A perfect fit: Liisa Rihko-Struckmann checks the centerpiece of a ceramic membrane reactor.
When laboratory researchers rummage through the toy box, it can absolutely be service of the world to basic research. Some 30 years ago, researchers at the Max Planck Institute for Psycholinguistics in Nijmegen decided they wanted a dollhouse – for research purposes, of course. "That research formed the basis for later psycholinguistic research, and is still valid today," notes Dutch psycholinguist Willem Levelt who, together with Co-Director Wolfgang Klein, a specialist in German studies, and his colleagues unpacked their dollhouse in 1980. His experiments with the dollhouse opened up new avenues in what was then still the rather new enterprise of experimental linguistics.

What mental processes take place when we formulate and comprehend spoken utterances? How do children acquire their first language and adults their second or third? How do thought and language influence each other, and what role does the environment play? These are the types of questions that psycholinguists are investigating today. They essentially want to discover the basic principles of the human language faculty — how language is anchored and processed in the brain. For 27 years now, the Max Planck Institute for Psycholinguistics has been delivering important insights into this and other questions.

When the institute began its work in 1963, the branch of language research was still in its infancy. Thus, when Willem Levelt and his colleagues unpacked their dollhouse in those first few years, they were conducting truly groundbreaking research. Apart from one American study, they were the first to show interest in a phenomenon that psycholinguists are investigating today. They essentially want to discover the basic principles of the human language faculty — how language is anchored and processed in the brain. For 27 years now, the Max Planck Institute for Psycholinguistics has been delivering important insights into this and other questions.

After this initial success, the psychologists refined their methods and developed a new linguistic task: a two-dimensional matrix through which they sent their subjects on imaginary walks. "That also functioned brilliantly," says Levelt, now Founding Director Emeritus of the institute: "I still use it in presentations today." He also supplemented the laboratory tests with descriptions of walks the subjects went on outside the institute. "It was as important to us then as it is now to always combine our laboratory work with field work," stresses Levelt. "So we also sent our subjects into town, into the village or to the zoo."

These virtual and real research walks provided the Max Planck researchers with new insights into the nature of language. "For instance, we developed a theory of linearization based on simple principles — a theory that remains valid today. In those first pioneering years of research, the scientists discovered that speakers combine various strategies to solve the linearization problem. "First, we have maximum connectivity," says Levelt. "That simply means that things that are spatially linked also follow one another in a description." For example in the statement: "There is a cupboard in the corner."

The second problem-solving strategy that Levelt and his colleagues observed was the speakers' attempts to branch off their route as little as possible. They constructed their description in a very similar linguistic choices when describing the house. "Most of them went on a tour through the house," remembers Levelt. "Just like in real life, they started at the front door and described the rooms they saw, like a visitor in a real house. They took the tour in small steps, mentioning relevant objects and features as they went along.

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Here, the stage you are in when something is “right on the tip of your tongue.” In lemma selection, the brain chooses the word, for example “dog,” “cat,” or “mouse,” that corresponds to the concept to which the word would normally appeal. That word form appears during the next stage: phonological coding. A string of retrieved word forms is now going to be syllabified; that is, the precursor to articulating the syllables of the word. “A different articulatory gesture is required for each syllable in the word,” says Levelt. He and his colleagues have invested much time in researching this language phenomenon, and have discovered a further linguistic secret, the noticeably small vocabulary of syllables. “In 80 percent of the cultural environments, only 500 different syllables, which we continuously use and re-use, are known to linguists. They are not aware of that because they don’t know that they are using them,” he explains. Levelt observes that these frequently used syllables are “stored” in the memories as motor-articulatory programs. “We continuously call up the phonological program needed for the word ‘dog’ or ‘cat’ as well as the phonological program needed for the word ‘mouse,’” he explains.
Only the Big Bang Was More Powerful

For around 40 years now, astronomers have been registering flashes in the gamma-ray spectrum that abruptly appear in the sky. Some 10 years ago, it was discovered that these are the most powerful explosions in the universe. Since then, the field of research into these gamma-ray bursts has experienced more turbulent development than nearly any other in astrophysics. At the invitation of the Max Planck Institute for Astrophysics in Garching, more than 50 researchers met at Ringberg Castle to discuss the topic.

C

eriously, this chapter of modern astrophysics began with a discovery by the American military. In the 1960s, surveillance satellites orbited the Earth to search for gamma radiation emitted by underground atomic bomb tests. In 1969, one of these instruments did, indeed, register a flash of gamma radiation. However, it had not come from the Earth, but rather from space. Further such bursts followed and soon around the curiosity of a few astronomers. But detailed studies were difficult, because the Earth’s atmosphere swallows up the gamma radiation. Space-based telescopes were needed.

The situation changed significantly when, in 1991, the American space agency NASA sent the Compton Observatory, in which physicists from the Max Planck Institute for Extraterrestrial Physics in Garching were also involved, into orbit. The result was absolutely astounding: Compton registered a cosmic flash somewhere in the sky about once per day, the duration varying between a few hundredths of a second and a few minutes.

There were absolutely no clues as to the cause. The Compton telescope could determine the positions only very imprecisely, so it was not possible to subsequently track down the outbursts with optical telescopes. Since then, the astrophysicists have proposed more than a hundred theories regarding the nature of the bursts, including the – naturally not entirely serious – idea of exploding intelligent beings.

Then the Italian-Dutch space telescope BeppoSAX came to the rescue. It was able to precisely localize the gamma bursts and automatically sent the celestial coordinates to a network of astronomers who, as quickly as possible, pointed their telescopes at the indicated spot in the sky. Thus, 1997 saw the first success in observing, in the visible spectrum, the afterglow of two gamma-ray bursts.

A spectral analysis then showed that these celestial bodies were in galaxies located billions of light-years away. This makes them the most extreme explosions in the universe – only the Big Bang was more powerful. The record holder so far, named GRB050904, was some 13 billion light-years away. If it had exploded at a distance of about 4,000 light-years, it would have radiated on our terrestrial sky as brightly as our Sun for a few seconds.

In some cases, a supernova was discovered at the location of the gamma burst, and occasionally, evidence of these exploding stars was seen in the late afterglow. After this, the theory became popular that these were very massive, rapidly rotating stars that burst at the end of their life and collapse to form a black hole. In this process, matter heats up to several hundred billion degrees and shoots into space in two collimated beams, so-called jets, along the rotation axis, emitting gamma radiation like two gigantic head-lights. When the particles zipping along at nearly the speed of light strike surrounding matter, it heats up and then also glows in the X-ray and visible spectra.

A Telescope Sets Its Sights on the Afterglow

These fireballs were observed with the terrestrial telescopes. Since the regular stellar explosions are even more violent than normal supernovas, they were called hypernovas. “We suspect that, among several hundred supernovas, only one hypernova occurs,” explains Thomas Janka from the Garching-based Max Planck Institute for Astrophysics, which co-organized the Ringberg workshop. It appeared that a decades-old mystery of astrophysics had finally been cleared up. But, as is so often the case in celestial research, things turned out differently. Even with the Compton telescope, the astronomers had noticed that there are apparently two classes of gamma-ray bursts: long flares that can last up to several minutes, and short ones with a duration of up to about three seconds. The latter account for no less than one-third of all bursts, but they fade so quickly that, for years, it was not possible to locate their afterglow with optical telescopes. This changed with the American space telescope Swift, launched in November 2004, heralding the beginning of a new era for this research field. In the two years following its commissioning, the number of publications on gamma-ray bursts quadrupled. As NASA project manager Neil Gehrels reported at Ringberg Castle, in the best case, this instrument can notify the astronomers by e-mail or text message within 15 to 20 seconds. In this way, two years ago, the first observation of short bursts succeed with large telescopes or sensitive X-ray detectors on satellites. The surprise was great when the bursts were localized in elliptical galaxies. Supernovas almost never occur in these star systems – and thus certainly not the far less common hypernovas. In the few cases in which the afterglow could be observed with an optical telescope, there were also
none of the signatures that are typical of supernovae.

Do, perhaps, the two classes of gamma-ray bursts have two different causes? This was one of the questions the experts discussed at Ringberg Castle, often until late into the night. To date, the luminous celestial fireball has been spectroscopically observed. Max Planck gamma-ray bursts, and in additional new cases, the afterglow was registered in the visible spectrum as well as in the X-ray and radio ranges. As Gehrels explained, these few cases show that the short gamma bursts radiate only about a thousandth of the energy of the long ones. But that is still about as much as is released in the form of light in a supernova, and corresponds approximately to the energy our Sun emits over the course of several billion years.

Since the fireballs of the short bursts appear much more weakly than those of the long ones, and also fade faster, the largest telescopes are needed to observe the handful of fireballs shortly before they die out. As Sylvia Klose of the Thueringer Landessternwarte (State Observatory) Taunusenbg reported, among the large telescopes in the visible spectrum, the Very Large Telescope of the European Southern Observatory (ESO) holds the world record for speed: in the past year, it was able to track down a short flash just seven and a half minutes after the gamma burst.

For short gamma-ray bursts, the evidence is still very meager, but one thing seems clear: when such a huge amount of energy is emitted within just a few seconds, only very compact celestial bodies come into question as the cause. The existing observational evidence of such a link was reviewed and evaluated by Ehud Nakar (Caltech, USA) and Edo Berger (Carnegie Observatory, USA). Two neutron stars that coalesce and collapse to form a black hole are considered the most probable explanation. Using computer simulations, Maximilian Ruffert from Edinburgh Observatory, Roland Oechslin and Miguel Aloy (Max Planck Institute for Astrophysics), Emmanuela Rantsiou (Northwestern University, USA) and William Lee (UNAM, Mexico) demonstrated what happens in such a process.

**Death Throes of Dying Stars**

Neutron stars are the most compact celestial bodies whose existence is observationally established. They are created when a massive star has used up the nuclear fuel in its interior at the end of its life. Then the internal energy production stops and the star that was once larger than the Sun collapses into itself. When it has reached a diameter of about 20 kilometers, the collapse stops — and a neutron star is born. The matter is then so dense that a piece the size of a sugar cube would weigh several hundred million tons on Earth. Since generally more than half of all stars belong to double systems, there must also be double neutron stars that circle each other. When this happens, they emit gravitational waves, which withdraws energy from the pair. As a result, the two bodies slowly draw closer to one another on a spiral pathway. At the moment their surfaces touch, they merge within a few thousand sandhills of a second. The new body then becomes so massive that it collapses into a black hole under the force of its own gravity. A portion of the matter, in which temperatures of up to one hundred billion degrees and densities of up to one million tons per cubic centimeter prevail, continues to race around the black hole in the form of a ring-shaped torus for a short time before, finally, it is likewise swallowed up. Thus, the matter of two to three Suns disappears within a few seconds.

In this cataclysmic process, a process of fusion of nuclear and particle reactions takes place that Reiner Bikir (Max Planck Institute for Astrophysics) studied in depth. A burst of high-energy matter in two concentrated gas jets occurs in the direction of the rotation axis and thus perpendicular to the dense torus. Magnetic fields are also discussed as the reason why energy shoots into space in such jets with a beam semi-opening angle of just 10 to 20 degrees. “According to our knowledge, this matter has a speed of around 99.9995 percent of the speed of light,” says Thomasanka.

At distances of 10 to 100 million kilometers, the jets produce the short flash of energetic radiation that is visible as a gamma burst. If the jet matter subsequently collides with surrounding interstellar matter (gas and dust), this matter, too, heats up and glows. That is likewise the luminous fireball that astronomers observe with X-ray and optical telescopes, and whose light reveals, for example, how far away the object is located.

In principle, current computer models can explain the observation results of the short gamma-ray bursts. Nevertheless, much is still unclear: What role do magnetic fields play in creating and accelerating the jets? How, exactly, do two neutron stars coalesce? When does the resulting object collapse to form a black hole and how much matter remains in the torus for some time afterward? The latter questions depend, as James Lattimer (Stony Brook University, USA) and Madappa Prakash (Ohio University, USA) explained, on the as yet insufficiently known properties of dense neutron star matter, and determine which double-star systems can emit gamma bursts in the last moment of their existence.

**Neutron Stars in the Universe**

So, basically, it is not just merging neutron stars that could be the cause of the long gamma bursts. It could be the luminous fireball that astronomer observes with X-ray and optical telescopes, and whose light reveals, for example, how far away the object is located.

**Neutrino Telescopes: Tracing Gamma-Ray Bursts**

When a black hole with 2.5 solar masses and a neutron star with 1.6 solar masses collide in the computer, an enormous vortex results and the matter heats up.

The observable energy emission of a short gamma-ray burst is enormous. Nevertheless, up to a thousand times more energy goes into the invisible particles: the neutrinos. They are also created in great numbers in normal supernovas. The first and, to date, only detection of such neutrinos, when the — astronomically speaking — nearby supernova 1987A in the Large Magellanic Cloud exploded, was a sensation and was rewarded with the Nobel Prize. New underground detectors with which it is hoped that it will also be possible to detect neutrinos from future gamma-ray bursts are currently under construction. However, the measurable neutrinos in this case are expected to have extremely high energies, as theoretical models for their creation in the jets predict.

Neutrino telescopes have nothing in common with known telescopes for photons. Currently, the largest instrument, named IceCube, is being built in the Antarctic and is designed especially to capture such extremely high-energy neutrinos. It consists essentially of many sensitive light detectors that are sunk into the ice at depths between 1,400 and 4,200 meters. These electronic eyes monitor the ice mass located between them. If a neutrino approaching from the cosmos collides with an atomic nucleus here, a charged particle is created that produces a short flash of light that the instruments register. In this way, since the direction of the neutrinos’ origin can also be determined, the causative source in the heavens can be localized. As Marek Kowalski from Berlin’s Humboldt University...
reported, neutrinos should reach the Earth 10 to 100 seconds after the observed gamma burst. This neutrino flash could easily be matched to its source and the astrophysicists would have entirely new avenues through which to observe this phenomenon. One part of the IceCube is already in operation, with overall completion expected in 2010. The 4,800 sensors will monitor one cubic kilometer of ice.

**Gravitational Waves as Touchstones for Theory**

Gravitational wave researchers, too, have a strong interest in studying gamma-ray bursts. This was also expressed by the fact that the German Research Foundation (DFG) co-financed the Ringberg workshop through its Transregional Collaborative Research Center 7 “Gravitational Wave Astronomy.” Merging neutron stars and black holes are among the most intense sources of gravitational waves and thus among the top candidates for detection.

Einstein’s general theory of relativity predicts the existence of gravitational waves, but to date, it has not been possible to detect them directly. They are thus considered a major touchstone for the current theory of gravitation, which holds that every body produces a depression in space, similar to a ball on a rubber blanket. If another body enters into this curved area, its path follows the curvature of space. This gives the impression that the two bodies exert an invisible pull (gravity) on each other. Light, too, travels on a curved path through a gravitational field.

Gravitational waves are always created when a distribution of matter rapidly changes its shape. Then the curved space is overlapped by a ripple-like structure that propagates at the speed of light. This can be imagined as something similar to waves on the surface of a body of water. If two massive objects merge, a gigantic gravitational wave distorts the fabric of space-time. If the gravitational wave passes over the Earth, it briefly compresses space—in other words, the distances between all objects change. To date, it has never been possible to detect this phenomenon directly, because it is unimaginably small: compression and expansion of only a fraction of the diameter of an atom’s nucleus have to be measured. For the first time, with the German-British gravitational wave antenna GEO 600 in Ruthe near Hannover and the two LIGO facilities in the US, researchers have achieved the immense sensitivity needed to capture this rhythmic compression of space.

A successful detection would mean, for one thing, that Einstein’s general theory of relativity could be tested; for another, gravitational waves contain information about astrophysical processes that cannot be obtained in any other way. Only in this way will it be possible, for example, to positively prove the connection between short gamma bursts and merging double stars.

“At present, with GEO 600, we can measure changes in length of 10^-19 meters, which is one ten-thousandth of the diameter of a proton. This allows us to detect coalescing neutron stars and black holes up to the edge of the Virgo Galaxy Cluster,” says Peter Aufmuth from the Max Planck Institute for Gravitational Physics (Albert Einstein Institute) in Golm. Improving the sensitivity by a factor of two would bring GEO 600 into the range of the Virgo Cluster, some 70 million light-years away, and increase the number of galaxies in the measurement range by well over a thousand.

The question of how frequently short gamma-ray bursts occur is of major importance to the success of the gravitational wave detector, as well as to cosmology research. The figures presented by several astrophysicists, such as Chris Belczynski (New Mexico State University, USA) and Richard O’Shaughnessy (Northwestern University, USA), demonstrated how far the astronomers still are from a comprehensive understanding of these processes. For an average galaxy like the Milky Way, between 3 and 200 collisions of two neutron stars are expected every one million years. Composite systems comprising a neutron star and a black hole are somewhat less common, but can be detected at greater distances.

**Pushing Computers to Their Limits**

Thus, the chances for GEO 600 and LIGO are not yet very good for a detection. Only after about 2014, when the instruments have been equipped with new technology, should a few dozen events be detectable each year. In view of the uncertainty of the predictions, however, Aufmuth was unperturbed.

In any case, the gravitational wave detectors in Germany and the US are in operation and are becoming even more sensitive. When the instruments detect a wave, theoreticians will analyze its time curve and compare it with computer models that they are currently making of colliding objects. At present, these calculations are pushing available computers to their limits. If, namely, a black hole or a neutron star moves, these bodies relentlessly bend the fabric of space and, moreover, change the course of time. Space-time thus itself becomes a variable physical quantity that must be recalculated for every step of the simulation.

Thus far, the calculations have regularly crashed after just one revolution of the bodies, or delivered meaningless results. But as Luca Baiotti and Bruno Giacomazzo from the Max Planck Institute for Gravitational Physics reported, particularly recent months have seen astonishing progress. Now the calculations remain stable throughout several revolutions, and also the form of the gravitational wave upon collision can be calculated. These computer simulations will allow conclusions to be drawn about the properties of the celestial sources based on the measured signals. This would usher in the beginning of gravitational wave astronomy.

Researchers in Antarctica are currently building a case for neutrinos. The detectors of the IceCube observatory are buried 1,400 to 2,400 meters deep into the ice and are expected to detect the cosmic ghost particles. **With the Hubble space telescope, it has been possible to record the afterglows of several long gamma-ray bursts. Here, the galaxies in which they exploded also become visible.**

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Humans don’t need all that much to survive. But merely satisfying our basic needs will by no means make us perfectly content. We want more – and we can never get enough of, say, vacationing. A new approach to evolutionary economics being pursued by Ulrich Witt at the Max Planck Institute of Economics analyzes why this is so. It finds, for example, that the historical impetus for embarking on vacations was closely related to a quest for better health.

A couple of days off – and away we go. To the coast or the mountains, to London, Paris or New York, the Canary Islands or the Mediterranean, Africa, Asia or South America. This undertaking, which is often coupled with substantial effort and considerable financial expense, is called vacation. It is more or less a mystery: to date, no one has been able to say where our need for vacation comes from and why this need is so insatiable. How else can it be explained that the tourism industry continues to grow year after year even in such countries as Italy, France and the United Kingdom?

The group headed by Director Ulrich Witt at the Max Planck Institute of Economics in Jena aims to close the gap in empirical knowledge about how the motives and desires of vacationers develop in tandem with the economic emergence of the tourism industry.
industry. In doing so, the researchers are pursuing an approach that is unique in economics: they analyze how the growth of modern consumption is grounded in the behavioral predispositions present in the evolved human genetic endowment. Guided by a general theory that Ulrich Witt outlined a few years ago, the scientists examine, for example, the markets for washing machines, shoes, sugar and tourism (MaxPlanckResearch 3/2001, page 36 ff.).

FROM SANATARIUM TO HOLIDAY DESTINATION

“What we hope to gain from this,” explains Witt’s student Andreas Chai, “is not so much new findings about the cultural history of the respective goods as, in fact, evidence for the general theory, to be expanded and refined through work on case studies.” The various projects aim to explain how, starting from basic human needs, those specialized desires developed that, in today’s economic context, are summed up in the term demand.

Various mechanisms play a role here. For example, in the model developed by the evolutionary economists in Jena, consumers develop acquired wants that emerge in the course of satisfying their basic needs. This happens when people associate certain other things with the fulfillment of basic needs – and, ultimately, also experience satisfaction through them. “In this way,” says Andreas Chai, “one could explain, for instance, how the need for health stimulated demand for a large variety of consumption activities, such as the demand for the natural glow of a suntan, vitamin supplements and nordic walking.”

The concept of acquired wants also answers the question of why we humans simply can’t get enough of some things – although we have a limited capacity to eat, sleep and engage in other key activities. Demand can grow continuously because each of the acquired needs is not linked to just a single basic need, but to several – and these can hardly all be fully satisfied at the same time. In Witt’s model, products and services that accommodate multiple needs simultaneously are called combination goods.

Applied to concrete economic development processes, this theoretical background facilitates surprising insights – for example, when one wants to understand how the tourism industry has been able to develop across different regions. Andreas Chai, a Ph.D. student in the Evolutionary Economics Group, studied a few chapters of this development, including the metamorphosis of former sanatoriums into vacation retreats for tourists, using the history of the English resort towns as an example.

TRAVELING FOR HEALTH

The research design drafted by Andreas Chai, a 27-year-old who expressly came to Jena from Australia, puts the focus on human needs. In this way, it differs from existing cultural and economic-historical depictions of the tourism phenomenon. What determines the demand for tourism services? How do people know which service fits their desires? How is this knowledge communicated? How do consumer expectations change – and how does that entail not only a functional change of tourism facilities, but also a growth of business segments? These are questions the study tries to answer.

At the beginning of the story that Andreas Chai tells is the desire for medical treatment. In the early stages of what we today refer to collectively as the tourism industry, it was, among other things, this desire that drove people to take a trip. At a time when there were not yet any hospitals or modern medical treatment techniques, many consumers traveled to particular regions to have all kinds of illnesses treated there with natural remedies that were not available elsewhere, such as mineral water, sea air and sun.

At the beginning of the 20th century, a vacation in Brighton was a status symbol, but even today, the coastal city still draws masses.
"This raises the question of how people actually knew what things would make them healthy and what makes them sick," explains Andreas Chai. The first guess, of course, is based on the immediate physiological reaction to treatment. Being healthy also means being free from pain. However, all questions that go beyond this element experience posed difficulties for the early health-seeking tourists.

When spa tourism began in the 16th century, there were no medical experts. For this reason, suspects Andreas Chai, people resorted to a rule of thumb: whenever it was not known whether a certain treatment would have a positive effect on one's health, a therapy was accepted that induced any kind of physical reaction whatsoever. "At the time, no one formulated such a rule in those words," says Chai, "but it explains many of the popular behaviors.

For example, it is conspicuous that the most popular mineral springs were those that had bitter or rotten-tasting or dark-colored water. Later, it was discovered that some of the springs were harmful to health. But against the backdrop of the medical knowledge of the time, the preference for water with these special properties is plausible.

Most of the physicians at that time assumed that water is not merely a chemical compound, but harbors certain "spirits" that elude analysis. This belief was reinforced by the experience that it was possible to determine the mineral content of various waters, but not to analyze the gases dissolved in the water, which were responsible for fuzziness, taste, consistency and smell.

A Preference for Visible Therapy

For lack of alternatives, the medicine of the time pursued, as we would call it today, a holistic approach. The goal of treatment was to calm the nervous system and to support the natural healing process. This also meant that patients observed the changes in their own health very closely – and were satisfied when there was some visible reaction they could report to the doctor or to their fellow patients. The preference for visible therapy can also be found later. When the institution of sea bathing emerged in the 18th century, applications using cold water became popular and were used to induce shocks and numbness. Thus, fall and winter were the preferred seasons for a vacation in a bathing area.

In light of a new emerging medical paradigm that favored a comprehensive healing process rather than targeted therapeutic measures, the function of the spa towns changed as well, and thus dawned the age of modern tourism. Spa vacations turned into pleasure trips. The pleasant influences of good food, peaceful surroundings and amusement became just as much a part of the treatment as the effects of the water.

A new generation of sanatoriums had thus become – as the theory terms it – a combination good: a service that addresses an entire range of needs and desires at once. Since they can hardly all be satisfied simultaneously, the service promises quasi-permanent demand.

This change in the function of travel had important implications for the viability of resort tourism. Specifically, at the beginning of the 19th century, advances in medicine and chemistry created modern alternatives to traditional spa therapies involving bio-meteorological remedies. In many cases, strong sedatives and pain relievers, vaccinations and, above all, modern hospitals made these therapies redundant.

Nevertheless, the popularity of the resort towns grew. In 1911, around half of the population of England and Wales took at least one trip to the coast each year. Now there were also many members of the working class among them – despite the costs associated with the trip. For a one-week stay, the labors had to save, on average, for an entire year. So what drove them to the seaside spas in spite of this? It couldn't have been status or proximity to VIPs and the "in" crowd; at that time, the rich and famous had already moved on to inland towns or to the better-appointed spas on the continent.

While a variety of amusements were available locally to the increasingly urbanized consumer population, the resort vacation offered them something different: an opportunity to escape the unhealthy living conditions in the cities of the early 19th century. Thus, as in the early days of spa tourism, the need for health took center stage. It had simply taken on a different form than in the days of the early tourists.

Tourism Growth in the Modern Era

Not everything in this story is new. What is new, however, is the combination of events – the attempt to reconstruct how changing consumer desires and needs led to a change in an entire economic sector. This is the only way the resort towns could cope with the lack of demand for medical treatment and, in fact, grow at the same time.

Although the evolutionary economic analyses of the history of tourism are not aimed at gaining new historical insights, Andreas Chai did uncover astonishing details: "Who knew," he says, "that these major changes in vacation preferences saved 19th-century
How people can find out which products determine new goods and services. The epistemic environment also determines the willingness to adopt new things – things they previously did not even consider necessary. When the production of such things is associated, for example, with a high environmental impact, says Ulrich Witt, that is not unproblematic. A new approach is the only chance.

Witt’s concept of evolutionary economics already existed as a research field when he created the Evolutionary Economics Group. For the most part, however, it was about innovation research. “Our colleagues who worked in that field had a 20-year head start – that’s how long they were already at it,” says Witt. “It was clear that we would never be able to catch up with that. That is why we focused on different niches.”

One of these niches is Ulrich Witt’s theory of consumption. Of all the topics the research group covers, this one generates the greatest interest, Witt reports, with just a touch of pride. “At international conferences, we notice that people are curious. That’s why I think, sooner or later, we will no longer be the only ones doing it. And then the methods will also become more sophisticated.”

At present, his group is working on developing mathematical models for the new demand theory. The researchers want to use them to test it statistically on a large scale – and not just verify it based on case examples. Witt is certain that they will then also succeed in convincing the mathematics-loving economists of his approach.

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Nicht suchen. Finden!
Ulrich Christensen

The Red Army in Afghanistan, a military coup in Turkey, and the mujahedeen have Iran in an iron grip – 1980 is a year of crises in the Middle East. It is also the time when Ulrich Christensen, having just finished his doctoral studies, treats himself to a year off and a journey to distant lands – with his wife and an old Ford Transit, all the way to India. “Many people told us we were crazy to drive through Iran,” says Christensen today. And the situation was anything but relaxed; a US military action in the Persian Desert had failed a couple of months earlier. The Americans’ attempt to free the hostages from the hijacked embassy in Tehran ended in a debacle. The authorities had just barely given permission for a quick seven-day transit – a tourist visa was out of the question.

“Of course the dangers of such a trip always get exaggerated, but adventure did play a bit of a role, too,” says Christensen in hindsight. The powder keg exploded just a short time later. The route through Persia was already blocked by the time they began the trip back, with the intervening outbreak of the Iraq-Iran war. The main motivation for the trip was not, however, the thrill: “It was about getting to know foreign countries and the cultures there.”

Nevertheless, Ulrich Christensen does not consider himself to be a scientist in the style of a geographer – painstakingly gathering details, scrutinizing virtually every little stone. He prefers to leave that sort of approach to others. “I am interested in the fundamental phenomena in the geosciences,” says the geophysicist, who was appointed Director at the Max Planck Institute for Solar System Research in Katlenburg-Lindau in 2002. He also has held the position of Managing Director there since 2005. “After all, Earth is a planet, too, in the company of seven others in the solar system. Comparing Earth with these other worlds teaches us a lot about our own home,” he says, citing a popular reason for working on other planetary bodies.

So what fascinates him personally about forging the way to other worlds? “Just 50 years ago, planets were faint little images in the eye-piece of a telescope – you didn’t exactly see much.” Then the space missions came along, and practically every successful mission brought truly great discoveries: Mars has gigantic volcanoes – the largest in the solar system. Io, a satellite of the gas planet Jupiter, is extremely volcanically active, and on Europa, another of Jupiter’s moons, there is very likely a saline ocean lying hidden beneath a crust of ice.

Researchers Glimpse below the Surface

“The discoveries made exploring these worlds are thrilling and spectacular. It is like the first sight of terra incognita. When else can a researcher still be part of something like that today? Scientific progress is normally a very slow affair,” says Ulrich Christensen.

However, when the Max Planck Director trains his gaze on the Earth and other planetary bodies, what he notices is not so much the exotic landscapes in those worlds. Instead, armed with the laws of physics, he penetrates beneath their surface. Why do continental plates drift? How do rock masses in the Earth’s mantle move? What formed the gigantic volcanoes on Mars? What force drives the planets’ magnetic fields? As a theoretician, Christensen attempts to obtain answers using model calculations. The data needed for this comes from the instruments on planetary probes that traverse the solar system on their information-gathering expeditions. And often enough, the researchers are perplexed when, after years of travel, the much-awaited data flashes across their computer screens.

So it was in 1975, as well. At the time, the US probe Mariner 10 inspected Mercury on a flyby mission. The surprise came when the onboard magnetometer registered a global magnetic field. The experts had hardly expected that, of all the terrestrial planets, the smallest of them should have such a field. Even its larger siblings Mars and Venus had no global magnetic field to boast, as other missions had already revealed. Of the four terrestrial planets, the researchers knew of the magnetic field of only the geologically active planet Earth. “Mercury’s field, however, is really quite weak by comparison, about 1 percent of that of the Earth – a finding that at first is scarcely comprehensible in the context of dynamo theory,” says Christensen.

According to dynamo theory, planetary magnetic fields follow the same basic principles as technical dynamos, similar, for example, to generators in cars. Currents in the planet’s electrically conductive liquid core play a role equivalent to that of dynamo coils. If dynamo theory is applied to Mercury, the strength of its magnetic field can certainly be calculated, but the theoretical result is 30 times greater than the figure measured by Mariner 10. So is the planet closest to the sun a magnetic anomaly?

From Mercury back to Earth and on to the small steel-producing town of Peine in Lower Saxony, where Ulrich Christensen was born into a family of five children in 1954. His father worked his way up the ranks in the steel mill to become a master of his trade, and higher education...
was encouraged in the family. Ulrich Christensen is a geoscientist and, for the past five years, Director at a Max Planck Institute. The diversity of the planets in our solar system fascinates him.

For a while, the young researcher toyed with the idea of studying chemistry. When physics eventually won out, it was initially unclear what direction to take. What was clear, however, was that he had an affinity for the natural sciences. His own sons, now teenagers, are likewise drawn to the natural sciences.

The 1960s were a time of radical change within the geosciences. The tectonic plate revolution had turned the entire field inside out. Sure, geophysicists had long resisted Wegener’s decades-old plate tectonic hypothesis, since his approach—which held that the movement of the continental plates is driven by the “pole-fooling force”—was not tenable. Furthermore, seismologists had already shown in the 1920s that the first 3,000 kilometers of the Earth’s interior are not fluid at all, but solid.

As a result, the majority also rejected continental drift. Things did not change until the notion that solid rock, too, can flow had gained some support. In this respect, it is similar to glacial ice—and as is commonly known, water in the solid state flows slowly down the mountainside.

**Everything Flows – Including Solid Rock**

“The transition was completed around 1970, but it took a couple years longer in Germany,” says Christensen. The static Earth was now history and was replaced by a new model—heat flowing outward from the hot core of the Earth through the Earth’s mantle. This heat transport propels slow-moving convection currents within the solid rock of the mantle, and these, in turn, drive plate tectonics. By the mid-1970s, these ideas were widely accepted here in Germany, too.

“That was at the time when I was looking for a topic for my thesis,” says the Max Planck researcher. In addition, an initial qualitative theory and the very first numerical analyses were already on the market. That interested me right from the start. I wanted to employ model calculations like that, too.”

However, the new theory skipped over the researchers at the Institute for Geophysics in Braunschweig: “We didn’t have any real experts for that back then.” Christensen made inroads during a team meeting when the subject of a potential thesis on the new research topic was raised. “I can do it!” Concerns were immediately voiced—too ambitious, suitable only as a topic for a doctoral dissertation. “But if he can do it,” says Christensen, quoting a sentence from Walter Kzer, who thus ended the debate. To this day, Christensen credits his later Ph.D. supervisor for showing this faith in him. So his research would now delve into Earth’s dynamic mantle. His dissertation was also devoted to the subject.

Three taxing years passed until he obtained his Ph.D., and then a year between Nepalese jungle and crocodile-infested countries in the Middle East. This was followed by an intensive period spent in the laboratories of various research projects. For 27 years, Christensen served at the University of Mainz, Arizona State University and the Geochemistry Division of the Max Planck Institute for Chemistry, as well as guest lectureships at the Universities of Karlsruhe and Utrecht. Finally, in 1992, Ulrich Christensen headlined the call of the Institute for Geophysics at the University of Göttingen. Scarcely two years later, he was awarded the Leibniz Prize, Germany’s best-endowed funding award, for all of his scientific achievements to that date. Soon the Earth’s core—and particularly a model of the magnetic field generated there—joined the Earth’s mantle as the focus of his research.

**3-D Sectional Images Shed Light on the Earth**

So his work focused on the Earth for almost 20 years. What results is Ulrich Christensen especially proud of? He has to think about it for a bit: “My model predictions of the role of the phase boundary 660 kilometers deep inside the Earth’s mantle. That is where a transition occurs between two crystalline structures, similar to the well-known transition between the two carbon variants diamond and graphite. This was confirmed using the new method of seismic tomography, which allows the Earth to be analyzed through 3-D cross-sectional images similar to the tomography familiar from medical diagnostics, where 3-D images provide a glimpse into the internal workings of the human body.”

“This new technology had reached a sufficient level of refinement by 1990. For instance, it was possible to see where surface plates in the Earth’s mantle subduct. It turns out that, although the phase boundary hinders the convection currents, they can indeed cross the boundary in some places, which means that it is semipermeable,” says Christensen. He had already postulated the hypothesis in the mid-1980s based on his model calculations: “So there are no distinctly separate levels within the Earth’s mantle.” At the time, a lot of geoscientists still made that assumption.

Christensen suspects that there is a similar phase boundary inside Mars, albeit at a greater depth. Such a transition influences the convection currents there—enormous bulges in the Tharsis region, the site of the huge Martian volcanoes, is the expression of a single large mantle plume on the red planet. In this respect, Mars differs from Earth, which has at least a few dozen of these tectonic plumes.

However, no evidence has yet been found to support the hypothesis. If there were such a thing as a fairy godmother who grants planet researchers’ wishes, there would be no question about where to install automatic seismometers in the solar system: “Definitely Mars,” says the Max Planck Director without hesitation. But since they aren’t waiting for miracles to happen in Katlenburg, the institute is participating in the European-led ExoMars mission with a proposal to record earthquakes on the surface of Mars for the first time. Then the red planet, too, would have to reveal its innermost secrets. Back to Mercury’s unusually weak magnetic field. To understand the mechanism that drives such a field, it is important to visualize the structure of the planet. Mercury, like Earth, probably has a solid metallic inner core at its center, surrounded by a liquid metallic outer core.

According to Ulrich Christensen, “The solid core cools down and iron freezes on it from the inside out.” A few percent of a lighter chemical element, probably sulfur, are dissolved in the iron and nickel core. This, too, is known from analyzing how earthquakes propagate within the Earth. The core of Mercury is thought to have a similar admixture. Due to the hardening of the solid core, this material accumulates on the liquid side of the boundary layer. There, it reduces the density, and uplift pressure sets the liquid in motion. This triggers chemical convection, which is based on the differences in

Looking at a terra incognita: What formed the gigantic volcanoes on Mars? What force drives the magnetic fields? Christensen seeks answers to questions such as these.
Probes explore the planets at close range – using instruments from the laboratories at the Max Planck Institute for Solar System Research.

In late September, the institute will sign in this agricultural region – an oddity (MAXPLANCKRESEARCH 2/2007, page 13).

TAKING OFF FOR THE ASTEROID BELT

When Ulrich Christensen travels to his remote workplace each morning, he sees the Harz Mountains on the horizon. The virtually flat area around Katlenburg-Lindau, however, has none of the romantic charm of the Brocken. One would more likely expect a department of landscape design in this agricultural region – an institute for scientific forays into the solar system seems a bit out of place here. Yet even the American space agency, NASA, values the expertise of the Katlenburg-based researchers. In late September, the institute will once again turn its excited gaze toward Cape Canaveral when the Dawn spacecraft thunders into the sky over Florida. The asteroid mission already

landed on the political chopping block twice, but now it is finally scheduled for launch – with participation from Katlenburg: the probe’s ‘eyes’ stem from the Max Planck Institute.

Dawn’s first destination is the asteroid Vesta, and the two onboard cameras are to examine it minutely over the course of many months. The asteroid has a diameter of just about 500 kilometers and revolves around the Sun between Mars and Jupiter. In the company of tens of thousands of other boulders, Vesta, however, might be something special. “Some call it the smallest terrestrial planet,” says Christensen.

A certain group of meteorites, known as the HED meteorites, are thought to be debris from Vesta. From their analysis, planetary researchers know that there was once volcanic activity there. What Ulrich Christensen finds particularly exciting is that the chemical analysis of the rocks provides proof of an early melting of Vesta; this small celestial body likely had a liquid metallic core at one time, and possibly a magnetic field. A rendezvous with Vesta is planned for 2011. “It’s really a shame that an American magnetometer was removed from the scientific payload. That would have made it possible to detect traces of a former Vestian dynamo,” says Christensen.

For Christensen’s Mercury model, the moment of truth will come even sooner – in January 2008. After a four-year flight, NASA’s Messenger probe will pass a mere 250 kilometers above the crater landscapes of the closest planet to the Sun – favorable conditions for the onboard magnetometer. It will certainly be an exciting situation for Christensen - for the first time in more than 30 years, new measurement data is expected from the long-neglected celestial body. The scientist will have to wait a while longer, however, for the data from the European Space Agency’s planned BepiColombo mission, whose start is currently expected in 2013.

RELAXATION ON THE HIGH SEAS

As in his research, Christensen enjoys alternating phases of excitement and relaxation in his scant spare time, as well. He finds it in, for instance, sailing. Even if the waves occasionally get a bit rough, he can relax better there than on the dusty trails through the Middle East.

Where will his continued journey through planetary magnetic field theory lead? The big differences between the various planets in the solar system are still not fully understood. There are good working models of Earth’s magnetic field, and Jupiter’s magnetic field behaves as expected, says Christensen. But Saturn already gave the researchers one surprise. The ringed planet’s almost perfectly axially symmetric field contradicts basic dynamo laws. Christensen is thus searching for something like a unified dynamo theory that would satisfy the conditions of all the planets in the solar system equally.

Ulrich Christensen has one dream for his future work: when the Voyager probes first examined the moons of Jupiter in the late 1970s, they found the inner moon, Io, in turmoil, kneaded by tidal forces. The two spacecraft spied not one, but several active volcanoes during their short flybys. “Hardly anything was previously known about Io, but shortly beforehand, an American colleague had predicted volcanic activity on Io based on model calculations,” states Christensen appreciatively. A successful forecast of that calibre would be the crowning achievement of his work as a theoretician.
"We must be sure to win the contest for the finest minds"

It might be described as a gift of a special kind – to help shape the future of the Max Planck Society, and with it, the German and, indeed, the international research landscape. Now, with a greater fund of experience to call on, it is an exciting challenge that I look forward to. I have received an incredible amount of support over the years, and this, too, has encouraged me to carry on.

MPR: What has been your biggest challenge as President of the Max Planck Society?

Peter Gruss: Back in November 2002, we learned that the rug had been pulled out from beneath our budget for 2003, and suddenly we not only had to shelvel ideas that were on the point of implementation, but also cut back on current research activities. That was a difficult time. But it also had a positive side, for the solidarity I experienced within the Max Planck Society, both from the Vice Presidents and the entire management team and from individual members, was impressive, despite our occasional differences of opinion. We are now an efficient and close-knit community. After a financially weak start, we have recovered well. The Pact for Research and Innovation gives us planning security until 2010, with a 3 percent increase each year that we can count on. We are taking advantage of this position to add fresh momentum in a wide variety of ways – not least by developing new departments. We have also been successful in amplifying private research sponsorship. I am especially pleased at the formation last year of the Excellence Foundation in support of research activities of the Max Planck Society. That was a pioneering decision.

MPR: When you were elected five years ago, you had the big advantage that, as an outstanding scientist in your own right, you knew the Max Planck Society from the inside. During your term of office, you have established some important emphases. To what extent did your experience as a Max Planck Director hold you in good stead?

Peter Gruss: I was both optimistic and confident when I took up my post, and perhaps also just a little naive. As a scientist, I had to deal with provable findings, whereas now, of course, as President of the Max Planck Society, my strategic planning must take some very subjective assessments of other people into account. That’s the sort of balancing act I was unfamiliar with as a scientist. But one learns, and that’s what gives me the necessary confidence for a second term of office.

MPR: As a Director at a Max Planck Institute, you were able to decide what goals to work toward and how to achieve them. Do you not find that, as President, your hands are much more firmly tied?

Peter Gruss: Of course the duties of the office can be properly carried out only with the support of the scientists at the institutes. On the other hand, the constitution gives the President of the Max Planck Society a great deal of latitude. Let me explain that with an example: The most important thing for us today and in the future is to attract and retain the finest minds worldwide and to define which areas of research offer particular promise. We have developed a variety of tools by which to achieve these goals, such as the Perspectives Committee and the Perspectives Commissions, which, together with their Section colleagues, do just that, generating fresh impetus and establishing new subject areas in the portfolio of the Max Planck Society. This provides a context in which the President can act. But it is also true that politics is the art of the possible.

MPR: Don’t you sometimes miss the everyday work in the laboratory?

Peter Gruss: For the first few years, I certainly missed scientific work – the more so as I was still attending conferences. Even today, I still feel the urge when I read the results of colleagues working in similar fields to mine. But you can do only the one thing or the other. However, I am firmly convinced that the one is possible only if you have mastered the other. Because the respect this office demands derives ultimately from one’s own scientific record.

MPR: What challenges do you see the Max Planck Society facing in the near future?

Peter Gruss: In the competition between the best, the Max Planck Society ranks among the top 10. We are no longer talking about just the US, the UK and Japan, but to an increasing extent also about countries like China, India and Russia, which are investing heavily in research. The whole world is in on the act, competing for the best scientists. If we wish to remain competitive, we have to make correspondingly attractive offers. That is the only way for the Max Planck Society to maintain its place as one of the frontrunners among research organizations. As far as Germany is concerned, there is no alternative; science is the sole key to our success, and that means making a greater financial effort.

MPR: Let’s dream about the future for a moment...

Peter Gruss: The office of President of the Max Planck Society is a dream vocation in itself. The Max Planck Society is one of the most innovative and successful scientific organizations. Worldwide we are on a par with universities like Harvard, Stanford and the ETH Zurich. They are the ones we...
The Birth of Aging Research

Which biological processes determine our life span, and how do they function? These and other aspects of the natural process of aging form the focus of the basic research that will be conducted at the new Max Planck Institute for the Biology of Aging. Now the Senate of the Max Planck Society has taken a decisive step toward getting this research project off the ground. At its meeting in Kiel on June 28, 2007, the Senate approved the foundation of a new institute in Cologne, subject only to securing the necessary financing. Top international researchers are to be appointed to head the new MPI. The new institute in Cologne will make an even dozen Max Planck Institutes in North Rhine-Westphalia, adding further support to the development of a life science cluster of worldwide significance.

The Max Planck Institute for the Biology of Aging will study the fundamental biological processes that control the normal aging of living organisms. In this respect, the institute in Cologne differs from other institutions that focus on clinical or pathological processes. The primary emphasis here will be on basic research using model organisms. One of the most important laboratory findings in this field in recent years has been the discovery that changes in individual genes can extend the life span of these organisms. For example, it has been found that mutations in genes in the insulin signal pathway can substantially affect the life expectancy of mice, roundworms and fruit flies.

The mouse Mus musculus, the fruit fly Drosophila melanogaster, the roundworm Caenorhabditis elegans and the single-cell yeast Saccharomyces cerevisiae are particularly suited to a study of the interaction between changes in genetic composition and their effects on the structure of the individual, since all of the genes of these model organisms are known. Other advantages include their short life span and high fertility. The one-millimeter-long worm comprises barely a thousand genes, matures in three to four days and lives for only three to four weeks. It is no coincidence that this tiny creature has become a favorite beast of burden in both genetics and age research. And it is now known that over a hundred of its genes have an impact on life expectancy.

The institute will initially comprise three departments. One area of emphasis will be on evolutionary biology, developmental biology and genetics against the background of longevity in the fruit fly Drosophila. The second area of study to which the Institute for the Biology of Aging will devote itself will comprise molecular signal pathways and their interaction with the environment, focusing on the duration of development, maturity and aging of Caenorhabditis elegans. The third research department is expected to focus on the influence of mutations on the basic energy balance of mitochondria, the power stations of cells, and consequently also on the life span of mammals, as represented by mice.

The plans drawn up to date anticipate a five-year development period for the institute. By 2012, a total of four departments are expected to have started work, along with four independent junior research groups. The roughly one hundred members of staff – scientists, administrators and technical personnel – will, in the final stage of development, dispose over an annual budget of the order of 15 million euros.

The Max Planck Society chose Cologne as the location "because North Rhine-Westphalia offers considerable scientific potential, as well as the right conditions to develop a successful life science research cluster," explained Max Planck Society President Peter Gruss. "The University of Cologne in particular will contribute substantially to this cluster." As part of the Excellence Initiative, the university has, in fact, already submitted an application to form an Excellence Cluster devoted to the subject of age research. The extra funding will enable additional scientists to be appointed. The new Max Planck Directors will also have links with the Faculty of Medicine, and the university is planning a master’s program in this field.

The scientific environment is further enriched by the Max Planck Institute for Neurological Research in Cologne, Molecular Physiology in Münster, as well as the soon-to-be-reoriented research center in Bonn. The new Max Planck Institute to join the scene will also be ideally located on campus, directly adjacent to the University of Cologne.
Max Planck researchers working in Manaus have been investigating the significance of the tropical rainforest for the global climate. On a boat trip along the “Encontro dos Aguas,” a tropical outpost in Manaus, Brazil, Meinrat Andreae, Director at the Max Planck Institute for Chemistry in Mainz, explained the significance of this sensitive ecosystem. The Amazon basin, which accounts for more than half the world’s area, is a tropical rainforest that is destroyed is another page torn from the book of evolution. “It is therefore imperative to protect and preserve Amazonia as the ‘library of life.’”

The question of how to put a stop to climate change is taxing more than a few politicians at present. The issue has taken Federal President Horst Köhler as far afield as Amazonia: during a state visit to Latin America, he sought advice from an expert group of Max Planck scientists on what politicians in Germany and worldwide can do to mitigate the effects of our changing climate. The Max Planck Society has for many years maintained a tropical outpost in Manaus, Brazil.

Sensitive ecosystem: For many years, Max Planck researchers working in Manaus have been investigating the significance of the tropical rainforest for the global climate.

The consequences of climate change and the ecological significance of the rainforests were also the focal point of a subsequent round of discussions in which Andreae and the Federal President were joined by Wolfgang Junk of the Max Planck Institute for Chemistry and the Federal President’s advisor Holstein for her research into roundworms. She showed that Hamburg’s air has improved substantially over 23 years ago. However, a comparison with earlier surveys proved to be worse due to the sulfur dioxide produced in the combustion of marine diesel fuel. However, a comparison with earlier surveys showed that Hamburg’s air has improved substantially over 23 years ago.

The “Jugend forscht” (youth research) competition reached its grand finale in mid-May when Germany’s best young researchers met in Hamburg for the final round of the national contest. At the beginning of the year, over 3,000 young people first answered the call of “Champions wanted!” and entered the 42nd round of Germany’s best-known contest for junior scientists. In the end, only 189 of them qualified. Out of a total of 109 projects, the jury had to choose the winners in six different categories, as well as the recipients of various special prizes. The prizes in the biology field were all do-nated by the Max Planck Society, and the presentations were made – on behalf of the President – by Nobel Prize winner and Director at the Max Planck Institute for Biophysics in Frankfurt, Hartmut Michel.

The jurors found Ajecha Proezl’s work on wasps as hazardous substance testers for insecticides in classrooms impressively simple. The project earned the 15-year-old the first prize, worth 1,500 euros, in the biology segment. Andreae made use of the sensitivity of wasps and other two insect species to various chemical compounds. Her test was simple, quick, highly economical, the jury explained, and made her the clear winner in her class. Second place was shared by two young researchers from Baden-Württemberg: 18-year-old Samuel Fink and 17-year-old André Kroker were awarded the 1,000-euro prize for their work on the growth of cress seeds. Their project addressed the question of what happens to the plant when it is exposed to an increased gravitational force. To answer this question, they developed a centrifuge for their experiments with cress seedlings. They subsequently observed that, to maintain their stability, the plants adapted the thickness of their cell walls according to the load imposed by the centrifuge.

Research into red wine earned Dominik Herzog from Kirchheimbolanden in Rhineland-Palatinate third place and 500 euros in prize money, or disbursed, now that the MPI in Pils has changed its focus of study. Under the leadership of Meineat Andreae, the Max Planck Institute for Chemistry in Mainz will accede to the cooperation agreement with the INPA, with the task of research coordination falling to Jürgen Kesselmeier of the Max Planck Institute for Chemistry. The host country was represented by Virgilio Viana, the Minister of the Environment for the State of Amazonas, and Muriel Sarauwi, Secretary of State at the Brazilian Ministry of the Environment. The scientists and politicians unanimously agreed that measures to protect the climate must be delayed no longer. “It is now quite clear that the time has come for action,” declared the Federal President at the end of the discussion.

On a boat trip along the “Encontro dos Aguas,” a tropical outpost in Manaus, Brazil, Meinrat Andreae, Director at the Max Planck Institute for Chemistry in Mainz, explained the significance of the tropical rainforest for the global climate, and the havoc resulting from the overexploitation of this sensitive ecosystem. The Amazon basin, which accounts for more than half the total area of tropical rainforests, is in effect an all-embracing life support system for the planet as a whole. However, human intervention and global climate change are threatening the key functions of this system, namely its ability to rid the atmosphere of pollution, stabilize the climate and regulate the water balance.

Andreae placed particular emphasis on the incomparable wealth of species that inhabit the tropical rainforests. Besides thousands of species of birds and mammals, there are tens of thousand of plants, hundreds of thousands of invertebrates, and insect species by the million. “The vast majority have not even been scientifically described, and never will,” said the Director of the MPI in Mainz. “Every hectare of rainforest that is destroyed is another page torn from the book of evolution.” It is therefore imperative to protect and preserve Amazonia as the “library of life.” The federal government has been investing in Amazonia for forty years as a joint project between the Brazilian Ministry of Science and Technology, the Max Planck Institute for Limnology in Pilsen and the Instituto Nacional de Pesquisas da Amazônia (INPA). Wolfgang Junk, who has headed the Tropical Ecology group at the MPI for Limnology since 1980, has used the base to research and classify the waters and floodplains of the Amazon. Upon his retirement in the middle of this year, his research group will be disbanded, now that the MPI in Pils has changed its focus of study. Under the leadership of Meinrat Andreae, the Max Planck Institute for Chemistry in Mainz will accede to the cooperation agreement with the INPA, with the task of research coordination falling to Jürgen Kesselmeier of the Max Planck Institute for Chemistry and will be integrated into the new research profile of the Manaus branch, which will be oriented toward biogeochemistry and climate research.
EUROPE’S STRONGEST MAGNET can now be found at the Max Planck Institute for Neurological Research in Cologne. Since May, it has been part of a newly installed nuclear magnetic resonance tomograph that is used by scientists to study the brain. The new instrument operates at 11.7 Tesla, which is 235,000 times the strength of Earth’s magnetic field. The Max Planck researchers in Cologne are using the nuclear magnetic resonance tomograph to investigate changes in the brain at a molecular level. What happens before, during and after a cerebral infarction? How do stem cells implanted after a stroke behave? How does the brain start to work once more in response to treatment? These are some of the questions to which it is hoped the new equipment will provide detailed answers. Nuclear magnetic resonance imaging is a procedure that uses the magnetic properties of atomic nuclei to create images of the human or animal subjects under investigation. If placed in a very strong magnetic field, which causes the atoms to modify their spin. When the magnet is switched off, the atoms revert to their original condition – in other words, their spin changes and specific signals are emitted from it which is possible to calculate a cross-sectional image of organs and tissue.

MARATHON CELEBRATION: For an entire day, research formed the focal point of political life in Brussels. The day’s events marked both the 50th anniversary of science-related activities in Europe and the launch of the European Commission’s Seventh Research Framework Program. And what better day could there be for the Science Tunnel, the Max Planck Society’s multimedia exhibition, to open its doors in Brussels? The MPS also chose to highlight on the evening of the presentation of the Descartes Prizes: one of Europe’s first major prizes for science. With his 750,000 euros, putting a smile on the faces of researchers from three more Max Planck Institutes.

ELITE MEETS EXCELLENCE: No fewer than 10 Max Planck Institutes are partnering a special master’s degree course at Julius Maximiliani University in Würzburg. The course is aimed at exceptionally accomplished and motivated students of physics and non-structure technicians and was established as part of the newly created Bavarian Elite network that embraces universities across the state of Bavaria. In cooperation with the Max Planck Institutes for Solid State Research, Metals Research, Physics, Astrophysics, Extraterrestrial Physics, Biophysical Chemistry, Dynamics and Self-Organization, Physics of Complex Systems, Microstructure Physics and the Fritz Haber Institute, students will be introduced, at the earliest possible stage, to current leading-edge research. By working together in small groups and as members of various teams, they will benefit from optimum intensive, individual training. Special practical research deployments and block seminars in interim periods between lectures, reinforced by personal support and progressive examinations, will substantially curtail the time needed to graduate with a master’s degree with a “Focus on Physics,” as the course is named.

AN INVITATION TO CAESAR – and 1.5 million euros were cause for celebration for neurobiologists Ray Dolan and Hans-Christian Pape. They share this year’s Max Planck Research Prize, the international award presented by the Alexander von Humboldt Foundation and the Max Planck Society. The Prize will be presented in mid-November in Bonn, where the caesar research center is based. Irish scientist Ray Dolan of University College London and his German colleague Hans-Christian Pape of the WWU Münster were chosen to receive the award funded by the German Federal Ministry of Research for their work in the field of neuromodulation and behavior. Dolan is regarded as one of the pioneers in modern neurobehavioral research, a branch of science that uses imaging techniques to investigate cognitive processes in the brain and their relationship with behavior. Pape intends to use the prize money in cooperation with colleagues in Germany to extend his studies on the neurochemical mechanisms that underlie human emotional learning and decision-making processes. Hans-Christian Pape has been researching the molecular and cellular bases of fear and the memory of fear, as well as the processes that regulate wakefulness and sleep in animals. With his 750,000 euros, he hopes to demonstrate corresponding processes in humans and thereby create a basis with which to treat anxiety disorders and epilepsy. •
IN THE SPOTLIGHT

Bats cause a stir: The secret of a bat’s agile and acrobatic flight lies in its elastic and highly flexible wing membranes, which function like hands with skin between each finger. This allows the bat to control the curvature and compartmentation of their wings. Engineers and biologists call this membrane, which is so well adapted to flying, "aerodynamically active." Now, the mystery of the aerodynamics of bat flight has been revealed in Lund, Sweden: researchers, including scientists from the Max Planck Institute for Ornithology in Seewiesen, filmed the aerodynamic footprint of *Glossophaga soricina*. Brief laser flashes traveled through the air, which held tiny reflective drops of water, taking momentary images of the eddies. Like a flip-book, the series of reflective images show the characteristic turbulence caused by the bat’s flight. Each beat of its wings creates turbulence on both the up and the down stroke (the flow direction is indicated by the arrows; the length of the arrows shows the speed of the air molecules at each point). With the impact, the eddies at the center of the wings and at the wing tips rotate in different directions, creating a force that lifts the body with a down force on the wing tips. The agile bats were trained to stay in one position and allow the air to flow past them in the wind tunnel in Seewiesen. *Glossophaga soricina* is particularly suitable because it hovers to drink from flower calyces, like a hummingbird. The researchers used this fondness for sweet nectar to attract the bat into the wind tunnel, setting up a thin tube containing diluted honey. As the bat drinks the honey, it hovers in one place for several seconds, which allowed scientists to observe the wake created by the wing beats.

PHOTO: L.C. JOHANSSON, M. WOLF AND A. HEDENSTRÖM